Developing an ontology of mechanisms of action in behaviour change interventions

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Declaration

I, Paulina Margarete Schenk, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

The following work was carried out at the Department of Clinical, Educational and Health Psychology, University College London (UCL), under the supervision of Professor Susan Michie, Doctor Alison Wright and Doctor Fabiana Lorencatto. This work formed part of a larger project, the Human Behaviour-Change Project (HBCP). This thesis has not been submitted, in whole or in part, for any other degree, diploma or qualification at any other University.

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Abstract

Background: Behaviour change interventions can influence behaviours central to health and sustainability. To design better interventions, a strong evidence base about 'why' interventions work is needed, i.e., their mechanisms of action (MoAs). MoAs are often labelled and defined inconsistently across intervention reports, creating challenges for understanding interventions and synthesising evidence. An ontology can address this problem by providing a classification system that labels and defines classes for MoAs and their relationships.

Aims: To develop an ontology of MoAs in behaviour change interventions, and to explore challenges in understanding MoAs and their links to behaviour change techniques (BCTs)

Methods: Behavioural scientists' challenges to understanding MoAs and BCT-MoA links were investigated using a thematic analysis (Study 1 [S1]). To help better understand MoAs, Studies 2-7 developed the MoA Ontology: (S2) Identifying and grouping MoAs from 83 behavioural theories; (S3) Converting the groupings into an ontology by drawing on relevant ontologies; (S4) Restructuring the ontology to be more usable and ontologically correct; (S5) Applying and refining the ontology to code MoAs in 135 intervention reports; (S6) Nine behavioural scientists reviewing the ontology's comprehensiveness and clarity, informing revisions; (S7) Investigating the inter-rater reliability of researchers double-coding MoAs in reports using the ontology, informing changes to the ontology.

Results: Study 1 suggested challenges to understanding broad and underspecified MoAs. To form the basis of a detailed ontology, Study 2 identified 1062 MoAs and formed 104 MoA groups. Building on these groups, Studies 3-7 created the MoA Ontology, which had 261 classes (e.g., 'belief') on seven hierarchical levels. Inter-rater

3

reliability was 'acceptable' for researchers familiar with the ontology but lower for researchers unfamiliar with the ontology (Study 7).

Conclusions: The developed ontology captured MoAs with greater detail than previous classification systems. With its clear class labels and definitions, the ontology provides a controlled vocabulary for MoAs.

Impact statement

The key contribution of the research in this thesis is the development of an ontology of mechanisms of action (MoAs) in relation to behaviour change interventions. The MoA Ontology provides a classification system that includes, labels and defines classes that capture MoAs in behaviour change interventions and specifies their relationships. This ontology can support understanding, communicating, and synthesising evidence about MoAs across interventions. This research therefore has the potential to improve our knowledge about 'why' interventions work, which can lead to designing more effective interventions in the future.

There are several areas of impact or potential impact for the MoA Ontology in academia. First, the ontology can improve the reporting of MoAs in behaviour change interventions. Researchers can use this ontology to clearly label and define MoAs in study protocols and intervention reports. Secondly, the ontology can be applied in scoping and systematic reviews as a classification scheme to help synthesise evidence about MoAs in intervention reports. An early version of the ontology (Study 5) was applied in a systematic review about infectious diseases conducted by researchers from University College London and the University of Warwick. As part of the Behaviour Change Intervention Ontology, the MoA Ontology can support detailed evidence synthesis about MoAs in relation to other aspects of behaviour change interventions. Thirdly, as the MoA Ontology reuses classes from other related ontologies, thesis studies (Studies 3-7) that refined the MoA Ontology's classes also helped refine the classes that were reused from other ontologies. For instance, by closely collaborating with a developer of the Emotion and Mental Functioning Ontologies in Studies 3-7, the definitions of classes reused from these ontologies were updated to be more accessible.

Finally, the stepwise method to develop the MoA Ontology (Studies 2-7) can provide a detailed roadmap for developing other ontologies in behavioural or social sciences. The work to develop the MoA Ontology has been presented at the International Congress of Behavioral Medicine 2021 (Studies 2-5) and UK Society for Behavioural Medicine Conference 2022 (Studies 2-6). The final version of the ontology (Studies 2-7) will be presented at Division of Health Psychology Annual Conference 2022.

Researchers in organisations, such as the UK's What Works Centres, can apply the ontology to synthesise evidence about MoAs in behaviour change interventions from different sources (e.g., intervention protocols and reports or summaries). By enabling more systematic evidence synthesis about MoAs and helping structure this evidence, the ontology could support investments in more evidence-based interventions in the future. Beyond academia, policymakers and research funders can use the MoA Ontology to evaluate whether intervention proposals clearly specify the interventions' targeted MoAs.

Acknowledgements

Table of content

List of Abbreviations

APA – American Psychological Association

BCIO – Behaviour Change Intervention Ontology

BCT – Behaviour Change Techniques

BCTTv1 – Behaviour Change Technique Taxonomy Version 1

BFO – Basic Formal Ontology

GO – Gene Ontology

HBCP – Human Behaviour-Change Project

HBCO – Human Behavior Change Ontology

JSON – JavaScript Object Notation

MF – Mental Functioning Ontology

MFOEM – Emotion Ontology

MoA – Mechanism of action

OBMS – Ontology-based Modelling System

OBO Foundry – Open Biological and Biomedical Ontology Foundry

OGMS – Ontology for General Medical Science

OSF – Open Science Framework

PATO – Phenotype And Trait Ontology

PDF – Portable Document Format

TaT Project – Theories and Techniques Project

TaT Tool – Theories and Techniques Tool

TDF – Theoretical Domains Framework

UBERON - Uber-anatomy ontology

UCL – University College London

URI - Uniform Resource Identifier

List of Figures

List of Tables

List of Appendices

Contributions

Study 1 (reported in Chapter 2): This study drew on data that was collected as part of another project, led by Susan Michie (SM), Rachel Carey (RC) and Lauren Connell Bohlen (LC). I curated the data and conducted the thematic analysis with support from Candice Moore (CM). The resulting themes were refined with the help of Alison Wright (AW), Fabiana Lorencatto (FL), Marie Johnston (MJ) and Susan Michie (SM). I wrote the chapter and revised it based on the feedback from AW, FL and SM.

Study 2 (reported in Chapter 3): I conceived the study with AW and SM. I identified mechanisms of action (MoAs) from behavioural theories and grouped these with support from CM and Emily Hayes. AW, SM and Robert West (RW) provided feedback to resolve disagreements that occurred during the identification and grouping tasks. I wrote the chapter and revised it based on the feedback from AW, FL and SM.

Study 3 (reported in Chapter 4): I conceived the study with AW and SM. I identified, labelled, defined and hierarchically structured classes for the MoA Ontology with support from AW. FL, Janna Hastings (JH), SM and RW provided feedback on the ontology. I wrote the chapter and revised it based on the feedback from AW, FL and SM.

Study 4 (reported in Chapter 5): I conceived the study with AW, JH, SM and RW. To restructure the MoA Ontology, JH, SM and RW selected the ontology's upper-level classes. I labelled and defined these classes with support from AW. Based on the refined upper-level of the ontology, I identified the ontology's lower-level classes with support from AW. These classes were reviewed and revised by JH, SM and RW,

according to which I updated the ontology. I wrote the chapter and revised it based on the feedback from AW and SM.

Study 5 (reported in Chapter 6): I conceived the study with AW and SM. I used the MoA Ontology to double code MoAs in the behaviour change intervention reports, with the help of CM, Emily Hayes, Vivi Antonopoulou and Aikaterini Grimani. I discussed coding disagreements to refine the ontology with AW, JH, SM and RW and accordingly updated the ontology. I wrote the chapter and revised it based on the feedback from AW and SM.

Study 6 (reported in Chapter 7): I conceived the study with AW and SM. I collected and analysed the data with support from AW, JH, SM and RW. I wrote the chapter and revised it based on the feedback from AW and SM.

Study 7 (reported in Chapter 8): I conceived the study with AW and SM. I, AW, Ella Howes and Verena Schneider each used the MoA Ontology to code MoAs in 50 behaviour change intervention reports. I compiled the coding data and analysed it with support from Ailbhe Finnerty Mutlu. I discussed changes to the ontology with AW, JH, SM and RW. I wrote the chapter and revised it based on the feedback from AW and SM.

Summary of thesis

Behaviour change interventions work through mechanisms of action (MoAs) to influence behaviour. To target relevant MoAs, intervention designers can use evidence about MoAs from past behaviour change interventions. However, the reporting of MoAs creates challenges to understanding which MoAs were targeted in interventions: many intervention reports include different labels for MoAs with the same definitions, or the same labels but different definitions for MoAs. A controlled vocabulary about MoAs could facilitate better understanding and more efficient evidence synthesis about MoAs. Such a vocabulary could be provided by an ontology for MoAs, a classification system that labels and defines classes for MoAs and their relationships. The thesis aims were to (1) investigate the challenges to understanding and applying MoAs to link these to behaviour change techniques (BCTs) and (2) develop an ontology for MoAs in relation to behaviour change interventions.

To address Aim 1, Study 1 (reported in Chapter 2) investigated behavioural science experts' disagreements and uncertainties about MoAs, BCTs and their links in online written discussions via a thematic analysis. The findings revealed three key issues that contributed to disagreements and uncertainties. First, experts differed in their knowledge and experience about behaviour change and had different approaches to linking BCTs and MoAs, leading them to disagree. Secondly, when experts perceived MoAs or BCTs to be broad, overlapping with other constructs or defined unclearly, they seemed to have challenges understanding these MoAs and BCTs and linking them together. A final issue was that BCT-MoA links were often considered to be complex and variable (e.g., across different interventions and their contexts), creating challenges to judging one-to-one BCT-MoA links. To help understand MoAs and link them to

BCTs, some of these challenges could be addressed by developing an ontology with clearly labelled and defined classes that captured MoAs in detail.

To develop the MoA Ontology (Aim 2), Studies 2-7 (reported in Chapters 3-8) were conducted. To identify the preliminary content for the MoA Ontology in Study 2 (reported in Chapter 3), two researchers identified MoAs from 1733 constructs extracted from 83 behavioural theories. Then, to form an initial hierarchical structure for this content, three researchers grouped MoAs together based on shared attributes. Disagreements were resolved through discussions with three behavioural science experts. As a result, 1062 MoAs were identified from the 83 behavioural theories. Of these MoAs, 763 were organised into 104 MoA groups, 153 remained ungrouped and 146 were judged to be too broad to be grouped.

Study 3 (reported in Chapter 4) developed the first draft of the MoA Ontology with unique, clearly labelled, defined and hierarchical structured classes that were reused from other ontologies where relevant. To identify, label, define and structure the ontology's classes, one researcher and one behaviour science expert drew on the MoA groups and ungrouped MoAs from Study 2 and classes in other ontologies. After they created a draft ontology, three behavioural science experts and one ontology expert reviewed this draft to ensure that it was clear and comprehensible. The resulting draft ontology had 412 classes on eight hierarchical levels, but the expert review suggested that this draft was too complex (e.g., included too many detailed classes) and did not accurately capture the nature of MoAs.

Study 4 (reported in Chapter 5) aimed to revise the ontology to be comprehensive yet more usable and ontologically correct. To do this, two senior experts in behaviour science and one ontology expert selected and restructured the MoA Ontology's upper-level classes to broadly and comprehensively capture MoAs in behaviour change interventions. Based on this upper level, a researcher and another behavioural science expert selected lower-level classes that captured important distinctions between MoAs by drawing on the ontology's previous version. The selected lower-level classes were revised by the senior experts to ensure that the ontology was usable, comprehensive and parsimonious. The resulting version of the ontology had 202 classes.

Study 5 (reported in Chapter 6) aimed to refine the MoA Ontology's content (classes, their labels and definitions) to be clear and comprehensive enough to capture MoAs reported in behaviour change interventions. Five researchers used the ontology to double code MoAs in 135 intervention reports. To identify changes to the ontology, the coding disagreements were discussed with three behavioural science experts and an ontology expert. Accordingly, 35 new classes were added to the ontology and three classes were removed. Eight classes' labels and/or definitions were updated. The resulting ontology had 234 classes.

In Study 6 (reported in Chapter 7), for the MoA Ontology to be clear and reflect wider scientific consensus about MoAs, nine international behavioural scientists provided feedback on the classes' comprehensiveness and clarity, which informed changes to these classes. Accordingly, the 34 class labels, 127 class definitions and the parent classes of 25 classes were changed. In addition, 23 classes were removed, and 43 classes were added to the ontology, which now had 254 classes.

Study 7 (reported in Chapter 8) aimed to investigate whether the MoA Ontology's class labels and definitions could be reliably applied to capture MoAs reported in behaviour change interventions, and refine the classes applied with low inter-rater reliability. Two researchers familiar with the ontology used the ontology to code MoAs in 50 intervention reports, and two researchers unfamiliar with the ontology coded MoAs in another 50 reports. For each set of 50 reports, the inter-rater reliability of researchers' coding was assessed for the whole ontology. The results showed that researchers familiar with the ontology applied it with 'acceptable' inter-rater reliability, while those unfamiliar with it had lower inter-rater reliability. Disagreements on classes with 'low' inter-rater reliability were reviewed leading to three class labels and 12 class definitions being refined, and seven classes being added. The MoA Ontology's final version had 261 classes on seven hierarchical levels. Examples of classes were 'belief', 'learning', 'social behavioural opportunity' and 'inter-personal behaviour'.

The developed MoA Ontology's classes extensively capture MoAs. By clearly labelling and defining classes and logically organising them, the ontology can provide a controlled vocabulary for MoAs. Such a vocabulary can facilitate clearer and more consistent reporting and systematic evidence synthesise about MoAs in behaviour change interventions, and sharing of knowledge across disciplinary boundaries.

1   Chapter 1: General introduction

The way people behave influences health and wellbeing, environmental sustainability, and many other areas of people's life and their impact on the world (Norman & Conner, 2005). Behaviours[g] have been defined as actions (motor or verbal) that involve voluntary muscles and are directed by the brain in response to internal or external stimuli (Davis, Campbell, Hildon, Hobbs, & Michie, 2015). Behaviour change interventions have the potential to improve individual and population level behaviours and thereby their outcomes (e.g., health) (Michie, Van Stralen, & West, 2011; National Institute for Clinical Excellence, 2007). Behaviour change interventions[g] are 'policies, activities, services or products designed to induce or support people to act differently from how they would have acted otherwise' (Michie et al., 2017). For instance, interventions to reduce doctors' prescriptions of antibiotics (behaviour) can slow the spread of antibiotic-resistant bacteria (Davey et al., 2013). This chapter introduces the concepts and work conducted for this thesis on developing an ontology of mechanisms of action (MoAs). Since many of the terms are technical, below is a glossary of definitions for terms, indicated in the text with superscript[g] (see Table 1-1).

Table 1-1. Glossary of definitions for terms in this chapter

Term	Definition
Annotation	A process during which sections of texts in a document are identified and recorded as relevant to an ontological class (Michie et al., 2017; Norris, Finnerty, Hastings, Stokes & Michie, 2019).
Aristotelian definition	A definition about an entity that specifies the entity's general category (parent class) and its essential distinguishing attributes from that category (Seppälä, Ruttenberg, & Smith, 2017).
Basic Formal Ontology (BFO)	An upper-level ontology that proposes broad classes to support the integration of ontologies focusing on specific scientific domains (Arp, Smith & Spear, 2015; Michie et al., 2017).

Term	Definition
Behaviour change intervention	Sets of activities, services or products that support changing behaviour (Michie et al., 2017; West & Michie, 2016).
Behaviour Change Intervention Ontology (BCIO)	An ontology that includes, labels and defines classes relating to behaviour change interventions and specifies the relationship between these classes (Michie et al., 2017).
Behaviour Change Technique (BCT)	A systematic procedure used as the active component of an intervention to change behaviour (Michie et al., 2013; Michie, Johnston, & Carey, 2016).
Class	A category of entities that is represented in an ontology (Arp et al., 2015).
Continuant	An entity that exists as a whole at any given time during its existence (Arp et al., 2015)
Dependent continuant	An entity that depends on an independent continuant to exist (Arp et al., 2015).
Entity	Anything that exists in the universe, including objects, the attributes of objects and processes (Arp et al., 2015; Michie et al., 2017).
Behaviour	A process that occurs in an organism's body, involves them responding to an internal or external event and is controlled by their brain (Davis et al., 2015).
Independent continuant	An entity that exists on its own at a given time (Arp et al., 2015)
Interoperability	For two systems to be interoperable, the data collected through and/or stored in either system need to be usable for both systems (Open Biological and Biomedical Ontology [OBO] Foundry, 2019b; Wright et al., 2020).
Mechanism of action (MoA)	A process through which a behaviour change intervention influences a behavioural outcome (Michie et al., 2017).
Occurrent	An entity that has temporal parts (Arp et al., 2015).
Ontology	A standardised framework that includes, labels and defines entities relevant to a scientific discipline, and specifies the relationships between these entities (Arp et al., 2015; Michie et al., 2017).
Open Biological and Biomedical Ontology (OBO) Foundry	A repository for hosting interoperable ontologies related to life sciences (OBO Foundry, 2019i).
Parent class	A class that has a hierarchical relationship with a more detailed class which inherits all its attributes (Arp et al., 2015).
Process	An entity that exists by unfolding over time and requires at least one continuant as participant (Arp et al., 2015; Michie et al., 2017).
Relation Ontology	An ontology that proposes relations to help standardise the relations specified across various ontologies (Smith et al., 2005).

Term	Definition
Taxonomy	A classification system that has categories and specifies hierarchical relationships between these categories (Michie et al., 2017; Stravi & Michie, 2012).
Theoretical construct	A concept that is proposed by a theory (Michie et al., 2005).
Theory	A system that proposes concepts or statements to explain or account for facts and/or phenomena (Michie et al., 2005).
Uniform Resource Identifier (URI)	A unique sequence of characters that is assigned to an ontology or a class in an ontology (OBO Foundry, 2019h).

1.1 Mechanisms of action (MoAs) of behaviour change interventions

Behaviour change interventions cause effects by targeting processes that influence behaviour, referred to here as mechanisms of action[g] (MoAs). MoAs of behaviour change interventions have been defined as 'processes that mediate the effect of the intervention on the behavioural outcome' (Michie et al., 2017). Figure 1-1 illustrates a simple relationship between an intervention, its MoA and behaviour. MoAs include complex processes that may be neurobiological, psychological, behavioural, social and/or structural (Nielsen et al., 2018). Examples of MoAs are changes in reward signals within the brain, beliefs, habits and the physical or social opportunity in an environment.
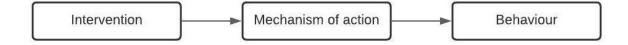
Figure 1-1. The relationship between an intervention, its MoA and behaviour

Behaviour change interventions are designed, sometimes implicitly, to target MoAs, i.e., influences on a behaviour (Michie et al., 2011). By investigating interventions' MoAs, researchers learn why these interventions variably succeed or fail to change behaviours under various conditions (Michie & Abraham, 2004; Hardeman et al., 2005).

An illustration of this is a physical activity intervention's evaluation: The intervention was found to have increased participants' beliefs that their partner helped them exercise (MoA), which was associated with participants exercising more frequently (Berli, Stadler, Shrout, Bolger, & Scholz, 2018). Such evaluations can help design more effective interventions for similar contexts and predict how well specific interventions might work for behaviours and contexts beyond those directly evaluated (Davidson & Scholz, 2020). For instance, by drawing on the example intervention, other researchers could investigate whether increasing people's beliefs that they had social support (MoA) would also increase physical activity in other target populations, such as school children.

1.1.1 MoAs in behaviour change interventions

Various aspects of a behaviour change intervention and its context can influence MoAs, including the intervention's behaviour change techniques[g] (BCTs), its delivery and context (Michie & Johnston, 2012; Moore et al., 2015; Riddle & Science of Behavior Change Working Group, 2015). BCTs have been defined as 'observable, replicable, and irreducible component[s] of an intervention designed to alter or redirect causal processes that regulate behavior' (Michie et al., 2013). When designing interventions, BCTs are often selected in order to target specific MoAs and thereby change behaviour (Davis et al., 2015; Michie & Johnston, 2012). Examples of BCTs are 'Demonstration of the behaviour', 'Behavioural practice/rehearsal' and 'Material rewards' (Michie et al., 2013).

Specifying and testing links between BCTs, MoAs and behaviour allow researchers to evaluate how BCTs influence behaviour (Carey et al., 2019; Hardeman et al., 2002;

Nielsen et al., 2018). For instance, several studies found that self-regulatory BCTs, such as self-monitoring, can be used to change the MoA of self-efficacy beliefs and thereby increase physical activity (Olander et al., 2013; Prestwich, Conner, Hurling, Ayres, & Morris, 2016). Such studies of BCT-MoA-behaviour links can inform predictions and intervention development by identifying which BCTs can be used to change specific MoAs and thereby behaviours (Carey et al., 2019). Accordingly, funding can be focused on developing interventions that are more likely to be effective at changing behaviours (Davidson & Scholz, 2020; Sumner et al., 2018).

1.1.2   MoAs in behavioural theories

Theories can be helpful to identify MoAs relevant to a behaviour in order to target these in interventions (Collins et al., 2011; Craig et al., 2008; Glanz & Bishop, 2010; Michie et al., 2005). Theories[g] of behaviour and behaviour change propose sets of theoretical constructs[g] as key influences on behaviour. Theories also describe the relationships between constructs and behaviour (Davis et al., 2015; Michie & Johnston, 2012; Ogden, 2003). For instance, the Reflective Impulsive Model posits that constructs in the 'reflective' motivational system, such as knowledge and values, can work synergistically or antagonistically with constructs in the 'impulsive' system (e.g., associative memory) to generate a behavioural response (Strack & Deutsch, 2004). Some theoretical constructs are changeable (e.g., knowledge and beliefs) and some are considered to be less malleable (e.g., age, personality, intelligence) (Eccles, Grimshaw, Walker, Johnston, & Pitts, 2005). The changeable constructs serve as potential MoAs that can be targeted in interventions.

Good theories not only guide which MoAs should be targeted in interventions but define and point to how to measure their constructs (Colquhoun et al., 2014; Foy et al., 2011; Ogden, 2003). Accordingly, intervention designers can use theories to select and define MoAs for their interventions and assess whether their interventions changed the potential MoA and thereby behaviour. In turn, the findings of such theory-based interventions can inform refinements to theories, helping develop theories that better predict behaviour (Hagger & Hamilton, 2020; Noar & Zimmerman, 2005).

1.2 Limitations in the guidance and reporting on MoAs in theories and intervention evaluations

1.2.1 Limitations in theories

Despite the potential for theories to serve as frameworks to guide and synthesise research on MoAs, in practice, behavioural theories are often not updated in line with evidence (Noar & Zimmerman, 2005; Ogden, 2003). In a review of 47 studies testing behavioural theories, no study authors suggested changes to the tested theory, when the findings contradicted the respective theory (e.g., a construct was not predictive of behaviour) (Ogden, 2003). While new theories have been proposed as alternatives to established theories with variable predictive success, many of these established theories continue to be used in research (Sniehotta, Presseau, & Araújo-Soares, 2014). Accordingly, there has been a proliferation of behavioural theories (Johnston, 2016; Noar & Zimmerman, 2005; Sniehotta et al., 2014).

The proliferation of theories, many of which are partial and overlapping, creates challenges for deciding which theoretical MoAs are relevant targets for interventions. (Davis et al., 2015; Sheeran, Klein, & Rothman, 2017). A literature review of theories

of behaviour and behaviour change identified 83 theories (Davis et al., 2015). These theories were often partial, describing a limited range of MoAs (Davis et al., 2015). For instance, the Theory of Planned Behaviour focuses on conscious psychological MoAs, such as beliefs and intentions, but fails to consider unconscious psychological or social MoAs (Sniehotta et al., 2014; Taylor et al., 2006).

Across different theories, there are many potential MoAs with the same or very similar definitions (Nigg, Allegrante, & Ory, 2002; Sheeran et al., 2017; Rothman & Sheeran, 2020). However, the same MoAs are often labelled differently and/or have different measurements. For instance, across three behavioural theories, the labels 'attitude', 'outcome expectancy' and 'costs and benefits' were used for the same MoA, 'evaluative belief about behavioural outcomes' (Ajzen, 1991; Janz & Becker, 1984; Sheeran et al., 2017; Schwarzer, Lippke, & Luszczynska, 2011). On the other hand, many theories include potential MoAs with the same label but define these differently (Nigg et al., 2002). For instance, the label 'social norm' is often used for potential MoAs that are defined as 'injunctive norm' (beliefs about what people should do) or 'descriptive norm' (beliefs about what people actually do) (Rothman & Sheeran, 2020). Without a shared language or measurement framework for MoAs, comparing and synthesising evidence about MoAs from different interventions remains challenging and slow (Noar & Zimmerman, 2005).

1.2.2 Limitations in intervention evaluations

Few behaviour change intervention protocols and reports provide details on the hypothesised MoAs of interventions or how these MoAs are tested (Abraham, Johnson, De Bruin, & Luszczynska, 2014; Carey et al., 2019; Prestwich et al., 2014; Prestwich,

Webb, & Conner, 2015). In a review of 'theory-based' intervention reports, 90% of reports were found not to describe which MoA was targeted by each of the BCTs selected for the intervention (Prestwich et al., 2014). Another review of 438 US grant applications for behavioural and social interventions found that 37% of applications did not propose testing MoAs, while 34% only proposed an exploratory analysis of MoAs (Nielsen et al., 2018). The findings suggested that the target MoAs of interventions might not be sufficiently considered when developing or evaluating interventions.

Even when MoAs are tested, researchers often use different measures for MoAs with the same label (Eisenberg et al., 2018; Hertwig, Wulff, & Mata, 2018). For instance, one study found that self-report and behavioural measurement tasks for 'risk preferences' (MoA) across various studies had low convergent validity, indicating that these measurements might be capturing different underlying processes (Frey, Pedroni, Mata, Rieskamp, & Hertwig, 2017). Accordingly, the evidence about 'risk preference' from different studies would be challenging to synthesise to inform future research. As behavioural theories currently do not provide a shared language or agreed measurements for MoAs, other approaches are necessary to support more consistent reporting and assessments of MoAs, as well as to synthesise evidence about MoAs. One such approach involves developing classification systems for MoAs (Hastings, Michie, & Johnston, 2020; Nilsen et al., 2018).

1.3   Classification systems in behaviour change

Various classification systems, such as typologies and taxonomies[g], propose categories for aspects of behaviour change interventions, such as BCTs (Johnston et al., 2018; Kok et al., 2016; Michie et al., 2011; Norris et al., 2019). These systems intend to structure

terms about interventions and thereby facilitate a shared language and understanding of interventions, enabling more consistent reporting and the synthesis of evidence about interventions. For instance, the 93-item BCT Taxonomy (BCTTv1) hierarchically organises BCTs in 16 groups (Michie et al., 2013). Through this taxonomy[g], researchers can use shared labels and definitions of BCTs to describe their interventions and understand and synthesise evidence across interventions (e.g., Gardner, Smith, Lorencatto, Hamer, & Biddle, 2016; Schwarzer, Antoniuk, & Gholami, 2015). For instance, by using the BCTTv1, a systematic review compared the BCTs used in 'promising interventions' to reduce sedentary behaviours to those used in 'non-promising interventions' (Gardner et al., 2016). Thereby, this review synthesised evidence about which BCTs from the BCTTv1 are likely to reduce sedentary behaviours across different interventions, providing guidance for selecting BCTs in similar interventions.

1.3.1 Classification of theoretical constructs and MoAs

Classification systems have also been developed to guide selecting MoAs for interventions and consolidating evidence about MoAs from studies using different behavioural theories (e.g., Cane, O'Connor, & Michie, 2012; Johnston et al., 2018; Michie et al., 2005; Nilsen et al., 2018). For instance, the Theoretical Domains Framework (TDF) (Cane et al., 2012; Michie et al., 2005) aimed to provide more accessible guidance for selecting MoAs in interventions by synthesising the constructs from various behavioural theories. To develop this framework, experts on behavioural theories identified 128 constructs from 33 behavioural theories (Michie et al., 2005). These constructs were grouped into 12 domains, which were validated through discussions with implementation scientists. In a later study to validate the framework

with a new group of experts (Cane et al., 2012), open and closed sorting tasks were used

to re-group theoretical constructs. The resulting groups were compared to the original

theoretical domains. While most original domains were validated in the study, some

changes were made to the TDF (e.g., the domain 'Motivation and Goals' was divided

into two domains, 'Motivation' and 'Goal'), producing 14 theoretical domains.

Examples of the resulting domains are 'Beliefs about capabilities', 'Skills' and 'Social

influences'. By providing a broad overview of theoretical constructs, the TDF reduces

the complexity of the large number of overlapping behavioural theories (Francis,

O'Conner, & Curran, 2012).

 The TDF has been widely used to design interventions (e.g., selecting target MoAs for

an intervention), evaluate these interventions (e.g., investigating an intervention's

MoAs) and synthesise evidence about MoAs across various interventions (Atkins et al.,

2017; Birken et al., 2017). For instance, to synthesise target MoAs for self-care

interventions of minor ailments, one study used the TDF to triangulate the findings of

three systematic reviews on relevant interventions (Richardson, Khouja, Sutcliffe, &

Thomas, 2019). One of the findings was that the MoA 'Knowledge' (Knowledge of

services and management) was a necessary but insufficient target of interventions to

improve self-care behaviours. More recently, the TDF has also been used to synthesise

knowledge about which BCTs can be used to target specific MoAs (Johnston et al.,

2018).

1.3.2   Application of categorisation systems for mapping aspects of behaviour change interventions: BCT-MoA links

Using classification systems, researchers have attempted to map relationships between different aspects of behaviour change interventions (e.g., Kok et al., 2016; Johnston et al., 2018). For instance, by narratively reviewing theories, the Intervention Mapping approach proposed potential links between BCT and MoA categories (e.g., the BCT 'Scenario-based risk Information' was linked to the MoA 'Risk perception') (Bartholomew Eldredge et al., 2016; Kok et al., 2016). To provide evidence-based guidance, the Theories and Techniques Project (TaT Project) also identified 'likely' links between frequently occurring BCTs from the BCTTv1 and 26 MoAs via a literature review of hypothesised links and an expert consensus study (Carey et al., 2019; Connell Bohlen et al., 2019; Johnston et al., 2018; Michie et al., 2018). The TaT Project selected 26 MoAs from two sources: the 14 TDF domains and a review of behaviour change theories (Davis et al., 2015). From the latter, 12 MoAs that occurred most frequently in the 83 theories from the review and did not overlap with the TDF domains were selected (Michie et al., 2018).

The TaT Project's literature review helped synthesise reports of previously hypothesised BCT-MoA links but was limited to intervention reports about funded and published research (Carey et al., 2019; Connell Bohlen et al., 2019). To complement the review, the expert consensus study investigated the current thinking of experts about BCT-MoA links (Connell Bohlen et al., 2019). This study involved initial ratings of links, followed by discussions about links with high disagreement and uncertainty to build consensus and then the final ratings of links. By triangulating the results from the literature review and expert consensus study, the TaT Project identified evidence for 92

links between BCTs and MoAs and evidence that 465 links do not exist (Johnston et al., 2018). For instance, a finding was that the MoA 'Belief about Capabilities' could be targeted using the BCT labelled 'Problem solving' (see

https://theoryandtechniquetool.humanbehaviourchange.org/tool/330). These results provided researchers initial guidance on which BCT-MoA links could be investigated in systematic reviews or be tested in new interventions. However, research is needed to investigate where the mapping of BCTs and MoAs might be limited, which can inform the development of resources that provide better guidance for researchers on BCTs, MoAs and their links.

To identify the limitations of the project's BCT-MoA mapping, the discussions about BCT-MoA links with high disagreement and uncertainty from the expert consensus study could be further explored (Connell Bohlen et al., 2019). These discussions can reveal insights into the challenges in applying the 26 MoAs to link to BCTs, thereby informing where classification systems about MoAs could be improved to make them easier to understand. For instance, the findings could help identify whether any MoAs were too granular or broad to link to BCTs.

One limitation of one-to-one BCT-MoA maps is that they do not account for variability across behaviours and intervention contexts (e.g., French, Olander, Chisholm, & McSharry, 2014; Olander et al., 2013; Prestwich et al., 2016). To synthesise such detailed evidence and provide targeted guidance about complex behaviour change interventions and their contexts, more sophisticated methods for representing aspects of behaviour change interventions and their MoAs might be necessary. One such method

for representing aspects of a scientific field is to create an ontology (Larsen et al., 2017; Michie et al., 2017).

1.4   Ontologies

Ontologies[g] are defined as standardised frameworks that specify, label and define entities[g] relevant to a scientific domain and denote relationships between these entities (Arp et al., 2015; Larsen et al., 2017; Norris et al., 2019). The entities in an ontology can include anything that exists in the universe, such as humans, objects, their attributes and processes. In ontologies, entities are represented as categories referred to as 'classes[g]', which are labelled and defined. The relationships between classes usually include hierarchical ones (e.g., the class 'self-efficacy belief' is a subclass of 'belief') as a backbone, similar to taxonomies (Arp et al., 2015). Ontologies have been used in scientific disciplines, most notably biomedicine (i.e., the Gene Ontology), to unify complex theoretical and empirical knowledge (Norris et al., 2019; West, Marsden, & Hastings, 2019).

1.4.1   Advantage of ontologies over other classifications systems

Ontologies allow its developers to capture more complex knowledge than many other classification systems, such as taxonomies (Norris et al., 2019). For instance, taxonomies only contain parent-child relationships (e.g., 'intrinsic motivation is a type of motivation'), while ontologies can detail more complex relationships (Norris et al., 2019). For instance, in the Mental Functioning Ontology, a relationship helps capture that the process 'judging' creates a 'belief' (Hastings, Ceusters, Jensen, Mulligan, & Smith, 2012). This relationship can be expressed as: 'judging' has_output (relationship) a 'belief'. An ontology of MoAs in behaviour change interventions could specify

similar relationships to capture the processes involved in MoAs (e.g., judging) and their outputs (e.g., belief). Moreover, it can be part of a broader ontology of behaviour change interventions, which can also specify other aspects of an intervention (e.g., its BCTs and delivery) and the causal relationships between these aspects (Michie et al., 2017). For instance, this ontology could specify that a BCT influences an MoA that influences behaviour within a specific context. In addition, ontologies are not static once created. Their classes and their relationships can be continually updated to reflect new evidence within a scientific domain (OBO Foundry, 2019c).

Ontologies have textual labels and definitions for their classes to be usable for humans (Seppälä, Schreiber, & Ruttenberg, 2014). However, unlike most other classification systems, ontologies also include rule-based language to define classes and specify their relationships, allowing these to be understood by computers (Hastings & Schulz, 2012; Seppälä et al., 2014). By being computer readable, ontologies can be used to develop algorithms that support the synthesis of evidence about an ontology's classes (Hastings & Schulz, 2012; Matentzoglu, Malone, Mungall, & Stevens, 2018). For instance, researchers can use an ontology's classes to annotate[g] (i.e., identify entities from documents using relevant classes in ontologies) relevant information in published scientific papers (Norris et al., 2019). Based on such annotations and the relations the ontology asserts between classes (e.g., parent-child class), algorithms can be developed to automate annotations for classes in papers or form predictions about classes (Hastings, Ceusters, Smith, & Mulligan, 2011; Michie et al., 2020; Rubin, Shah, & Noy, 2007). Particularly with the increasing number of published behaviour change interventions, automating the synthesis of evidence about behaviour change

interventions and their MoAs would be an important application of ontologies (Michie et al., 2017; Larsen et al., 2017).

1.4.2 The benefits of ontologies: the example of the Gene Ontology

The Gene Ontology provided researchers with a 'controlled vocabulary' to represent agreed classes in molecular biology (e.g., cellular components, biological processes and functions) and their relationships (Ashburner et al., 2000; Gene Ontology Consortium, 2001). This vocabulary has enabled better communication about findings (e.g., consistent terms used to report findings about a gene X in mice and flies) across different areas of biomedicine, helping to unify the field (Ashburner et al., 2000; Hastings & Schulz, 2012; Stenzhorn, Schulz, Boeker, & Smith, 2008). In addition, researchers have used the Gene Ontology to annotate more than 100,000 published scientific reports, thereby forming a large evidence base about molecular biology (Norris et al., 2019; Smith et al., 2007). This evidence base can be used to develop automated algorithms which make inferences about the data and predictions that can be tested in future studies.

1.5 Ontologies organising knowledge about behaviour change interventions

1.5.1 Ontologies relevant to behaviour change

There has been some work to develop ontologies in areas relevant to behaviour change interventions. In a scoping review of ontologies related to behaviour change, 15 ontologies in the areas of cognition, emotions and mental health were identified (Norris et al., 2019). The research team identified one ontology, the 'Human Behavior Change Ontology' (HBCO), that specifically addressed human behaviour change. This ontology

was created as part of efforts to develop an automated counselling system, simulating conversations between health counsellors and patients (Bickmore, Schulman, & Sidner, 2011). However, by only building on the Transtheoretical Model of Behaviour Change (Prochaska & DiClemente, 1982), this ontology did not represent other theories and concepts in behaviour change (Norris et al., 2019). In addition, during the review of the ontologies, no updated version of the HBCO could be found, suggesting that it was not changed since its initial development. None of the other reviewed ontologies were comprehensive or detailed enough to serve as a complete ontology of human behaviour or behaviour change interventions (Norris et al., 2019).

1.5.2   The Human Behaviour-Change Project and the Behaviour Change Intervention Ontology

Given the lack of a sufficiently comprehensive and detailed ontology to represent all aspects of behaviour change interventions, The Human Behaviour-Change Project (HBCP) is creating a large and multi-faceted Behaviour Change Intervention Ontology (BCIO) (Michie et al., 2017). The overall aim of the HBCP is to answer the big question of 'what works, compared with what, how well, with what exposure, with what behaviours, for how long, for whom, in what settings and why' (Michie & Johnston, 2017). The project applies ontological structures and machine learning to more efficiently organise and synthesise knowledge about behaviour change intervention effects and the influences on those effects (Michie et al., 2017). The BCIO will contain classes relevant to behaviour change interventions, including BCTs, MoAs, modes of delivery (e.g., face-to-face, digital) and intervention population and settings (Michie et al., 2017; 2021). This ontology will be used to structure and synthesise evidence about behaviour change interventions (e.g., in systematic reviews). In addition, by providing

clear labels and definition for various aspects of interventions, this ontology could support more detailed and consistent reporting of interventions.

1.5.2.1 An Ontology of Mechanisms of Action

An essential part of the BCIO is an ontology of MoAs (Michie et al., 2021). Such an ontology is required to help study 'why' behaviour change interventions change behaviour. This PhD thesis involves developing the Mechanisms of Action Ontology as part of the BCIO. The MoA Ontology will contain, label and define classes to describe MoAs and specify the relationships between these classes. By organising MoAs relevant to behaviour change, the MoA Ontology aims to support streamlining the process of synthesising evidence about these MoAs from published behaviour change intervention reports. For instance, the ontology could be used in systematic reviews to annotate and synthesise evidence about MoAs and their links to BCTs in published intervention reports. In the future, the ontology could also be used to develop automated reasoning algorithms with the potential to expedite the synthesis of evidence MoAs in the literature. Furthermore, by proposing a shared language for MoAs, this ontology could serve as a resource for theory authors to label and define constructs in their theories. Given the potential value of the MoA Ontology, it is important to review the steps required in ontology development.

1.6   Development of an ontology

1.6.1   What is the content of an ontology?

In its most basic form, an ontology has classes that are labelled and defined. It also specifies relationships between classes, which are usually hierarchically organised (Arp et al., 2015). Each class in an ontology has a unique identifier, referred to as Uniform

Resource Identifier[g] (URI) (OBO Foundry, 2019h). A class's URI has a string of characters reflecting the ontology that the class is from and a unique number for that class. For instance, the URI for the class 'mental process' in the Mental Functioning Ontology is 'MF:0000020' (Hastings et al., 2012) and that for 'learning' in the Gene Ontology is 'GO:0007612' (Gene Ontology Consortium, 2001). To support ontology users' understanding of classes in an ontology, classes can also have optional entries, such as 'comments', 'examples' and 'synonyms'. Comments are entries about a class that help clarify or elaborate on aspects of the class's definition. Example entries provide examples of a class in a specific context. Synonyms provide alternative terms for the class, that ontology users might be familiar with. To give a sense of how these entry fields appear to ontology users, examples of classes from the Mental Functioning Ontology (Hastings et al., 2012), with their URIs, labels and definitions, comments, examples and relationships are presented in Table 1-2.

Table 1-2. Example classes from the Mental Functioning Ontology (Hastings et al., 2012), with their labels, definitions, URIs, parent classes, and where relevant, comments, examples and non-hierarchical relationships

Class label	Class definition	URI	Comment (if relevant)	Example (if relevant)	Synonym (if relevant)	Parent class	Non-hierarchical relationship (if relevant)
Agreeableness	A personality trait manifesting itself in individual behavioral characteristics that are perceived as kind, sympathetic, cooperative, warm, and considerate.	MF:000 0022	Associated adjectives: appreciative, forgiving, generous, kind, sympathetic, and trusting.			Personality trait	
Extraversion	A personality trait manifesting itself in individual behavioral characteristics that are perceived as positive, assertive, social, and outgoing.	MF:000 0063	Associated Adjectives: active, assertive, energetic, enthusiastic, outgoing, talkative.			Personality trait	
Mental process	A mental process is a bodily process that is of a type such that it can of itself be conscious.	MF:000 0020	A bodily process which brings into being, sustains or modifies a cognitive representation or a behaviour inducing state.	Examples include thinking, feeling pain, remembering and emotion as occurrent experiences.		Bodily process	*has occurrent part* some consciousness
Thinking	A mental process that involves the manipulation of mental language and/or mental images.	MF:000 0013				Mental process	
Wanting	A mental process that involves thinking about a state of affairs that does not yet obtain together with a desire for that state of affairs to obtain.	MF:000 0045			act of wanting	Mental process	

1.6.2   Principles for 'gold standard' ontologies

A repository that hosts 'gold standard' scientific ontologies, the Open Biological and
Biomedical Ontology (OBO) Foundry[g] (2019i), proposed principles for developing
ontologies. These principles aim to ensure that ontologies are useful, interoperable[g] (i.e.,
compatible with each other, allowing two ontologies to use the data collected and stored
in either ontology) and accessible to a wide audience (Smith et al., 2007). One principle
posits that ontologies should have a specified scope (i.e., a defined subject area, such as
'MoAs of behaviour change interventions') and content (e.g., classes, their labels and
definitions) that aligns with this scope (OBO Foundry, 2019f; Wright et al., 2020).
Classes should also be clearly labelled and defined, have URIs and have logical
structures (e.g., a consistent hierarchical structure) (Smith et al., 2007). The principles
also recommend that ontologies should build on and reuse classes from existing
ontologies and frameworks where relevant, be open to user feedback and maintained
over time (Norris et al., 2019; OBO Foundry, 2019c, 2019i; Smith et al., 2007; Wright
et al., 2020).

1.6.2.1   *Specifying the scope of an ontology and identifying its content*

By requiring ontologies to have specified scopes, the OBO Foundry aims to ensure that
its ontologies cover unique subject areas and are not redundant (OBO Foundry, 2019f).
An ontology's scope can be specified in terms of the subject area the ontology intends
to cover (OBO Foundry, 2019f; Wright et al., 2020). For instance, The Gene Ontology's
scope is specified as describing 'biological process, molecular function and cellular
component' in all organisms (Ashburner et al., 2000). To include classes relevant to
their scopes, ontology developers are advised to draw on terms commonly used in the

domain literature (e.g., 'cellular growth' in the biomedical literature) and, where
relevant, related ontologies (Arp et al., 2015).

1.6.2.2 Writing clear labels and definitions for classes

Ontologies should have unique and clear labels and definitions for their classes (OBO
Foundry, 2019d, 2019g). The definitions should be simpler than their labels, i.e., the
terms they define (Arp et al., 2015; Seppälä et al., 2017). In addition, a class's definition
should avoid circularity, i.e., not include its label or its near synonyms.

Ontology developers are recommended to use Aristotelian definitions[g], which are
specified in the form 'A = def. a B that C': where A is the label, B is the parent class[g] of
A and C is an essential distinguishing attribute of A (Arp et al., 2015; Rosse & Mejino,
2008; Michie, West, & Hastings, 2019; Seppälä et al., 2017). For instance, an
immigrant could be defined as 'a person (B) who is currently a resident of a country
having previously been resident of a different country (C)' (Michie et al., 2019). By
using definitions in the Aristotelian form, it becomes easier to check whether classes are
consistently defined based on their hierarchical relationships to other classes (Seppälä et
al., 2017). For instance, in the Mental Functioning Ontology (Hastings et al., 2012), the
class 'thinking' is defined as 'A mental process that involves the manipulation of mental
language and/or mental images.' In the definition, the phrase 'mental process' specifies
the parent class of 'thinking', while the definition's later part ('involves the
manipulation of mental language and/or mental images') specifies the class's
distinguishing attributes from its parent class, 'mental process'.

1.6.2.3 *Specifying relationships between classes in the ontology*

The OBO Foundry also recommends ontologies to have logical relationships between classes, allowing ontologies to be used in algorithms (e.g., to make inferences) and making them more compatible with other ontologies hosted in the foundry (OBO Foundry, 2019e). To structure an ontology, a taxonomic hierarchy is generally used as a backbone of the ontology, with each class in the ontology being linked to this hierarchy (Arp et al., 2015; Smith & Ceusters, 2010). Applying a single inheritance principle (i.e., that each class should have only one parent class) to the ontology can facilitate computational performance, when using the ontology (Arp et al., 2015; Smith & Ceusters, 2010; Rector, 2003).

By specifying additional non-hierarchical relationships between classes in an ontology, classes become more connected, which facilitates the logical reasoning about these classes (Smith & Ceusters, 2010). To select a type of relationship between two classes, ontology developers can draw on the Relation Ontology[g] or other ontologies or develop definitions for new types of relationships (Smith et al., 2005). For instance, a key relation helps specify the hierarchical parent-child class relationship and is expressed with the phrase 'is_a' (e.g., heart is_a organ) (Smith et al., 2005; Smith & Rosse, 2004). Another key relation allows an ontology to express the parts of an entity (i.e., the things that make up a specific entity); this relation is expressed with the phrase 'part of' (heart is_part of human) (Smith & Rosse, 2004). Through other relations, the spatial and temporal relations between classes can be shown and processes can be linked to their outputs.

1.6.2.4 *Commitment to collaboration: Producing ontologies in line with scientific consensus and user needs and reusing relevant content from other ontologies*

To develop ontologies that are useful, the OBO Foundry recommends building ontologies that reflect consensus within a scientific domain (OBO Foundry, 2019b). For instance, the Emotion Ontology (Hastings et al., 2011) should specify relationships between its classes (e.g., 'emotion process' and 'appraisal') that align with thinking about these relationships in emotion-related research. Ontologies should be updated when new scientific findings suggest that the classes, their labels or definitions, or their relationships are missing or incorrect (OBO Foundry, 2019b, 2019c).

Ontologies should also reuse the relevant work (e.g., classes and relations) of other ontologies to avoid replicating work and be interoperable and scientifically corroborated (Arp et al., 2015; Masci et al., 2009; OBO Foundry, 2019b). For instance, the Mental Functioning Ontology (Hastings et al., 2012) reuses the class 'learning' from the Gene Ontology (Ashburner et al., 2000). By reusing classes, ontologies automatically benefit from the refinements about these classes in the original ontology, e.g., updates to the relationships between classes based on empirical advances (Masci et al., 2009; Smith & Ceusters, 2010).

1.6.2.4.1 *Structuring ontologies by linking them to an upper-level ontology*

To structure ontologies that are interoperable with others, ontology developers need to draw on common upper-level ontologies, which consist of very general classes that are domain-neutral, i.e., not specific to any one scientific domain (Arp et al., 2015; Bandrowski et al., 2016; Smith & Ceusters, 2010). These classes can be selected as upper-level classes when developing the hierarchy of an ontology (Smith & Ceusters,

2010). By having shared upper-level classes, different ontologies' structures are more compatible, and it becomes easier to identify and reuse relevant classes from other ontologies (Masci et al., 2009; Smith & Ceusters, 2010). For instance, the Gene Ontology and the Mental Functioning Ontology draw on the same upper-level ontology, Basic Formal Ontology[g] (BFO; Arp & Smith, 2008; Bittner & Smith, 2004; Hastings et al., 2012). Therefore, their classes are defined using the same upper-level classes (e.g., 'process[g]'), making the reuse of lower-level classes (e.g., 'learning') more straightforward.

Ontologies that are part of the OBO Foundry often draw on BFO (see Figure 1-2), which broadly divides entities into two classes: 'continuants' and 'occurrents' (Arp et al., 2015; Bandrowski et al., 2016; Norris et al., 2019; OBO Foundry, 2019a). Continuants[g] are entities, such as objects and spatial regions, which 'endure through time and are whole present at all times that they exist' (Hastings et al., 2011). For instance, a person, Louisa, will continue being that person, as long as she is alive (Arp et al., 2015). In contrast, occurrents[g], such as temporal regions or processes, are entities that 'unfold over time and have temporal parts' (Hastings et al., 2011). For instance, Louisa's life (a process) can be described as the same life only in its entirety; her life may include various periods and experiences, which altogether make up her life.
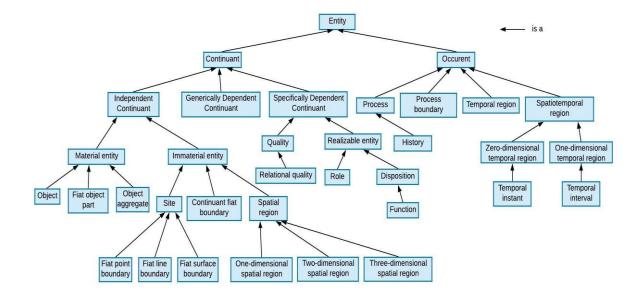
Figure 1-2. Classes (types or categories) in BFO (Smith, 2018)

As shown in Figure 1-2, BFO divides continuants into independent and dependent

continuants (Arp et al., 2015; Hastings & Schulz, 2012). While independent

continuants[g] exist on their own (e.g., the organism), dependent continuants[g] require an

independent continuant to exist (Arp et al., 2015). Dependent continuants include

qualities, i.e., attributes that an independent continuant (e.g., an organism) has at all

times (e.g., colour), and realisable entities, such as dispositions (e.g., illnesses,

personality traits and beliefs). In terms of their ontological relationship, a dependent

continuant 'inheres_in' an independent continuant (Arp et al., 2015). For instance,

influenza (dependent continuant, more specifically a disposition) 'inheres_in' a human

being (independent continuant), meaning the existence of influenza depends on a human

having influenza.

As dispositions are realisable entities, a human being can express the disposition of

influenza when they are in the 'right' circumstances, namely when they are infected

with the virus (Arp et al., 2015; Scheuermann, Ceusters, & Smith, 2009). Influenza will

be expressed through symptoms (processes), such as dizziness and acute inflammation.

Similarly, in the Mental Functioning Ontology (see Figure 1-3), the personality

(disposition) 'inheres_in' an organism (Hastings et al., 2012). Accordingly, a person

(independent continuant) with an angry temperament (personality trait, i.e., a

disposition) could react angrily (process) under stressful circumstances (Hastings et al.,

2011).
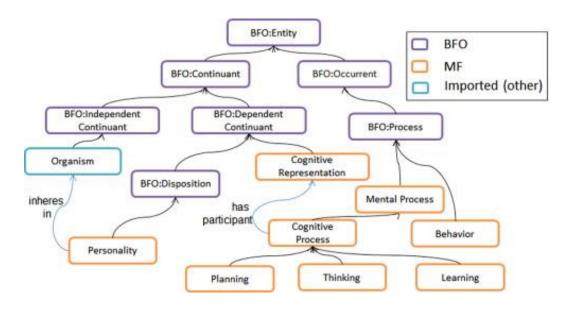
Figure 1-3. BFO classes used to structure in the Mental Functioning Ontology (Hastings et al., 2012)

To use the BFO, developers need to decide on the most fitting upper-level class for each

class (Hastings & Schulz, 2012; Smith & Ceusters, 2010). For instance, in the Mental

Functioning Ontology, 'organism' and 'brain anatomy' are categorised as continuants,

while 'mental process' is a process (Hastings et al., 2012; Hastings & Schulz, 2012).

These decisions often help to disambiguate the language used in scientific domains

(Hastings et al., 2011). For instance, the term 'angry' can often be used interchangeably

for the process of being angry (e.g., Henry is feeling angry) and a person's dispositional

anger (e.g., Henry is an angry person). In the Emotion Ontology, the ontology

developers distinguish between 'angry' as an emotional process and the mental disposition 'irascibility', which refers to 'a mental disposition to frequent or easily incited outbursts of anger' (Otte et al., 2021b).

1.6.3   Methods for developing ontologies

There are various methods that can be applied to develop ontologies (Arp et al., 2015; Norris et al., 2019; Noy & McGuinness, 2001; Wright et al., 2020). As a starting point, ontology developers can draw on relevant non-ontological classification systems (e.g., taxonomies) or theories and incorporate these into their ontology (Wright et al., 2020). Data-driven methods can be used to identify or refine classes and their relationships (Matentzoglu et al., 2018; Wright et al., 2020). One such data-driven method is annotations, i.e., applying ontological classes to identify and code relevant parts of a document in order to identify missing classes and refine the preliminary structure of classes.

To systematically apply the OBO Foundry principles, the Human Behaviour-Change Project follows a stepwise method for developing ontologies that make up the BCIO (Wright et al., 2020). As shown in Table 1-3, these steps are to (1) define the subject area of the ontology, (2) identify ontology classes, assigning labels and developing definitions, (3) refine the ontology by using it in a data-driven application (i.e., annotations), (4) carry out a stakeholder review of the ontology and refine the ontology based on this review, (5) test the inter-rater reliability of the class labels and definitions when annotating relevant entities in the literature, and refine classes that could not be reliably applied (6) specify relationships in the ontology and (7) disseminate and maintain the ontology.

Table 1-3. Stepwise method to develop ontologies part of the BCIO (Wright et al., 2020) and thesis studies that apply these steps

Step no.	Overall step description	OBO Foundry principles the step intends to address	Example of recommended activities	Thesis studies that implement relevant step
1	Defining the subject area of the ontology	*Specifying the scope of an ontology and identifying its content:* Delineating what scope an ontology intends to cover	Seeking relevant sources, such as scoping reviews or other relevant reviews, previous expert consensus work or dictionaries	Study 2
		Commitment to collaboration: Building on existing work where appropriate		
2	Identifying classes, and developing their labels and definitions where necessary	*Specifying the scope of an ontology and identifying its content:* Identifying the content that needs to be covered within an ontology's scope	Data-driven method of identifying classes, such as reviewing relevant entities reported in the literature	Studies 2-4
		Commitment to collaboration: Reusing content from other ontologies	Reusing classes from other ontologies, where relevant	
		Writing clear labels and definitions for classes	Developing labels and definitions for classes that were not reused from other ontologies	
3	Refining the ontology by using it in a data-driven application	*Specifying the scope of an ontology and identifying its content:* Refining the content of the ontology to cover its intended scope based on data-driven methods	Applying the ontology to annotate relevant information reported in the literature, and iteratively adding classes or revising class labels and definitions in the ontology based on discussions	Study 5
		Writing clear labels and definitions for classes: Refining the class labels and definitions based on data-driven methods		

4	Revision of ontology based on stakeholder review	*Commitment to collaboration:* Producing ontologies in line with scientific consensus and user needs	Consulting participants with experience relevant to the ontology whether the ontology captures all relevant classes and has clear class labels and definitions	Study 6
		Writing clear labels and definitions for classes: Refining the class labels and definitions to be clear to its potential users		
5	Testing the inter-rater reliability of the ontology and revising the ontology	*Writing clear labels and definitions for classes:* Evaluating whether the class labels and definitions are sufficiently clear to apply the ontology in annotations	Testing the inter-rater reliability of two researchers using the ontology to annotate relevant information in published behaviour change interventions	Study 7
6	Specifying relationships between the classes in the ontology	*Specifying relationships between classes in the ontology*	Using relations from the Relation Ontology, to specify relations between classes, adding parent classes for classes where necessary	Studies 3-7
7	Disseminating and maintaining the ontology	*Common format:* Formatting the ontology so that it can be accessed by potential users online	The ontology, stored as an Excel file, is converted into a Web Ontology Language file via a tool called ROBOT (http://robot.obolibrary.org/)	Study 7
		Maintenance: The ontology needs to be updated overtime with feedback and changes in scientific consensus		

1.7   Aims of this thesis

This thesis has two overarching aims: (1) to explore challenges in understanding and applying MoAs in relation to BCTs and (2) to develop an Ontology of Mechanisms of Action within the BCIO. Figure 1-4 presents the thesis chapters and their aims.

To address Aim 1, Study 1 investigates behaviour science experts' disagreements and uncertainties when judging potential links between BCTs and MoAs by drawing on the expert discussions in the TaT Project (Connell Bohlen et al, 2019). The study's findings informed the development of the MoA Ontology.

To achieve Aim 2, six studies were conducted according to the BCIO's stepwise method for developing ontologies (see relevant steps addressed by each chapter's study in Table 1-3). To define the scope and identify the content of the MoA Ontology, Study 2 aimed to identify MoAs from behavioural theories and establish initial MoA groups based on their shared attributes. Study 3 aimed to develop MoA groupings and ungrouped MoAs into ontological classes that are clearly labelled, defined and hierarchically structured, drawing on classes from relevant ontologies. In Study 4, the aim was to iteratively refine the draft MoA Ontology developed in Study 3 into a more usable and ontologically correct version. Study 5 aimed to refine the MoA Ontology's classes and their labels and definitions by applying the ontology to annotate hypothesised MoAs in behaviour change intervention reports. For the MoA Ontology to better reflect the scientific consensus about MoAs, Study 6 aimed to revise its classes based on international behavioural scientists' feedback on the classes' clarity and comprehensiveness. Finally, Study 7 aimed to investigate whether the MoA Ontology's

class labels and definitions could be reliably applied to annotate MoAs in behaviour

change intervention reports and refine those that could not be reliably applied.
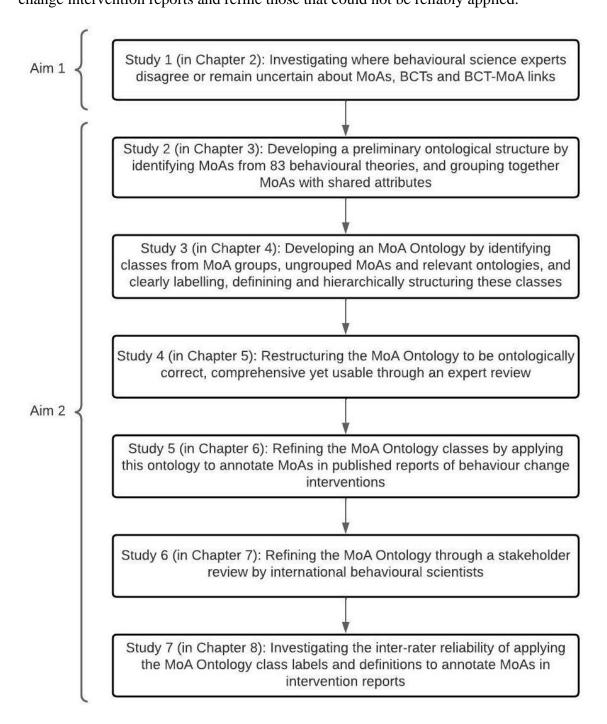
Figure 1-4. The studies in this thesis and the overarching aims they intended to address

2 Chapter 2: Linking MoAs to BCTs: A qualitative study investigation of areas of disagreement and uncertainty among experts (Study 1)

2.1 Abstract

Background: Evidence regarding the links between behaviour change techniques (BCTs) and mechanisms of action (MoAs) is essential to inform the selection of BCTs to target specific MoAs in intervention design. However, even expert behavioural scientists have difficulties judging and agreeing on which BCTs can alter which MoAs. Experts' disagreements and uncertainty can stem from problems with understanding what is meant by each MoA and BCT. Studying these can reveal areas where classification systems of MoAs and BCTs need to be improved.

Aims: To investigate expert behavioural scientists' areas of disagreement or uncertainty about the MoAs, BCTs and their links.

Methods: The current study used data collected during an expert consensus study identifying potential BCT-MoA links. In the study, 105 behavioural science experts rated the likelihood of links between BCTs and MoAs and their certainty in those judgments. They then participated in online discussions of the BCT-MoA links for which there was high disagreement or uncertainty ratings. For these discussions, the experts were allocated to one of five groups (21 experts per group) with each group discussing 22 BCT-MoA pairs. The online discussions were thematically analysed to identify why the experts disagreed or were uncertain about MoAs, BCTs and their links. After a researcher inductively coded 116 expert discussions, a second researcher coded 20 of these to refine the codes, and then coded another 20 to finalise the developed

themes. The themes and overarching themes were iteratively refined through discussions between the researchers and four behavioural science experts.

Results: Three overarching themes were identified relating to the areas experts disagreed on or were uncertain about MoAs, BCTs and their links. The first was 'Challenges to understanding MoAs and BCTs' and encompassed seven themes, such as 'Breadth of constructs'. The second was 'Challenges to understanding BCT-MoA links' and encompassed seven themes, such as 'Link dependent on aspects of an intervention and its context'. The third overarching theme was 'Experts' prior knowledge and approaches to the task' and encompassed four themes, such as 'Relying on assumptions about link'.

Discussion: The findings suggest that three key issues are associated with experts disagreeing or being uncertain about BCT-MoA links. First, some MoA and BCT labels and definitions were perceived as too broad or underspecified. Secondly, a BCT-MoA link's strength or existence may vary according to several factors, making it harder to judge these links. The third is that experts have varying prior knowledge and bring different approaches to the task. Creating a more precise categorisation system for MoAs and BCTs could make it easier to understand and link MoAs and BCTs. The results suggest that an ontology of MoAs with clear labels and definitions would facilitate better understanding and evidence-gathering about BCT-MoA links.

2.2   Introduction

By including malleable constructs (e.g., 'belief') that influence behaviour, behavioural theories can guide intervention designers in selecting and evaluating mechanisms of action (MoAs) in behaviour change interventions (Eccles, Grimshaw, Walker, Johnston, & Pitts, 2005; Noar & Zimmerman, 2005). However, there are over 80 behavioural theories, of which many theories are partial and overlapping (Davis, Campbell, Hildon, Hobbs, & Michie, 2015; Sheeran, Klein, & Rothman, 2017). In addition, few behavioural theories specify links between behaviour change techniques (BCTs) and potential MoAs (Michie, Johnston, Francis, Hardeman, & Eccles, 2008).

An evidence base about 'likely' links between BCTs and MoAs can show which BCTs are more likely to influence specific MoAs and thereby behaviour, informing the design of interventions (Johnston et al., 2018). To provide more a systematic overview of 'likely' BCT-MoA links, various research teams have synthesised theoretical knowledge and/or evidence about these links (e.g., Johnston et al., 2018; Kok et al., 2016; Michie et al., 2018). As outlined in Chapter 1, the Theories and Techniques (TaT) Project (Michie et al., 2018) aimed to identify evidence based 'likely' links between BCTs and 26 MoAs. The BCTs were from the Behaviour Change Techniques Taxonomy version 1 (BCTTv1; Michie et al., 2013). The 26 MoAs included 14 of the Theoretical Domains Framework (TDF) domains (Cane, O'Connor, & Michie, 2012; Michie et al., 2005) and 12 MoA groups generated from behavioural theories identified in a scoping review of theories (Davis et al., 2015). The links between these BCTs and MoAs were identified via three studies: a literature review of hypothesised links; an expert consensus study; and the triangulation of the evidence from the first two studies (Carey et al., 2019; Connell Bohlen et al., 2019; Johnston et al., 2018).

The expert consensus study aimed to investigate up-to-date expert thinking about BCT-MoA links (Connell Bohlen et al., 2019). To build consensus about the links, the expert consensus study included three rounds:

1. Initial ratings of BCT-MoA links

2. Online structured written discussions about the BCT-MoA links with the highest disagreement or uncertainty

3. Final ratings of the links presented in Round 1

2.2.1 Rationale for the current study

To improve classification systems for MoAs and BCTs, investigating where behavioural scientists have difficulties applying MoAs to link them to BCTs can provide useful insights. For instance, studying what aspects of MoAs and BCTs are associated with experts disagreeing or being uncertain about their links can reveal where MoA and BCT definitions need to be refined. The text of the online discussions from the TaT Project can be used as a data source in a qualitative analysis to investigate expert behavioural scientists' areas of disagreement or uncertainty about MoAs, BCTs and their links.

2.1.2 Aims and research question

This study aimed to explore areas in which experts disagreed or were uncertain about MoAs, BCTs and BCT-MoA links. To achieve its aim, the current study's research question was: What is the nature of disagreement and uncertainty about: MoAs, BCTs and BCT-MoA links?

2.3   Methods

This study was approved by the by the University College London Research Ethics Committee (ID 6056/001). Two researchers with PhD level qualifications in behavioural science (LC & RC) recruited participants and collected the data for this study (Connell Bohlen et al., 2019). The author of this thesis (PS) was not involved in earlier stages of the study but led the data curation and analysis presented here. The analysis also involved a second researcher with MSc level qualifications related to behavioural science (CM), and four expert researchers with PhD level qualifications in behavioural science and more than five years of professional research experience (AW, FL. MJ & SM).

2.2.1 Design

The study involves a secondary analysis of online expert discussions about BCT-MoA links with high disagreement or uncertainty. These discussions were used to facilitate agreement between experts about 'likely' BCT-MoA links in another study (Connell Bohlen et al., 2019) using a modified Delphi method (Harvey & Holmes, 2012).

2.2.2 Recruitment and participants

The individuals who took part in the TaT Project's expert consensus study were 105 experts with experience in designing and/or evaluating behaviour change interventions. They were recruited by emailing participants in BCT training courses run by the University College London (UCL)'s Centre for Behaviour Change, the TaT Project's International Advisory Board and the people on the email lists of the following scientific and professional societies and centres: UCL Centre for Behaviour Change, the Special Interest Group of the Society of Behavioural Medicine, European Health

Psychology Society, United Kingdom Society for Behavioural Medicine, and Division of Health Psychology of the British Psychological Society. Using a 'snowball' method, those recruited were asked to recommend other potential participants.

To select 105 experts for the study, those who expressed interest (n = 227) were asked to complete a self-assessment questionnaire concerning their experience in developing and/or evaluating behaviour change interventions. To qualify, potential participants needed to rate their experience with BCTs, behavioural theories and behaviour change intervention as 4 or above on a 7-point scale (0 indicating 'No expertise' and 7 indicating 'Profound expertise'). They also needed to indicate having some experience designing behaviour change interventions, which used specific BCTs and were based on behavioural theories (for details see Connell Bohlen et al., 2019).

Of 227 potential participants, 123 met the eligibility criteria. To select a diverse range of participants, those eligible to participate were emailed a second questionnaire asking about the countries they were based in, their professional backgrounds and academic disciplines. The 105 experts were selectively chosen in order to include participants from less represented countries and different professional backgrounds.

Of the 105 participants, approximately 50% were from the UK, 20% from other European countries, 20% from North America, 7.6% from Australia and New Zealand, 0.95% Africa and 0.95% Asia (Connell Bohlen et al., 2019). Most participants worked in a university setting (75%) and had a primary focus on psychological studies (60%). Experts were randomly allocated to one of five groups, with 21 experts in each group.

2.2.3 Collection of expert discussion data

The expert consensus study involved three rounds of expert activity to build consensus about BCT-MoA links: (1) experts rating BCT-MoA links, (2) online discussions and (3) revised ratings of the links, also presented in Round 1. Experts' ratings in Round 1 were completed on Qualtrics (https://www.qualtrics.com), an online survey software. To reduce the burden on experts, each group was presented with 13 to 14 BCTs and 26 MoAs. The participant discussions in Round 2 were hosted on Loomio (2015), an online platform for group discussions.

2.2.3.1 *BCT and MoA links presented to experts in Round 1*

The experts rated links between the 61 most frequently used of the 93 BCTs from the BCTTv1 and 26 MoAs. To be included in the study, BCTs needed to occur more than twice in a systematic review of 40 interventions for various behaviours (Michie et al., 2018). As 61 BCTs met this criterion, they were included in the study. From these 61 BCTs, 13-14 BCTs were selected for each expert group to limit the variation in how familiar experts were with these BCTs. This selection process involved ranking the 61 BCTs according to how frequently they occurred in the review of 40 interventions. The two most frequent BCTs, 'Instruction on how to perform the behaviour' and 'Social Support (Unspecified),' were presented to all expert groups in order to investigate the influence of group membership on the results. For each group, the remaining 11-12 BCTs were selected via stratified random allocation from the remaining set of 59 BCTs according to their frequency ranking. For instance, one of the most frequent five BCTs from the 59 BCTs was randomly allocated to each expert group.

The project's 26 MoAs (see Table 2-1) were selected from two sources: the 14 TDF domains (Cane et al., 2012; Michie et al., 2005) and 83 behaviour change theories identified in a scoping review (Davis et al., 2015). From the latter, 12 MoAs that occurred most frequently in the 83 theories and did not overlap with the TDF domains were selected (Connell Bohlen et al., 2019). Collectively, the experts were presented with 1,586 BCT-MoA links (61 BCTs x 26 MoAs). Of these links, 52 (the two most frequent BCTs x 26 MoAs) were presented to all experts.

Table 2-1. The labels and definitions of MoAs in the TaT Project

MoA label	MoA definition	Source
Behavioural Regulation	Behavioural, cognitive, and/or emotional skills for managing or changing behaviour	TDF
Beliefs about Capabilities	Beliefs about one's ability to successfully carry out a behaviour	TDF
Beliefs about Consequences	Beliefs about the consequences of a behaviour (i.e., perceptions about what will be achieved and/ or lost by undertaking a behaviour, as well as the probability that a behaviour will lead to a specific outcome)	TDF
Emotion	A complex reaction pattern involving experiential, behavioural, and physiological elements	TDF
Environmental Context and Resources	Aspects of a person's situation or environment that discourage or encourage the behaviour	TDF
Goals	Mental representations of outcomes or end states that an individual wants to achieve	TDF
Intentions	A conscious decision to perform a behaviour or a resolve to act in a certain way	TDF
Knowledge	An awareness of the existence of something	TDF
Memory, Attention, and Decision Processes	Ability to retain information, focus on aspects of the environment, and choose between two or more alternatives	TDF
Motivation	Processes relating to the impetus that gives purpose or direction to behaviour and operates at a conscious or unconscious level	TDF
Optimism	Confidence that things will happen for the best or that desired goals will be attained	TDF

MoA label	MoA definition	Source
Reinforcement	Processes by which the frequency or probability of a response is increased through a dependent relationship or contingency with a stimulus or circumstance	TDF
Skills	An ability or proficiency acquired through practice	TDF
Social Influences	Those interpersonal processes that can cause oneself to change one's thoughts, feelings, or behaviours	TDF
Social/Professional Role and Identity	A coherent set of behaviours and displayed personal qualities of an individual in a social or work setting	TDF
Behavioural Cueing	Processes by which behaviour is triggered from either the external environment, the performance of another behaviour, or from ideas appearing in consciousness	Behaviour theories
Feedback Processes	Processes through which current behaviour is compared against a particular standard	Behaviour theories
General Attitudes/ Beliefs	Evaluations of an object, person, group, issue, or concept on a scale ranging from negative to positive	Behaviour theories
Needs	Deficit of something required for survival, well-being, or personal fulfilment	Behaviour theories
Norms	The attitudes held and behaviours exhibited by other people within a social group	Behaviour theories
Perceived Susceptibility/ Vulnerability	Perceptions of the likelihood that one is vulnerable to a threat	Behaviour theories
Self-image	One's conception and evaluation of oneself, including psychological and physical characteristics, qualities, and skills	Behaviour theories
Social Learning/ Imitation	A process by which thoughts, feelings, and motivational states observed in others are internalized and replicated without the need for conscious awareness	Behaviour theories
Subjective Norms	One's perceptions of what most other people within a social group believe and do	Behaviour theories
Values	Moral, social or aesthetic principles accepted by an individual or society as a guide to what is good, desirable, or important	Behaviour theories
Attitude towards the Behaviour	The general evaluations of the behaviour on a scale ranging from negative to positive	Behaviour theories

In Round 1, experts were asked to rate whether their assigned 13-14 BCTs were linked to each of the 26 MoAs. BCTs were defined as 'the potentially active ingredients of behaviour change interventions.' MoAs were defined as 'the processes through which a

BCT affects behaviour.' To help experts conceptualise how BCTs could influence

MoAs and thereby behaviour, they were given a diagram (see Figure 2-1).
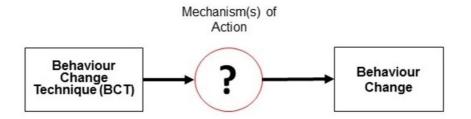
Figure 2-1. Diagram presented in the expert consensus study of the TaT Project

The experts were advised that they could use evidence, theory and their experience to

rate BCT-MoA pairs. The questions were phrased as 'Does the Behaviour Change

Technique [e.g., Goal Setting] change behaviour through the MoA [e.g., beliefs about

one's ability to successfully carry out a behaviour (Beliefs about Capabilities)]?' In

response to these questions, experts rated each BCT-MoA link on a 5-point scale

('Definitely No', 'Probably No', 'Don't Know/Uncertain', 'Probably Yes', 'Definitely

Yes'). The 26 MoAs were presented for each BCT in a randomised order.

2.2.3.2 *Online discussions between experts*

For the expert discussions in Round 2, each group was presented with 22 discussion

prompts. These prompts asked the experts to discuss:

1. 10 BCT-MoA links that were rated with high uncertainty (i.e., 'Don't

   Know/Uncertain' was selected most frequently)

2. 10 BCT-MoA links with high disagreement (i.e., similar proportions of

   'Definitely No' and 'Definitely Yes' ratings)

3. Two BCT-MoA links which were given to all expert groups to observe differences in their discussions

In total, the experts were presented with 110 discussion prompts about 98 different BCT-MoA links (see the frequency of links presented to groups in Appendix 2-1). Collectively, the threads prompted experts to discuss 53 BCTs from the set of 61 BCTs and 24 MoAs from the 26 included in Round 1.

The discussions in Round 2 started a week after experts received feedback about their individual ratings relative to their group's ratings in Round 1. Experts could anonymously comment on discussion threads at any time for two weeks. Open-ended prompts were used to stimulate discussions about specific BCT-MoA links with high disagreement or uncertainty. While the prompts provided the relevant MoAs' definitions, the definitions of BCTs were sent to experts before the discussions and made available online. Examples of the prompts for discussing these links were, respectively:

1. 'There was a high level of disagreement in your group about whether the Behaviour Change Technique [e.g., 'Social Support (Unspecified)'] changes behaviour through MoA [e.g., 'Moral, social or aesthetic principles accepted by an individual or society as a guide to what is good, desirable, or important' ('Values')]. Please use this thread to share your views about this BCT-mechanism of action link'

2. 'A large number of experts in your group were uncertain about whether the Behaviour Change Technique [e.g., 'Social Support (Unspecified)'] changes behaviour through MoA [e.g., 'Moral, social or aesthetic principles accepted by an individual or society as a guide to what is good, desirable, or important'

('Values')]. Please use this thread to share your views about this BCT-mechanism of action link.'

Two researchers (LC & RC) monitored the discussions but did not intervene in discussions unless experts asked them specific questions in the threads or via email. Experts could discuss their views flexibly with the unstructured discussion format (Gubrium & Holstein, 2002; Mathers, Fox, & Hunn, 2007). Each of the five groups were informed that they could start their own discussion threads about issues of their choosing (e.g., uncertainty about MoAs). Four of the five expert groups collectively initiated eight discussion threads (see the discussions topics in Appendix 2-2). One expert group did not initiate additional discussion threads. Altogether, experts participated in 118 discussion threads.

2.2.4 Analysis of expert discussions

Of the 118 discussion threads, two were excluded from analysis, as one discussion was initiated to request BCT descriptions in the task and another to discuss the study method. The remaining 116 discussion threads were included in the analysis. These threads were downloaded from the online platform Loomio (2015) and converted into Word documents, i.e., a format that could be uploaded onto the quantitative analysis software NVivo (Version 11).

As the discussions aimed to build consensus about BCT-MoA links rather than being structured to investigate the current research question, a flexible analytical approach was needed to identify where the experts disagreed or remained uncertain about MoAs, BCTs and their links. Thematic analysis is a broad analytical approach that involves

researchers interpreting qualitative data to identify themes that help address a research question (Braun & Clarke, 2019; Joffe, 2012). A codebook approach to thematic analysis allows a data-driven development of themes to address a question (i.e., inductive analysis) (Braun & Clarke, 2021; Joffe, 2012). However, this approach also involves developing a structured coding framework (i.e., a conceptual tool that helps categorise qualitative data and that can be hierarchically organised) and documenting the analysis process to increase trustworthiness (Joffe, 2012; Nowell, Norris, White, & Moules, 2017). For the current study, the researchers found this thematic analysis approach appropriate, as it allowed a flexible engagement with the data, while also considering the 'trustworthiness' of the analysis.

To broadly structure the analysis process, the six phases proposed by Braun and Clarke (2006) for thematic analysis were used: (1) Familiarisation with data, (2) Generation of initial codes; (3) Search for themes; (4) Reviewing themes; (5) Defining and naming themes; (6) Producing the report (see Figure 2-2). However, compared to the current approach to thematic analysis, Braun and Clarke's (2019, 2021) thematic analysis approach is more strongly grounded in a qualitative paradigm. They focus on reflexively developing themes, rather than considering trustworthiness criteria associated with quantitative research. Therefore, the six phases were adapted to increase the 'trustworthiness' of the current analysis.

For each phase, the researcher team considered and discussed potential steps to address 'trustworthiness' criteria (Lincoln & Guba, 1985; Nowell et al., 2017). These criteria included credibility (i.e., whether the participants' views were accurately represented in the findings), transferability (i.e., clarity about how generalisable the findings are),

dependability (i.e., the research process being logical, traceable and clearly documented) and confirmability (i.e., establishing that researchers' interpretations were derived from the data). To increase its credibility, the analysis was conducted by two researchers (PS & CM). One researcher (PS) was involved in analysing all expert discussions, while the second researcher (CM) participated in coding 34% of the discussions (two rounds of coding 17% of the discussions) and interpreting the data (Joffe, 2012). To further improve the analysis's credibility, the findings were discussed with at least one expert researcher (AW, FL, SM or MJ) in each analysis phase.

Phase 1: Familiarisation with data

> A researcher (PS) read and then re-read the 116 expert discussions, and noted down reoccuring ideas relevant to the research question in these discussions.

> The researcher and two behavioural science experts (AW &SM) discussed the initial coding ideas, according to which they were refined.

Phase 2: Generating initial codes

> A researcher (PS) coded 50% of discussions to develop an initial coding framework.

> A second researcher (CM) and two behavioural science experts (AW & SM) provided feedback on the clarity of the labels and definitions of the initial codes, according to which they were revised.

> A researcher (PS) applied the coding framework to 116 expert discussions, and revised the labels and definitions of the codes and hierarchically organised them.

> Two researchers (CM & PS) double coded 20 of the 116 discussions using the coding framework and discussed their discrepancy in coding and refined the labels and definitions of codes where relevant.

Phase 3: Searching for themes

> A behaviour science expert (AW) reviewed the initial codebook and discussed the organisation of the codes into themes with the two researchers.

Phase 4: Reviewing themes

> A researcher (PS) re-applied the coding framework to 116 expert discussions, and revised the labels and definitions of the themes and their organisation.

> For each theme, the researcher (PS) read through the extracts and judged whether each fit into the same theme, and revised the labels, definitions or organisations of themes or removed them.

> Two researchers (CM & PS) double coded 20 of the 116 discussions, and discussed their discrepancy in coding and refined the labels and definitions of themes where relevant.

> Four behavioural science experts (AW, FL , MJ & SM) provided feedback on the clarity of the initial labels and definitions and the organisation of the themes and sub-themes.

Phase 5: Defining and naming themes

> The labels and definitions of the themes were finalised in line with the expert feedback.

> The researchers and behavioural science experts identified, labelled and defined overarching themes for the themes in terms of how they fit into the research question.

Phase 6: Producing the report

> A researcher (PS) wrote the findings of the analysis and selected example extracts for each theme.

> The second researcher (CM) and the three behavioural science experts provided feedback on the write-up of the findins and the selected extracts, according to which these were revised.

Figure 2-2. Phases to analyse the expert discussions

2.2.4.1 Familiarisation with data

A researcher (PS) read and re-read the 116 expert discussions and noted down initial ideas for codes. To increase the credibility of the initial codes, these were discussed with two expert researchers (AW & SM) and updated accordingly.

2.2.4.2 Generating initial codes

PS coded experts' written comments in 50 of the 116 expert discussions (around 40%) using NVivo (Version 11). To select these 50 expert discussions, 10 discussion threads were randomly chosen from each expert group's discussion threads. The researcher coded text relevant to experts' disagreement and uncertainty regarding MoAs, BCTs and BCT-MoA links. After coding the 50 discussions, the researcher created preliminary labels and definitions for each code.

The initial codes, their labels and definitions and relevant extracts were discussed with a second researcher (CM) and the two expert researchers (AW & SM). The discussions were documented, and the codes revised accordingly. By using the agreed codes, the researcher (PS) iteratively coded the 116 expert discussions and amended the codes where necessary. The revised codes were organised into a coding framework.

Based on recommendations to improve the coding framework's credibility (Joffe, 2012), the two researchers independently applied the framework to code 20 of the 116 expert discussions (~17%) and refined the codes through regular discussions. The coded expert discussions consisted of four discussion threads from each expert group. For each group, the first two discussions were selected using random stratified sampling, so as to include at least one thread prompted about links with high disagreement and one with

high uncertainty. The other two discussions were randomly sampled from each group's remaining discussions. The MoAs, BCTs and themes discussed in each coded thread are presented in Appendix 2-3.

After applying the coding framework to sets of two or three discussions, the two researchers compared and discussed their coding with reference to extracts from these discussions. For codes they disagreed on, the researchers discussed whether these codes sufficiently addressed the research question and captured experts' statements. They also considered whether the codes' labels or definitions were clear and distinguished from other codes. The researchers made changes to the coding framework where necessary and documented the issues that occurred when applying the framework to the discussions.

2.2.4.3   Searching for themes

To identify which codes qualified as higher-level themes and which were subthemes, the two researchers and AW reviewed and discussed the framework, example extracts and reoccurring issues using the framework. They also discussed which themes needed to be further developed (e.g., subthemes needed to be developed).

2.2.4.4   Reviewing themes

PS re-coded the 116 expert discussions using the developed themes and subthemes in NVivo. To ensure that the developed themes were representative of the discussions (Nowell et al., 2017), the researcher updated the themes and recorded additional important extracts for themes where relevant.

For each theme, PS read through the extracts to judge whether the theme was internally consistent (Braun & Clarke, 2006; Nowell et al., 2017). When data extracts did not appear to fit into a theme, the researcher considered whether the extract should be removed from that theme, or the theme was problematic. Accordingly, the researcher reorganised or removed the themes.

To further strengthen the themes' credibility, the two researchers again independently double coded 20 expert discussions (~17%). These discussions were selected using stratified random allocation to include at least one thread addressing disagreement and one addressing uncertainty from each expert group. The selection was limited to the threads that were previously not coded by CM. After coding two or three discussions, the researchers compared their coding and discussed any disagreement with reference to the themes. They made changes to the themes or noted issues with coding to be discussed with the expert researchers.

The two researchers and the four experts (AW, FL, MJ & SM) reviewed the themes, their subthemes and example extracts, and these were revised. PS then re-read the extracts previously coded for each theme and removed extracts that no longer fit the revised themes and reorganised them where necessary.

2.2.4.5 Defining and naming themes

The final theme labels and definitions were discussed by the researchers and four expert researchers and accordingly revised. They discussed how the themes addressed the research question and identified three overarching themes, which were labelled and defined.

2.4　Results

Of the 105 experts, 92 actively participated in the discussions. The experts made a total of 1311 comments in the discussion threads. The comments per discussion thread ranged from 5 to 23. The BCT-MoA links with the most comments on them (> 20 comments) are presented in Table 2-2. Appendix 2-1 shows the total comment numbers and average comment number per thread for all discussed BCT-MoA pairs. As discussions were prompted about two BCT-MoA pairs ('Instruction on How to Perform the Behaviour' [BCT] – 'Intention' [MoA] and 'Social Support [Unspecified]' [BCT] – 'Attitudes towards the Behaviour' [MoA]) in all groups, these pairs were discussed the most frequently by experts.

Table 2-2. Most frequently commented on BCT-MoA links, the total comment number on these links and the average number of comments per discussion thread

BCT labels	MoA labels	No. of discussion threads	Total no. of comments in discussion threads	Avg. comments per discussion thread
Instruction on How to Perform the Behaviour	Intention	6*	70	11.7
Social Support (Unspecified)	Attitudes towards the Behaviour	5	41	8.2
Social Support (Unspecified)	Values	2	31	15.5
Instruction on How to Perform the Behaviour	Self-image	2	25	12.5
Social Support (Unspecified)	General Attitudes and Beliefs	2	15	7.5
Social Comparison	Intention	1	23	23
Body Changes	Emotion	1	22	22
Behavioural Contract	Self-image	1	21	21
Instruction on How to Perform the Behaviour	Feedback Processes	1	21	21

Notes. * Five of the six discussion threads about the link between 'Instruction on How to Perform the Behaviour (BCT)' and 'Intention (MoA)' were shown to all groups, as this link had the highest disagreement across groups. This link was presented a second time to one group, as this group rated the link as highly uncertain.

The researchers developed three overarching themes relating to areas of disagreements and uncertainty about MoAs, BCTs and their links, namely: (1) challenges to understanding MoAs and BCTs, (2) challenges to understanding BCT-MoA links and (3) experts' prior knowledge and approaches to the task. These overarching themes encompassed a total of 18 themes, which are broadly presented in Figure 2-3. Six of the 18 themes had subthemes, with the number of subthemes per theme ranging between one and seven.
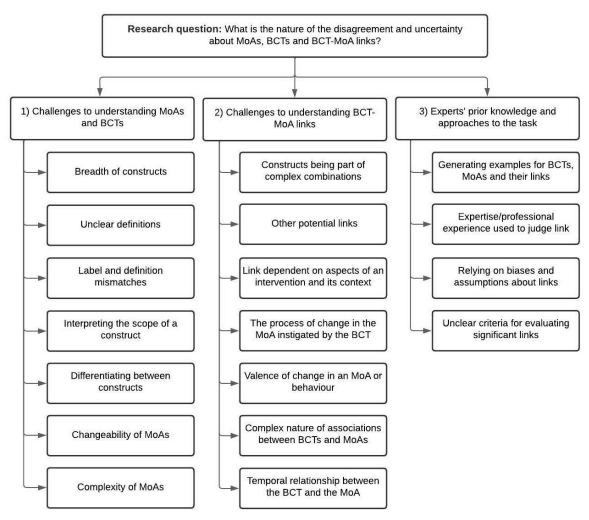
Figure 2-3. Three overarching themes and their respective themes relating to the nature of the disagreement and uncertainty about MoAs, BCTs and their links

2.3.1 Overarching theme 1: Challenges to understanding MoAs and BCTs

The overarching theme 'Challenges to understanding MoAs and BCTs' reflected instances when experts disagreed or were uncertain about how to interpret MoAs and BCTs in terms of their scope, changeability or complexity. Under this overarching theme, there were seven themes: (1) Breadth of constructs, (2) Unclear definitions, (3) Label and definition mismatches, (4) Interpreting the scope of a construct, (5) Differentiating between constructs, (6) Changeability of MoAs and (7) Complexity of MoAs. Table 2-3 presents the descriptions and examples of these themes and subthemes, and the number of threads in which the themes were identified.

2.3.1.1 *Theme 1: Breadth of constructs*

When discussing whether an MoA linked to a BCT, experts described difficulties in appreciating the nature of certain MoAs or BCTs because of their perceived breadth. For instance, Expert 6 in Group C (Expert C6) indicated that they were uncertain about the link between 'Body Changes' (BCT) and 'Emotion' (MoA), because "*the term 'Emotion' was far too broad… to come to a conclusion.*" Similarly, Expert E4 expressed finding the MoA 'General Attitudes and Beliefs' "*too vague… to confidently score as yes/no for most BCTs.*" Therefore, broadly defined MoAs appear to be more difficult to confidently relate to BCTs.

Experts suggested that some BCTs were difficult to understand or link to MoAs, because these BCTs were viewed as being made up of two or more different techniques ('Heterogenous BCTs'). For instance, when discussing whether 'Pharmacological Support' (BCT defined as 'Provide, or encourage the use of or adherence to, drugs to facilitate behaviour change') and 'Intention' (MoA) were linked, Expert B18 wrote "*the*

confusion here comes from the fact that the 'encourage the use or adherence to' part in the BCT could… probably affect Intention, but the 'provide' part probably wouldn't." Therefore, it seems more difficult to link MoAs to BCTs where BCTs' definitions include multiple processes.

In other discussion threads, experts reflected on some MoAs having multiple parts, with only specific parts being linked to the specified BCTs ('Only part of the MoA relates to the BCT'). For instance, Expert B18 wrote that they initially agreed with the link between 'Information about Health Consequences' (BCT) and 'Memory, Attention & Decision Processes' (MoA), because they focused on the MoA definition's "*decision making part*". Accordingly, when MoAs are defined as involving multiple parts or processes, the MoA might be more difficult to link to a specific BCT.

2.3.1.2   Theme 2: Unclear definitions

Experts sometimes expressed perceiving an MoA's or BCT's definition to be poorly specified, vague or difficult to understand. For instance, Expert C20 noted finding it difficult to decide whether 'Body Changes' (BCT) and 'Emotion' (MoA) were linked because of the MoA's definition. They wrote "*I am unclear what we… mean by 'emotion' here'.*" Regarding the BCT 'Restructuring the Social Environment', Expert A5 expressed that "*from previous experience with using the BCT, I have found this one of the harder definitions to get to grips with.*" Therefore, when MoAs or BCTs are not clearly defined, it seems to make it difficult to link an MoA to a BCT. Many comments that expressed perceiving MoAs or BCTs as too broad also referred to relevant construct definitions as being unclear. Consequently, the themes 'Breadth of constructs' and

'Unclear definition' were closely related because broader constructs might have less specific definitions that attempt to capture more than one process.

2.3.1.3 Theme 3: Label and definition mismatches

Experts noted that they perceived certain construct labels to suggest a different meaning to the constructs' definitions, contributing to challenges in understanding these constructs and linking them to an MoA or BCT. For instance, when discussing the link between 'Material Incentive' (BCT) and 'Behavioural Regulation' (MoA), Expert D5 wrote that "*if you just read the title* [the MoA's label] *it could appear that behavioural regulation is the mechanism but when you look at the definition which relates to skills it does not appear to be the mechanism.*" For some MoAs, experts suggested that the MoA's label seemed narrower than its definition. For instance, Expert D6 suggested initially not thinking 'Social Support (Emotional)' (BCT) and 'Social Learning/Imitation' (MoA) were linked, because the MoA's label prompted "*a narrow understanding of this mechanism*". However, they wrote that after "*considering the mechanism's description* [definition]*"* they thought this MoA would link to the BCT. Accordingly, when a mismatch between a construct's label and definition is perceived, a challenge seems to be deciding whether to focus on the label or definition in judging a BCT-MoA link.

2.3.1.4 Theme 4: Interpreting the scope of a construct

Experts sometimes reflected on whether the specified MoA and/or BCT had specific attributes (e.g., temporal attributes, interpersonal or intrapersonal based processes), which seemed to influence whether the expert perceived a link between the MoA and BCT. For instance, when discussing the 'Body Change' (BCT) – 'Emotion' (MoA) link,

81

Expert C5 described thinking of emotions as "*short-lived highly intense psychological state*". In response, Expert C12 explained that they had previously agreed to the link, but now considering emotion to be "*transient*" as opposed to an "*emotional state*", they questioned this link. The expert noted "*body changes are likely to be long-term*" and "*emotions are not playing that much role in the longer process of behaviour change*." Therefore, the labels and definitions of MoAs and BCTs seem to be used to make judgements about the constructs' attributes, which in turn influence perceptions on whether the BCT and MoA are linked. In several comments, experts seemed to consider how broadly or narrowly a construct should be interpreted, which then influenced whether they agreed with a BCT-MoA link ('Breadth of construct interpretation'). For instance, when discussing a link between 'Social Reward' (BCT) and 'Environmental Context-Resources' (MoA), Expert E11 wrote that "*I tended to take the broadest/most inclusive meanings when it came to MoAs.*" More inclusive interpretations of constructs' scopes seemed to lead to linking MoAs to BCTs more often, but also caused disagreements with others who interpreted the constructs' scopes more narrowly.

2.3.1.5 *Theme 5: Differentiating between constructs*

Experts indicated sometimes experiencing challenges in differentiating between constructs. Such difficulties included differentiating an MoA from other MoAs, a BCT from other BCTs and BCTs from MoAs. For instance, in a discussion about 'Self-Talk' (BCT) and 'Self-Image' (MoA), Expert B4 explained their uncertainty by saying "*I... see some overlap between self- talk influencing self-efficacy and self-image and don't have a clear distinction in mind*." In another discussion about 'Instruction on How to Perform the Behaviour' (BCT) and 'Feedback Processes' (MoA), Expert C1 noted that other experts in their group might be confusing BCTs relating to feedback with the

specified MoA, writing "*Remember we are here talking about feedback as a MoA, not as a BCT.*" Difficulties differentiating between MoAs or BCTs seemed to make it more difficult to decide whether a particular MoA was linked to a BCT.

2.3.1.6   Theme 6: Changeability of MoAs

For the MoA 'Optimism', experts deliberated whether the construct was mutable and therefore qualified as an MoA. For instance, in one discussion, Expert C21 expressed generally struggling with the MoA 'Optimism', as they regarded optimism *"as personality trait rather than a changeable determinant.*" However, Expert A4 pointed out that based on the 'Optimism' definition provided in the task ('Confidence that things will happen for the best or that desired goals will be attained'), optimism would be changeable and not a personality trait. Therefore, when an MoA's label suggested a non-malleable construct to some experts, there was confusion about whether the relevant construct indeed qualified as an MoA and should be linked to BCTs.

2.3.1.7   Theme 7: Complexity of MoAs

The MoA 'Emotion' was sometimes noted as particularly difficult to make judgements about, given its multifaceted nature. For example, Expert A5 wrote that they found "*emotional MoAs are particularly tricky to work with and get one's head around as emotions are so complex.*" Further evidence of the challenges posed by the 'Emotion' MoA was provided by experts in one group initiating a discussion thread specifically about this MoA. Accordingly, the complexity of an MoA seems to make it difficult to link to a specific BCT.

Table 2-3. Themes and subthemes organised under Overarching Theme 1 'Challenges to understanding MoAs and BCTs': Their descriptions, example extracts and number of threads in which the themes were identified

Theme	Subtheme	Description	Example extract	No. threads
Breadth of constructs		The expert considered or discussed whether the BCT or the MoA was too broad, making them difficult to understand or link to, respectively, MoAs or BCTs.	This BCT is so all encompassing that it is difficult to say… which are the key mechanisms of action it is likely to work through. (Expert D5 on 'Social Support (Unspecified)' – 'Attitude towards the Behaviour') Because the MoA is so broad… I found it hard to say that most BCTs would not probably act through it in some way (Expert A15 on 'Identification of self as role model' – 'Emotion')	25 Referring to a BCT 11 Referring to a MoA 20
	Heterogenous BCTs	The expert considered or discussed whether the BCT included different types of techniques or parts that could influence MoAs and/or behaviour differently.	The confusion here comes from the fact that the 'encourage the use or adherence to' part in the BCT could… probably affect Intention, but the 'provide' part probably wouldn't. (Expert B18 on 'Pharmacological Support' – 'Intention')	6
	Only part of the MoA relates to the BCT	The expert considered or discussed whether only specific aspects of an MoA's definition linked to the BCT to bring about changes in behaviour.	I could see how behavioural practice/rehearsal builds behaviour skills, but not necessarily cognitive or emotional. (Expert C21 on 'Behavioural Practice-Rehearsal' – 'Behavioural Regulation')	14
Unclear definitions		The expert considered or discussed whether the construct's definition was poorly specified, vague and/or difficult to understand.	I find the definition of this BCT a bit vague relative to many others, and that may be contributing to our disagreement. (Expert C8 on 'Reduce Negative Emotions' – 'Self-Image') I think there is a problem with the definition of emotion. If the word emotion	34 Referring to a BCT 18 Referring to a MoA 20

Theme	Subtheme	Description	Example extract	No. threads
			was not in brackets, I would say the MoA is so broad it could be anything. (Expert C15 on 'Social Comparison' – 'Emotion')	
Label and definition mismatches		The expert considered or discussed whether a construct's label had a meaning that was different from its definition.	I do see how the definition of 'Goals' here makes it difficult. When I think of 'goals' I think of setting a time/place for a specific action/behaviour, not just a 'Mental representations of outcomes or end states that I want to achieve.' (Expert C10 on 'Social Comparison' – 'Goals')	7
			One issue is perhaps that we need to stick to the definition provided for 'Body Changes' rather than the label. (Expert C8 on 'Body Changes' - 'Emotion')	Referring to BCT 1 Referring to MoA 6
Interpreting the scope of a construct		The expert considered or discussed whether the construct included specific attributes.	It would help to distinguish between 'emotion' meaning either rapid automatic response repertoires (approach/avoid/freeze), their subjective / experiential counterparts (feelings: shame, guilt, etcetera), and mood… I assumed the middle definition (feelings). (Expert E12 on Expert-initiated discussion)	19
	Breadth of construct interpretation	The expert considered or discussed whether they interpreted the construct narrowly or broadly.	Some interpretations above seem to go beyond the definition [for the BCT] provided of "Alter body structure, functioning or support directly to facilitate behaviour change"… which does not really seem to have anything to do with an emotional mechanism, its more… a capability issue... (Expert C8 on 'Body Changes' – 'Emotion')	5
			I tended to take the broadest/most inclusive meanings when it came to MoAs (Expert E11 on 'Social Reward' – 'Environmental Context-Resources')	Referring to a BCT 1 Referring to a MoA 4

Theme	Subtheme	Description	Example extract	No. threads
Differentiating between constructs		The expert considered or discussed whether two or more constructs are different from one another.	I understand what you describe about anticipating the reward, but I think that would represent another BCT…"information about social and environmental consequences" (Expert E18 on 'Reward (Outcome)' – 'Beliefs about Capabilities')	25
			I wasn't sure what this general attitude… reflects, as it doesn't concern the behaviour itself (as that would be the MoA attitude towards the behaviour) (Expert E14 on 'Information about the Social and Environmental Consequences' – 'General Attitudes and Beliefs')	Differentiating between BCTs 7
				Differentiating between MoAs 11
			Remember we are here talking about feedback as a MoA, not as a BCT. (Expert C1 on 'Instruction on How to Perform the Behaviour' – 'Feedback Processes')	Differentiating between BCTs-MoAs 10
Changeability of MoAs		The expert considered or discussed whether the construct proposed as an MoA was non-malleable, making it difficult to target in behaviour change interventions.	I struggle with optimism generally…, as I regard this as personality trait rather than a changeable determinant. (Expert C21 on 'Pros and Cons' – 'Optimism')	3
Complexity of MoAs		The expert considered or discussed the complexity of the MoA, making it difficult to understand or link to a BCT.	Emotional MoAs are particularly tricky to work with and get one's head around as emotions are so complex. (Expert A5 on 'Identification of self as role model' – 'Emotion')	2

2.3.2 Overarching theme 2: Challenges to understanding BCT-MoA links

The second overarching theme 'Challenges to understanding BCT-MoA links' was about experts disagreeing or being uncertain about the aspects of the links between BCTs and MoAs. Under this overarching theme, seven themes were developed: (1) Construct being part of complex combinations, (2) Other potential links, (3) Link dependent on aspects of an intervention and its context, (4) The process of change in the MoA instigated by the BCT, (5) Valence of change in an MoA or behaviour, (6) Complex nature of associations between BCTs and MoAs and (7) Temporal relationship between the BCT and the MoA. Table 2-4 presents the descriptions and examples of these themes and subthemes, and the number of threads in which the themes were identified.

2.3.2.1 Theme 1: Construct being part of complex combinations

Experts suggested that BCTs and MoAs are often perceived as part of complex combinations to bring about behaviour change, leading to disagreement and uncertainty about one-to-one BCT-MoA links. For instance, when discussing the link between 'Social Support (Practical)' (BCT) and 'Motivation' (MoA), Expert C12 stated that the aim of the BCT was not necessarily to influence motivation, but "*everything that enables or supports behaviour could improve motivation (in a chain of events)*". Many BCT-MoA pairs seemed to have a relationship through other BCTs or MoAs. However, when a BCT-MoA pair's relationship was perceived to depend on another BCT or MoA, there were challenges for deciding whether this pair was closely enough related to be linked.

In some threads, experts noted that interventions often use BCTs in sequences to bring about changes in MoAs and behaviour ('BCTs being used in sequence'). For instance, in a discussion about the link between 'Instruction on How to Perform the Behaviour' (BCT) and 'Self-Image' (MoA), Expert E10 wrote "*practising the behaviour* [another BCT] *that they* [intervention participants] *have been instructed on may… lead to a change in self-image and a view that they are competent (or not) to change a behaviour.*" As two or more BCTs can be used sequentially to influence an MoA and thereby behaviour, linking an MoA to only one BCT seems to involve uncertainty. Similarly, experts suggested that interventions often use BCTs together to change MoAs and behaviour, contributing to disagreement and uncertainty about links between specific BCT-MoA pairs ('BCT used together'). For instance, Expert A1 wrote "*It is very difficult to think about the individual BCTs in isolation… Although I might say 'yes' to a specific BCT, it's likely that what I'm really saying is that the BCT in question is part of a cluster.*" Accordingly, some BCTs were viewed as changing MoAs as part of clusters of BCTs, making it difficult to judge the link between a single BCT and an MoA.

Experts frequently noted that the specified BCT's influence on behaviour depended not only on the specified MoA, but also on one or more other MoAs ('Link dependent on other MoAs'). For instance, when discussing the link between 'Identification of self as role model' (BCT) and 'Emotion' (MoA), Expert A19 wrote "*there might be a link* [between the BCT and MoA]*, but only if mediated by another mechanism, in which case should it be included?*" Expert C6 also questioned whether a construct only qualified as an MoA if it was directly linked to behaviour or "*if a mechanism of action sets in motion a chain of mechanisms that are ultimately linked to behaviour.*" As

multiple MoAs were considered to work together to bring about the influence of a BCT on behaviour, judging links between only one MoA and a BCT seems to be difficult.

2.3.2.2 Theme 2: Other potential links

Experts referred to the specified BCT or MoA as having links with, respectively, other MoAs or other BCTs, contributing to experts' uncertainty and disagreement about one-to-one BCT-MoA links. For instance, Expert E16 expressed uncertainty about whether 'Information about Antecedents' (BCT) and 'Reinforcement' (MoA) were linked, as "*there are other mechanisms through which this BCT works*." Therefore, being able to think of other MoAs through which the specified BCT could work seems to make it difficult to decide whether this BCT was clearly enough linked to the specified MoA.

2.3.2.3 Theme 3: Link dependent on aspects of an intervention and its context

Experts frequently reflected on whether the BCT-MoA link depended on aspects of an intervention and its context, making it difficult for them to judge one-to-one links. For instance, several experts suggested that a BCT-MoA link would depend on the "*circumstances*". In some threads, experts suggested that the BCT-MoA link depended on how the BCT was operationalised ('BCT operationalisation'). For instance, Expert C8 indicated that other experts had operationalised the BCT 'Reduce Negative Emotions' as "*reducing self-image-related negative emotions*", which necessarily would link to the specified MoA, 'Self-Image'. As BCTs can be operationalised in various ways, there seem to be challenges confidently linking an MoA to a BCT without information about how the BCT is operationalised.

In a few discussion threads, experts suggested that the BCT-MoA link might depend on how frequently the BCT was delivered ('Repeated delivery of BCT'). For instance, Expert A1's comment proposed that 'Feedback on Outcomes of Behaviour' (BCT) would only link to 'Optimism' (BCT) "*with repeated experience*" of the BCT. In addition, experts referred to considering whether the BCT-MoA link depended on how and by whom the BCT was delivered ('BCT delivery'). For instance, Expert B9 expressed thinking that the link between 'Review Outcome Goals' (BCT) and 'Optimism' (MoA) depended "*on the manner of the person who was helping the participant/patient to review their goals*." With the BCT-MoA links being perceived as conditional on how often and how the BCTs were delivered, there seem to be challenges in linking an MoA to a BCT.

Experts frequently suggested that the BCT-MoA link depended on where the intervention took place ('Intervention setting'). For instance, Expert E3 wrote that it was difficult to confidently judge which were "*key MoAs*" for a BCT, as these "*must surely differ across settings.*" Given the relationship between a BCT and MoA might vary across settings, linking an MoA to a BCT without further information seemed difficult. Similarly, experts noted that the BCT-MoA link would depend on the people the intervention was delivered to ('Intervention population'). For instance, in a discussion about 'Goal Setting (Outcome)' (BCT) and 'Feedback Processes' (MoA), Expert E15 questioned whether a link between a BCT and MoA could only be said to exist if it was true for all populations. Other experts provided examples illustrating that the BCT would link to the MoA for some target populations but not others. Therefore, there seems to be challenges in judging BCT-MoA links without acknowledging the possible variability of such links across different populations.

Experts also discussed whether the BCT-MoA link depended on the intervention's 'Target behaviour'. For instance, Expert A2 expressed uncertainty on whether 'Vicarious Consequences' (BCT) and 'Intention' (MoA) were linked, as they thought this link would be "*dependent upon the target behaviour.*' Accordingly, BCT-MoA links were seen as existing for some target behaviours and not others, making it difficult to definitively link an MoA to a BCT.

In a few discussion threads, there were mentions of whether the BCT-MoA link depended on how the target population reacted to or interacted with the intervention ('Engagement with intervention'). For instance, in a discussion about 'Credible Source' (BCT) and 'Emotion' (MoA), Expert D1 wrote "*Credible sources can elicit emotional reactions, should the individual be invested in what that source stands for/what they do/perceived attractiveness.*" Therefore, when linking some MoAs to certain BCTs, a consideration seems to be how a BCT would be engaged with by the target population.

2.3.2.4 Theme 4: The process of change in the MoA instigated by the BCT

Experts considered what kind of difference the BCT needed to cause in an MoA (e.g., form a new belief or change an existing belief) in order to judge whether the BCT and MoA were linked. For instance, Expert B2 wrote that they thought 'Self-Talk' (BCT) would not change 'Self-image' (MoA) but draw on existing 'Self-image'. They expressed being uncertain whether this meant that the BCT and MoA should be judged as linked, as it was unclear "*whether the mechanism is through changing, endorsing or enhancing self-image.*" In another discussion, Expert E16 explained their uncertainty about the 'Information about Antecedents' (BCT) - 'Reinforcement' (MoA) link: "*I don't think this BCT necessarily works by setting up new reinforcements, it just makes*

people aware of existing reinforcements." Therefore, when judging a link between a BCT and an MoA, there seems to be some uncertainty on whether a BCT needs to create an MoA or whether it is sufficient for the BCT to change the MoA's salience.

2.3.2.5 Theme 5: Valence of change in an MoA or behaviour

Experts also reflected on whether a BCT-MoA link would only exist if (1) the BCT causes a positive increase in the MoA and/or (2) the BCT-MoA pair causes a positive change in behaviour. For instance, in a discussion about 'Social Comparison' (BCT) and 'Belief about Capabilities' (MoA), Expert C6 questioned whether an MoA "*can only be considered a… MoA if it has the potential to positively affect behaviour.*" While most experts suggested that the influence of the MoA on behaviour could be positive or negative, there was more uncertainty in discussions about MoAs usually considered to have positive valence (e.g., 'Optimism'). Therefore, when an MoA's label suggested a positive valence, there seemed to be confusion about whether the BCT-MoA link would exist if the BCT caused a decrease (negative change) in the MoA and/or the resulting behaviour.

2.3.2.6 Theme 6: Complex nature of associations between BCTs and MoAs

Several experts considered whether the BCT and MoA were causally associated or linked in a specific sequence. In some threads, experts suggested that the specified BCT-MoA pairs were correlated but were uncertain about whether this relationship was "*causal*". In other threads, expert comments considered the ordering of the BCT and MoA in a sequence of events leading to behaviour change. Where experts felt the BCT did not clearly precede the MoA, this reduced certainty or led to disagreement about their relationship. For instance, Expert E10 wrote that they agreed with the link between

'Comparative Imagining of Future Outcomes' (BCT) and 'Values' (MoA) as "*defining a future outcome as either good or bad is done from the frame of ones on beliefs and values.*" The expert further explained that "*a person will only change a behaviour if, when looking into the future, that behaviour is consistent with their values.*" However, Expert E15 expressed disagreeing with the link by writing "*values might serve as input for the comparison, but… they are not a MoA through with this comparison has an effect on behaviour.*" Therefore, where the construct described by the MoA (e.g., 'Values') is perceived to precede and interact with the BCT to influence behaviour, there seems to be uncertainty if this is a BCT-MoA link.

Experts also seemed to consider whether the construct proposed as an MoA was an outcome or side-effect of the BCT or behaviour, rather than qualifying as the MoA of the specified BCT ('Construct as an outcome of the BCT or behavioural change'). For instance, Expert C8 expressed disagreeing with a link between 'Social Comparison' (BCT) and 'Emotion' (MoA), writing that this BCT would mainly lead to "*capability changes which leads to behaviour change*". The expert elaborated that "*As a result of that behaviour change, there may be some consequences that lead to positive emotions, but that's no longer a mechanism of action.*" Responding to this comment, Expert C9 agreed that there was a "*distinction between a mechanism of action and outcome of the behaviour change*". However, in this discussion, other experts seemed to focus on the BCT resulting "*in a change in emotion*" and so argued in favour of the existence of a BCT-MoA link. Therefore, there seems to be disagreement and uncertainty on whether a BCT changing a construct is enough for this construct to qualify as its MoA or other conditions are necessary.

2.3.2.7 Theme 7: Temporal relationship between the BCT and the MoA

Some experts indicated that links from BCTs to MoAs were harder to judge if the BCT and MoA were thought to lack a straightforward linear temporal relationship. For instance, Expert E4 suggested that 'Goal Setting (Outcome)' (BCT) and 'Feedback Processes' (MoA) would be linked as part of a cyclical loop: "*Feedback works as part of a self-regulation loop by setting a goal/target/standard (which may be a behavioural goal/outcome goal), and then providing information on the extent to which that goal/target/standard is or is not achieved.*" Therefore, BCTs and MoAs being linked in a more complex relationship, beyond a linear BCT→MoA→behaviour relationship, led to disagreement and uncertainty. In some discussions, experts considered whether the specified BCT influenced the MoA after a longer time period ('Longer-term effect of the BCT on the MoA'). For instance, Expert A7 suggested that 'Restructuring the Social Environment' (BCT) and 'Social-Professional Role-Identity' (MoA) would not be linked "*for a long time*". Drawing on the smoking ban example as a BCT, the expert explained that this BCT did not "*immediately change* [smokers'] *sense of themselves as smokers*". The BCT-MoA relationship only being present in the longer term seems to contribute to confusion on whether the BCT sufficiently influences the MoA to qualify as linked.

Table 2-4. Themes and subthemes organised under Overarching Theme 2 'Challenges to understanding BCT-MoA links': Their descriptions, example extracts and number of threads in which the themes were identified

Theme	Subtheme	Description	Example extract	No. threads
Construct being part of complex combinations		The expert considered or discussed the BCT and/or MoA being part of complex pathways to change behaviour.	I felt that not all practical support could be motivating or increase motivation... On the other hand, everything that enables or supports behaviour could improve motivation (in a chain of events). (Expert C12 on 'Social Support (Practical)' – 'Motivation')	10
	BCTs being used in sequence	The expert considered or discussed two or more BCTs being used sequentially to bring about behaviour change.	I was trying to think of… how that BCT moves someone along to the next step of the causal chain... Once that next step is reached, there are often other BCTs required to move the individual to the next step of the causal chain or to actual action. (Expert C5 on 'Social Comparison' – 'Intention')	7
	BCTs used together	The expert considered or discussed two or more BCTs being used together to bring about behaviour change.	Increasing one's knowledge of how to perform a behaviour does not necessarily link by itself - but I would certainly see instruction as one of a combination of BCTs (including, for example, goal-setting) that would contribute to increased intention. (Expert A14 on 'Instruction on How to Perform the Behaviour' – 'Intention')	16
	Link dependent on other MoAs	The expert considered or discussed whether the BCT-MoA link was mediated by other MoAs.	I… assume an indirectly association via self-efficacy. (Expert B9 on 'Pharmacological Support' – 'Intention')	58
Other potential links		The expert considered or discussed whether the BCT or MoA had links to MoAs or BCTs other than those specified by the thread prompt.	If we are talking about… more powerful methods for generating emotion, such as fear…, then… Social Comparison may not be the first-choice technique. (Expert C19 on 'Social Comparison' – 'Emotion') I… struggled with 'intention' as an MoA in general - I thought it would be involved but not necessarily key to achieving change for almost all BCTs. (Expert E6 on 'Social Support (Unspecified)' – 'Intention')	69 Other compatible BCTs for target MoA 26

Theme	Subtheme	Description	Example extract	No. threads
				Other compatible MoAs for target BCT 58
Link dependent on aspects of an intervention and its context		The expert considered or discussed whether the BCT-MoA link depended on the features of the behaviour change intervention and/or its context.	Would providing social comparison always result in change in intention? Or only in certain circumstances. (Expert C21 on 'Social Comparison' – 'Intention')	34
	BCT operationalis ation	The expert considered or discussed whether the BCT-MoA link depended on how the BCT was operationalised.	Could be a MoA depending on content of support, but does not affect BoC [the MoA] by default. (Expert A3 on 'Social Support (Unspecified)' – 'Beliefs about Capabilities')	48
	Repeated delivery of BCT	The expert considered or discussed whether the BCT-MoA link depended on how often the BCT is delivered.	Perhaps one-time biofeedback such as a lung function test among smokers might not operate through reinforcement… but multiple biofeedback episodes… could be reinforcing? (Expert D4 on 'Biofeedback' – 'Reinforcement')	5
	BCT delivery	The expert considered or discussed whether the BCT-MoA link depended on how the intervention was delivered and by whom.	The behavioural contract would have to be delivered very specifically and involve a high level of discussion with the individual… to impact upon self-image. (Expert A1 on 'Behavioural Contract' – 'Self-Image')	13
	Intervention setting	The expert considered or discussed whether the BCT-MoA link depended on the intervention's setting.	I think it would be context specific (as it usually is) and so not necessarily the main mechanism. (Expert B16 on 'Non-Specific Reward' – 'Behavioural Cueing')	22

Theme	Subtheme	Description	Example extract	No. threads
	Intervention population	The expert considered or discussed whether the BCT-MoA link depended on the target population of the intervention.	I think it probably depends on the role…. A GP smelling of smoke who then talks to patients about smoking cessation may be compromising their own credibility (and so the BCT may be stronger). In other professions and for non-health related behaviour change the… link… may not be so apparent. (Expert D17 on 'Commitment' – 'Social-Professional Role-Identity')	22
	Target behaviour	The expert considered or discussed whether the BCT-MoA link depended on the target behaviour.	For some behaviours… I can see how some BCTs can operate through certain mechanisms and not for other behaviours. (Expert D4 on expert-initiated discussion)	12
	Engagement with intervention	The expert considered or discussed whether the BCT-MoA link depended on how the target population reacts to or engages with the intervention.	I am… moving more from a no to a yes… Credible sources can elicit emotional reactions, should the individual be invested in what that source stands for/what they do/perceived attractiveness. (Expert D1 on 'Credible Source' – 'Emotion')	10
The process of change in the MoA instigated by the BCT		The expert considered or discussed what type of difference a BCT needs to cause in an MoA, e.g., changing the MoA or influencing its salience.	Thinking about it a bit more, couldn't this BCT increase the use or application of existing skills even if it doesn't change the skills themselves? (Expert E5 on 'Verbal Persuasion about Capability' – 'Behavioural Regulation')	14
Valence of change in an MoA or behaviour		The expert considered or discussed whether the BCT needed to positively change the MoA and/or behaviour for there to be a BCT-MoA link	I was uncertain about this one because it would all depend on the direction the monitoring and so the emotions would go. If monitoring leads to a negative feeling it won't really result in optimism. (Expert A6 on 'Monitoring of Emotional Consequences' – 'Optimism')	8
Complex nature of associations		The expert considered or discussed whether the BCT and the MoA were causally associated or linked in a	I think they are correlated (many behaviours become easier when there is support), but not necessarily in a causal way. (Expert A11 on 'Social Support (Unspecified)' – 'Beliefs about Capabilities')	37

Theme	Subtheme	Description	Example extract	No. threads
between BCTs and MoAs		specific sequence to judge whether these constructs are linked.	Restructuring the physical environment would likely support those already motivated to adapt the targeted behaviour…. but may have no motivational effect on those not motivated to act... In sum, a kind of "moderated" effect. (Expert D13 on 'Restructuring the Physical Environment' – 'Motivation')	
	Construct as an outcome of the BCT or behavioural change	The expert considered or discussed whether the BCT changed or set into motion events that change a construct proposed as an MoA, without this construct necessarily qualifying as the BCT's MoA.	I too agree the body changes can lead to emotions, but this is not a mechanism of change. (Expert C1 on 'Body Changes' – 'Emotion')	12
Temporal relationship between the BCT and the MoA		The expert considered or discussed whether the BCT-MoA link depended on their temporal relationship.	I think that self-monitoring will lead to behaviour change via setting/re-setting of goals. This is in line with a broad self-reg (control) theory...in which goals and self-monitoring are linked via a continuous loop (Expert A4 on 'Self-Monitoring of Behaviour' – 'Goals')	2
	Longer-term effect of the BCT on the MoA	The expert considered or discussed whether the BCT influenced the MoA after a long time.	Changing my environment doesn't change how I see myself (at least not for a long time). Smokers who had their social environment changed with smoking bans didn't immediately change their sense of themselves as smokers. (Expert A7 on 'Restructuring the Social Environment' – 'Social-Professional Role-Identity')	5

2.3.3 Overarching theme 3: Experts' prior knowledge and approaches to the task

The third overarching theme concerned experts relying on different information about MoAs, BCTs and interventions to judge links, and approaching the expert consensus task differently. Under this overarching theme, there were four themes: (1) Generating examples for BCTs, MoAs and their links, (2) Expertise/professional experiences used to judge links, (3) Relying on assumptions about links and (4) Unclear criteria for evaluating significant links. Table 2-5 presents descriptions and example extracts for these themes and subthemes and the number of threads in which the themes were identified.

2.3.3.1 Theme 1: Generating examples for BCTs, MoAs and their links

Experts referred to different examples (e.g., operationalisation of BCTs, and intervention delivery, context, and target behaviour) to judge BCT-MoA links. Experts sometimes drew on intervention scenarios that fit the BCT-MoA link, suggesting that these recalled scenarios led them towards agreeing with the link. For instance, Expert D15 wrote "*You could make a case that almost all of the techniques could work through almost all of the mechanisms if that is what you set out to do, i.e., the content of the technique (e.g., feedback/instruction/support) and the context in which it is delivered.*" Depending on the examples experts drew on to judge links, they seemed to have different views about whether there was a link between a BCT and MoA. For instance, when discussing the link between 'Self-Monitoring of Outcomes of Behaviour' (BCT) and 'Self-Image' (MoA), Expert C8 wrote "*I'm… worried that we're focused on self-image salient outcomes such as weight*" when thinking of examples for operationalising the BCT. The expert questioned whether they would *"think that self-monitoring an outcome of behaviour such as blood pressure or cholesterol also change behaviour*

through one's self-image?" Therefore, there seem to be contradictory examples for the relationships between a BCT and MoA, leading to difficulties deciding whether there is sufficient evidence for a link.

Experts seemed to draw on behavioural theories to generate examples of BCTs and MoAs to interpret these constructs and their relationships ('Theory/model used'). For instance, in a discussion about the BCT 'Social Support (Unspecified)' and 'Beliefs about Capabilities' (MoA), Expert A4 stated that they "*saw social support as being similar to the concept of verbal persuasion within Self-efficacy Theory.*" To judge the link between 'Demonstration of Behaviour' (BCT) and 'Social-Professional Role & Identity' (MoA), Expert B12 wrote "*General identity theory suggests that the more we are rewarded for doing a behaviour, the more likely we will be to use that identity in the future. So, a one-off demonstration may not necessarily do the trick.*' With theories proposing different relationships between an MoA and a BCT (e.g., different temporal relationships), the perception of a BCT-MoA link appears to be influenced by familiarity with certain theories.

2.3.3.2 Theme 2: Expertise/professional experiences used to judge links

In several discussion threads, experts explicitly referred to their prior knowledge and professional experience to help interpret BCTs, MoAs and judge their links ('Expertise/professional experiences used to judge links'). For instance, in one discussion, Expert C19 wrote that the BCT 'Graded Tasks' had been used to successfully change 'Behavioural Regulation' (MoA) in their work around pro-environmental behaviours. Also demonstrating that experts based their judgements on prior knowledge, Expert B8 cited their lack of experience regarding smoking cessation

as contributing to their uncertainty judging the link between 'Pharmacological Support' (BCT) and 'Beliefs about Capabilities' (MoA).

2.3.3.3 Theme 3: Relying on assumptions about links

Some expert demonstrated that they or other experts made assumptions to judge BCT-MoA links, which seemed to contribute to disagreements and uncertainty about BCTs, MoAs and their links. For instance, when discussing the link between 'Social Comparison' (BCT) and 'Beliefs about Capabilities' (MoA), Expert C8 wrote "*the longer the consecutive causal chain we propose* [between the BCT and MoA]*, the more tenuous the assumptions, and the less comfortable I become with expert consensus without some form of empirical testing*." However, the same expert also expressed concern that that limiting BCT-MoA links to one-degree separations would be overly simplistic and contradict most behavioural theories. Therefore, there appear to be difficulties in judging BCT-MoA links which often involve complex relationships between the BCT and MoA, without feeling one is making too many assumptions about how the link operated.

2.3.3.4 Theme 4: Unclear criteria for evaluating significant links

Some experts implied that the study's criteria for judging BCT-MoA links were unclear and open to interpretation. Various comments addressed difficulties in deciding whether a BCT-MoA relationship was direct or frequent enough to be judged as linked. In an expert-initiated discussion, Expert B5 explained their uncertainty about the criteria by writing "*I could probably make a rough estimate of the proportion of times I thought a technique might work in this way* [through a specific MoA]*, but felt I needed some guidelines to indicate how this proportion should then translate into a 'yes' or a 'no'*."

The experts seemed to have employed different approaches to judging BCT-MoA links, with some describing more inclusive approaches and others more conservative approaches. For instance, Expert B7 suggested that experts should "*not focus too much on whether* [an MoA] *is or is not a main mechanism*" for a BCT, instead it was "*important to cover all relevant MoAs*" for a BCT. In contrast, Expert E13 wrote that experts should "*focus on the key and most direct pathway*" between the specified BCT and MoA, as they thought there were multiple, convoluted pathways of influencing behaviour. Therefore, there appear to be different ways to operationalise the existence a BCT-MoA link, some more inclusive than others, leading to disagreements and uncertainties judging that link.

Table 2-5. Themes and subthemes organised under Overarching Theme 3 'Experts' prior knowledge and approaches to the task': Their descriptions, example extracts and number of threads in which the themes were identified

Theme	Subtheme	Description	Example extract	No. threads
Generating examples for BCTs, MoAs and their links		The expert referred to or discussed examples to interpret the BCT, MoA and their link.	The conversation is starting to lean towards "no", but I think there could be situations where providing feedback on the outcomes of a certain behaviour (e.g., continuing to screen people for X may in fact increase harms...) might actually increase a person's knowledge. (Expert A19 on 'Feedback on Outcomes of Behaviour' – 'Knowledge')	83
	Theory/model used	The expert referred to or discussed examples from theories to interpret a BCT or MoA or evaluate their link.	Instruction on How to Perform the Behaviour could change behaviour via enhancing self-efficacy which in turn could increase the likelihood of forming an intention. It does not have to do this via intentions though - e.g., Ajzen's proposed direct link between self-efficacy and behaviour. Perhaps this is the source of disagreement. (Expert D16 on 'Instruction on How to Perform the Behaviour' – 'Intention')	17
Expertise/ professional experiences used to judge links		The expert referred to or discussed their professional experience or expertise, or lack thereof, to evaluate the link between the BCT and the MoA.	We will all naturally use familiar examples to draw conclusions which may be very different/irrelevant for others and their fields of practice. (Expert D15 on expert-initiated discussion)	19
Relying on assumptions about links		The expert explicitly referred to or discussed their assumptions influencing the perceptions of a link between the BCT and the MoA.	I have made a lot of assumptions here which are probably not born out in many cases. (Expert B2 on 'Pharmacological Support' – 'Intention')	15
Unclear criteria for evaluating significant links		The expert referred to or discussed the criteria for judging the significance of a BCT-MoA link being unclear or open to interpretation.	I usually think of what the key mechanisms are for a BCT to affect behaviour, rather than whether a BCT could possibly act through a possible MoA... I might be a little… conservative in my ratings. (Expert A3 on 'Behavioural Contract' – 'Self-Image') This 'yes' or 'no' vote depends on whether we should only vote for KEY (i.e.,	25

Theme	Subtheme	Description	Example extract	No. threads
			more frequent) MoA by which a BCT affects behaviour… or we should consider less frequent MoA (Expert C4 on 'Instruction on How to Perform the Behaviour' – 'Intention').	

2.5   Discussion

To inform the development of clear classification systems for MoAs and BCTs, the current study aimed to explore why experts disagreed or were uncertain about MoAs, BCTs and their links. The findings suggested that three key overarching themes were associated with experts disagreeing or being uncertain about MoAs, BCTs and their links. First, some MoA and BCT definitions were perceived as too broad or underspecified or mismatching with their labels, increasing the difficulty of judging their relationships with other constructs. Secondly, a BCT-MoA link's strength or existence may vary according to several factors, making it harder to judge. Finally, experts vary in prior knowledge about behaviour change interventions and bring different approaches to the task.

The results showed that some experts thought several MoAs (e.g., 'Emotion') and BCTs (e.g., 'Social Support [Unspecified]) were too broad or underspecified to confidently link to, respectively, BCTs or MoAs. When experts perceived MoA or BCT labels and definitions to be mismatching, they also seemed to be confused on which information to prioritise to interpret these constructs. Several experts had difficulties distinguishing certain MoAs from other MoAs (e.g., 'Behavioural Regulation' and 'Skill') or BCTs and BCTs from other BCTs, particularly when these constructs had similar labels or definitions. The results also suggested difficulties in deciding whether a construct (e.g., Optimism) qualified as an MoA of a BCT, when the construct's label or definition did not clearly suggest that this construct was malleable. Therefore, the results supported that detailed categorisation systems with clearer definitions for MoAs and BCTs (e.g., Michie et al., 2017) could support better understandings of these constructs and linking them.

In terms of challenges to understanding BCT-MoA links, the findings suggested that many experts think about the inter-dependent relationships of multiple BCTs and MoAs within an intervention, making it difficult to judge one-to-one links. Moreover, there seem to be many potential BCTs to which an MoA can potentially link and vice versa many MoAs that a BCT can target, making it difficult to evaluate whether a particular one-to-one BCT-MoA relationship is clearly linked. The results also suggested that experts think about BCT-MoA links being dependent on aspects of a behaviour change intervention, its context and its target behaviour. Therefore, while the expert consensus study intended to investigate up-to-date expert thinking about BCT-MoA links (Connell Bohlen et al., 2019), the rated one-to-one links might not have captured more complex thinking about these links. The Theories and Technique (TaT) Project's final mapping of BCT-MoA links (Johnston et al., 2018), which are presented in the TaT Tool (https://theoryandtechniquetool.humanbehaviourchange.org/), might also not fully reflect variability of such links across different interventions and their contexts.

The findings revealed conceptual challenges in understanding the BCT-MoA links. One such challenge was the variability of temporal relationships and other complex associations between BCTs and constructs proposed as MoAs, beyond a linear BCT-MoA link. Another challenge was understanding what type of change a BCT needs to instigate in an MoA for these constructs to be linked, e.g., whether the BCT needs to create a belief or work through an existing one. In addition, the findings showed experts' disagreement and confusion about whether BCTs needed to cause a positive change in an MoA and subsequent behaviour for there to be a link. Experts' difficulties in conceptualising how a BCT works through an MoA may be experienced more generally by researchers, as BCT-MoA relationships are often underspecified in

intervention reports (e.g., Prestwich et al., 2014). Accordingly, there have been calls for researchers to more clearly conceptualise, test and report the pathways between delivered interventions, MoAs and subsequently behaviour (e.g., Sheeran et al., 2017; Nielsen et al., 2018).

The current findings suggested that experts vary in their prior knowledge, which can lead to disagreements on which BCTs and MoAs are linked. However, the TaT Project (Connell Bohlen et al., 2019) purposively selected a high number of experts with different experiences in behaviour change to provide a range of reflections on BCT-MoA links. The findings suggested that experts might have needed clearer instructions on approaching the task to link BCTs and MoAs, e.g., whether they should be inclusive when judging BCT-MoA links. However, there might be considerable variation in how many BCTs specific MoAs are linked to. Therefore, providing artificial constraints for judging BCT-MoA links might not have revealed better insights into experts' thinking about these links.

2.4.1 Strengths and limitations

A key strength of the current study was that it involved behavioural scientists with a variety of background expertise from a range of different countries. The discussions therefore reflected diverse understandings and challenges when linking MoAs to BCTs. However, the discussion prompts were not designed to investigate the current research question since the expert discussions were conducted to improve the expert consensus about BCT-MoA links within a different project. For instance, experts were not asked detailed questions that helped further explore challenges about applying MoAs to link these to BCTs. In addition, during their discussions, the researchers did not use any

probes to ask experts to elaborate on certain points. While the open-discussion format allowed experts to express themselves freely, experts did not always fully or clearly express their ideas. Therefore, it was difficult to interpret some of the experts' statements during the qualitative analysis.

A methodological strength of the current thematic analysis was balancing 'trustworthiness' and flexibility to develop themes that address the research question. The analytical phases were adapted to improve the analysis's trustworthiness. For instance, the research team regularly discussed the developed codes and themes to ensure that these were clear and reflected experts' thinking in the discussions. By iteratively refining the themes and re-applying them to code the discussion threads, the research team also ensured a flexible approach to developing themes informed by the data.

2.4.2   Implications

The study findings provided detailed insights into experts' thinking about the topic of BCT-MoA links. Having a large number of participants with various backgrounds in an expert consensus study can help capture different views, while ensuring that findings do not over-represent the views of a few. The findings also implied that the mapping of one-to-one BCT-MoA links might insufficiently reflect the complexity of such links (e.g., that they depend on intervention aspects). Therefore, maps of 'likely' BCT-MoA links can provide useful starting points for intervention designs or systematic reviews. However, when using these mappings, intervention designers still need to investigate the extent to which links are 'likely' for their intervention's population and setting and

target behaviour. Having passed this test, intervention designers then need to tailor their BCTs to delivery methods and to target relevant MoAs.

The current experts found certain MoAs and BCTs too broad to understand or make links, suggesting that these constructs needed to be separated into narrow categories. For instance, subclasses for certain MoAs, such as 'Emotion', could help people better understand the scope of what is meant by emotion. Such subclasses could be linked more precisely and confidently to BCTs. Similarly, the current findings implied that some MoAs' and BCTs' labels and definitions needed to be clearer to facilitate better understanding of these. When developing future categorisation systems, capturing these constructs in more detail and providing clearer labels and definitions for them will be important.

2.4.3 Future research

The Human Behaviour-Change Project is currently developing the Behaviour Change Intervention Ontology to represents aspects of behaviour change interventions, such as BCTs, MoAs and intervention settings (Michie et al., 2017, 2021). As part of this effort, the BCT Ontology is being developed based on the BCTTv1 (Michie et al., 2013) but incorporating user feedback and expert input to refine BCTs. The studies of this thesis will develop an ontology for capturing MoAs in more detail. By developing an ontology of MoAs as part of the broader Behaviour Change Intervention Ontology, more complex relationships between BCTs and MoAs will be able to be represented (Michie et al., 2017, 2021). For instance, this broad ontology can represent that BCTs influence MoAs which influence behaviours, and that this relationship is moderated by the intervention's setting and population. Accordingly, different parts of this ontology can

be used to synthesise evidence about BCT-MoA-behaviour links in relation to the delivery and contexts of interventions.

In parallel, as the TaT Tool (www.theoryandtechniquetool.humanbehaviourchange.org) allows its users to provide evidence-based feedback to support, or not, the existence of BCT-MoA links, this evidence base can be refined over time. For instance, systematic reviews could be used to investigate whether the BCT-MoA links proposed by the TaT Tool exist for different intervention contexts and target behaviours. Their findings could identify the range of application of 'likely' links currently proposed by this tool and support the synthesis of evidence about the variability of such links. The mapping could also be refined to capture which BCTs are usually used together (e.g., as clusters) to influence one or more MoAs, thereby better reflecting the complexity of links between BCTs and MoAs.

2.4.4   Conclusion

The current study investigated areas of disagreement and uncertainty about MoAs, BCTs and their links. The findings suggested that experts' prior knowledge and approaches to the task influence their judgements on BCT-MoA links, leading them to disagree on some links. The findings also suggested that some MoAs and BCTs were very broad and/or had underspecified labels and definitions, creating challenges for confidently linking these MoAs and BCTs. Finally, the findings illustrated that the complexity of BCT-MoA links and their variability led to challenges in judging one-to-one links. More detailed categorisation systems, such as ontologies, with clearer labels and definitions for MoAs and BCTs could facilitate better understandings of MoAs and BCTs. By developing ontologies for MoAs and BCTs as part of the broader Behaviour

Change Intervention Ontology (Michie et al., 2017, 2021), the complex relationships

between BCTs and MoAs can be represented with respect to other aspects of

interventions and their contexts.

3 Chapter 3: Developing a preliminary ontological structure for mechanisms of action in behaviour change interventions from behavioural theories (Study 2)

3.1 Abstract

Rationale: There are challenges to understanding and synthesising evidence about mechanisms of action (MoAs) when these MoAs are broad and have underspecified definitions. An ontology with clear labels and definitions for MoAs in behaviour change interventions can facilitate better understanding of MoAs and evidence synthesis about them. To develop an ontology, its scope needs to be identified (e.g., MoAs), along with content that aligns with this scope and draws on existing work in a scientific domain. Behavioural theories can serve as a starting point to identify the MoA Ontology's content, as theories include constructs that are malleable and influence behaviours, i.e., potential MoAs.

Aim: To reliably identify MoAs from behavioural theories and group these MoAs together to form a preliminary structure for an ontology of MoAs in behaviour change interventions

Methods: First, two researchers independently judged whether 1733 constructs extracted from 83 behavioural theories qualified as MoAs, based on iteratively developed criteria. The inter-rater reliability of their judgements across 72 identification sessions (~25 constructs in each session) was assessed using Krippendorff's alpha. The researchers reconciled their judgements through discussion, consulting three behavioural science experts where necessary, to create a list of identified MoAs. Second, the researchers judged whether any of the identified MoAs were composites of more than one MoA that could not be grouped with other MoAs (compound MoAs) and

removed such MoAs from the list. The researchers then grouped the identified MoAs. To do this, they started with a list of MoA groupings created by a previous project. They refined these groups by specifying their shared attributes and then judging whether any constituent MoAs did not share these attributes, and so should be ungrouped. Based on all ungrouped MoAs' attributes, the researchers judged whether any could be assigned existing groups or grouped together to form new MoA groups.

Results: 1062 MoAs were identified from the 1733 constructs extracted from 83 theories. The inter-rater reliability for judging these constructs as MoAs increased across the sessions to judge these constructs. Of the 72 sessions, 25 had a Krippendorff's alpha level above the 'acceptable' ($\alpha = 0.67$) benchmark. Of the 1062 MoAs, 146 were judged to be compound MoAs. From the remaining MoAs, 763 MoAs were organised into 104 groups, such as 'Self-efficacy', 'Need', 'Intention' and 'Knowledge'.

Conclusions and implications: As many behaviour theories include underspecified constructs, reliably identifying MoAs from these constructs is challenging. The organisation of MoAs into 104 groups serves as a preliminary structure to develop classes in the MoA Ontology, which can enable more consistent labelling and defining of MoAs across theories and behaviour change interventions.

3.2 Introduction

Study 1 (see Chapter 2) suggested that behavioural scientists perceive several challenges to understanding mechanisms of action (MoAs) and linking them to behaviour change techniques (BCTs). Some of these challenges were associated with MoAs being considered too broad, and their definitions being underspecified or poorly match the MoAs' labels. To help better understand MoAs and synthesise evidence about them, an ontology for MoAs can be developed (Michie et al., 2017). This ontology will include classes that capture MoAs in detail, clearly label and define these classes and specify relationships between classes (Arp, Smith, & Spear, 2015; Michie et al., 2017; Michie, West, & Hastings, 2019).

As outlined in Chapter 1, for the MoA Ontology to be usable and useful, its development will follow the principles for developing 'gold standard' ontologies (Open Biological and Biomedical Ontology [OBO] Foundry, 2019i; Smith et al., 2007; Wright et al., 2020). One of these principles requires an ontology to have a specified scope, i.e., define the subject area intended to cover, and content (e.g., classes and their labels and definitions) relevant to this scope (OBO Foundry, 2019f; Wright et al., 2020). Ontologies should also build on existing work where relevant (Arp et al., 2015; OBO Foundry, 2019b; Wright et al., 2020). For instance, to identify the content of an ontology, ontology developers can draw on expert consensus studies or concepts and terms commonly used across published studies (Arp et al., 2015; Wright et al., 2020).

To identify relevant content for the MoA Ontology, a potential source are the constructs of behaviour theories. These constructs are proposed to influence behaviour, and some of them are considered to be malleable, meaning they can be targeted as MoAs in

interventions (Eccles, Grimshaw, Walker, Johnston, & Pitts, 2005). A scoping review of theories of behaviour and behaviour change identified 83 theories, which included a total of 1733 constructs (Davis, Campbell, Hildon, Hobbs, & Michie, 2015). From these 1733 constructs, an extensive list of potential MoAs in behaviour change interventions could be identified.

3.2.1 Method used to create MoA groups in the Theories and Techniques (TaT) Project

Drawing on the 1733 constructs of the 83 behavioural theories (Davis et al., 2015), the Theories and Techniques (TaT) Project (Michie et al., 2018) identified and grouped MoAs to derive 12 of its 26 MoAs to link to BCTs. While this project's aim was not to identify or group MoAs, its method to derive these 12 MoAs can provide a useful starting point to identify the content of an ontology of MoAs. For the TaT Project, the 12 MoAs were selected by identifying MoAs that occurred most frequently in the 1733 theoretical constructs. The MoAs that overlapped with the Theoretical Domains Framework's (TDF) 14 domains (Cane, O'Connor, & Michie, 2012; Michie et al., 2005) were excluded, as these domains constituted the remaining 14 of the 26 MoAs included in the TaT Project.

To identify the 12 MoAs that were not captured by the TDF, researchers labelled and defined the 1733 theoretical constructs using descriptions in theories or dictionaries. The researchers developed guidance to identify which of the constructs were MoAs. Accordingly, MoAs were constructs that were posited to mediate the influence of BCTs on behaviour, including constructs defined as 'momentary states', 'traits', 'stages', 'processes' and 'aspects of the social/physical environment' (for the complete guidance,

see Appendix 3-1). Using this guidance, the researchers identified 1238 of the 1733

theoretical constructs as being MoAs.

The next step was to group together constructs with the same or very similar definitions

and/or definitions that seemed to refer to the same mechanism: this was done using a

card sort task. The researchers grouped 868 MoAs into 97 MoA groups. The remaining

370 MoAs were not grouped, as they were unique or specific to just one theory, or there

was no obvious grouping. The researchers then labelled and defined each of the 97

MoA groups. From the 97 MoA groups, the 12 MoA groups that contained the greatest

number of theoretical constructs and did not overlap with the TDF's 14 domains were

selected for the TaT Project. These 12 MoAs' labels and their definitions are presented

in Table 3-1.

Table 3-1. The labels and definitions of MoAs selected from 83 theories in the TaT
Project

MoA label	MoA definition
Attitude towards the behaviour	The general evaluations of the behaviour on a scale ranging from negative to positive.
Behavioural cueing	Process by which behaviour is triggered from either the external environment, the performance of another behaviour, or from ideas appearing in consciousness
Feedback processes	Processes through which current behaviour is compared against a particular standard
General attitudes/Beliefs	Evaluations of an object, person, group, issue, or concept on a scale ranging from negative to positive
Needs	Deficit of something required for survival, well-being, or personal fulfilment
Norms	The attitudes held, and behaviours exhibited by other people within a social group
Perceived susceptibility/ Vulnerability	Perceptions of the likelihood that one is vulnerable to a threat

MoA label	MoA definition
Self-image	One's conception and evaluation of oneself, including psychological and physical characteristics, qualities, and skills
Social learning/Imitation	A process by which thoughts, feelings, and motivational states observed in others are internalized and replicated without the need for conscious awareness
Subjective norms	One's perceptions of what most other people within a social group believe and do
Values	Moral, social or aesthetic principles accepted by an individual or society as a guide to what is good, desirable, or important

3.2.1.1 Limitations in the identification and grouping of MoAs in the TaT Project

There were some limitations in both the step to identify MoAs and the step to group MoAs in the TaT Project (Michie et al., 2018). First, this project did not measure the inter-rater reliability of researchers' judgements in identifying MoAs from the theoretical constructs. In addition, the procedure excluded 'very broad' constructs from qualifying as MoAs without clear guidelines. These broad constructs could have included broad MoAs, of which some could become higher-level classes in the MoA Ontology. Other broad MoAs might have been composites of MoAs which include different influences on behaviour (compound MoAs) and therefore are difficult to group. However, there needed to be an explicit rationale for excluding such compound MoAs from the MoA grouping task.

To group MoAs together, the TaT Project provided very general guidelines, rather than more explicit rationale for these groupings, e.g., based on the attributes MoAs shared. There were also no steps to review whether the grouping of all MoAs was appropriate or whether any ungrouped MoAs could actually be grouped. By addressing these limitations, a preliminary ontological structure for MoAs can be created, which can then serve as the basis for developing the MoA Ontology.

3.2.2 Aims and research questions

To develop a preliminary ontological structure for MoAs, this study aimed to reliably identify MoAs from 83 behavioural theories and group these MoAs together, based on their shared attributes. Figure 3-1 presents an outline of studies in this thesis that inform the MoA Ontology's development, with the current study highlighted. The research questions to address this study's aim are as follows:

1. Which MoAs can be identified from the constructs of 83 behavioural theories previously identified in a literature review?

2. With what level of inter-rater reliability can MoAs be identified from the constructs of 83 behavioural theories previously identified in a literature review?

3. Which MoAs identified from the 83 behavioural theories are compound MoAs (composites of MoAs that work differently) and so cannot be grouped together with other MoAs?

4. Which attributes are shared by MoAs in each MoA group from the TaT Project?

5. Which MoAs do not share all the attributes of their previously assigned MoA groups from the TaT Project?

6. Which ungrouped MoAs share attributes and so can form new MoA groups?
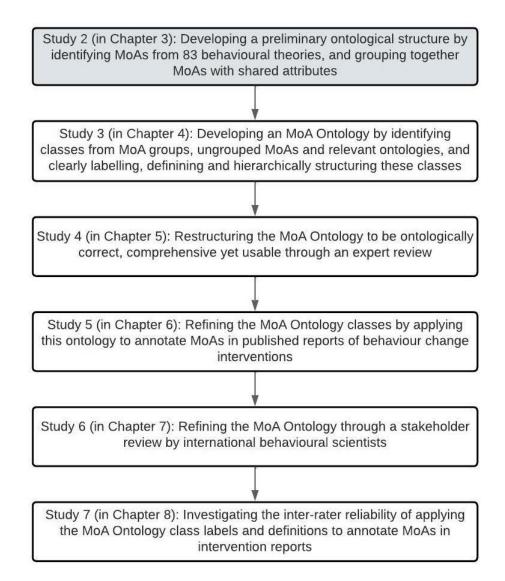
Figure 3-1. Studies used to develop the MoA Ontology in this thesis, with the current study highlighted

3.3   Methods

Developing this preliminary ontological structure for MoAs involved three steps: (1) identifying MoAs, (2) identifying compound MoAs (i.e., composites of MoAs working differently) which cannot be grouped and (3) grouping MoAs. These steps were conducted by three researchers with MSc level qualifications related to behavioural science (the author of this thesis, PS, CM & EH) and three behavioural science experts (AW, SM & RW) who are part of the Human Behaviour-Change Project.

3.3.1 Step 1: Identifying MoAs

The process to identify MoAs from theoretical constructs is outlined in Figure 3-2. For this process, the MoA Identification Guidance from the TaT Project (see Appendix 3-1) was updated to reflect the definition for MoAs from the Behaviour Change Intervention Ontology with the help of the ontological expert for the Human Behaviour-Change Project (JH). MoAs were defined as 'processes that are potentially causally active in bringing about the impact of a behaviour change intervention on the outcome behaviour.'
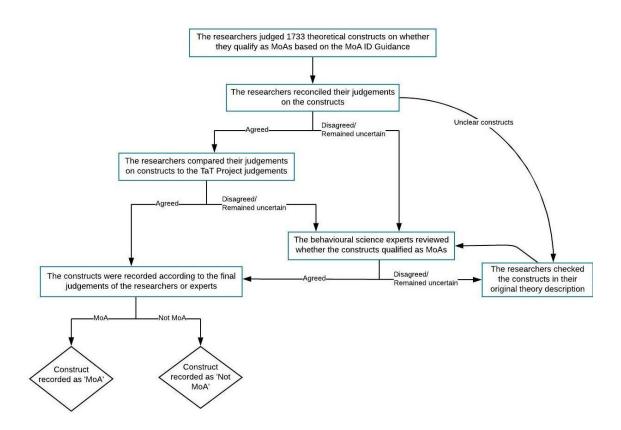
Figure 3-2. Overview of procedure to identify MoAs from theoretical constructs

3.3.1.1 *Selecting the theoretical constructs for researchers to judge in sessions*

To limit the burden on researchers, two researchers independently judged all 1733 theoretical constructs over 72 sessions. In each session, the number of constructs was between 10-33. This range was considered feasible to allow researcher to reconcile their judgments and identify any issues using the MoA Identification Guidance. The first five sessions each consisted of 10 theoretical constructs to allow the researchers to identify major issues using the MoA Identification Guidance early. For the next 66 sessions, the number of constructs was increased to 25. The final session included the remaining 33 constructs.

The theoretical constructs for each session were selected via stratified random allocation. Randomisation was stratified according to whether constructs had previously been identified as MoAs (1238 constructs) or not (495 constructs) in the TaT Project. For instance, in the sixth session, the 25 constructs judged by researchers consisted of 18 constructs previously identified as MoAs and seven constructs previously identified as not being MoAs. For the randomisation process, 10 theoretical constructs with missing judgements from the TaT Project were treated as not having previously been identified as MoAs.

3.3.1.2 *Judging theoretical constructs*

In each session, two researchers (PS & CM) first read the theoretical constructs' labels and definitions. To understand the theoretical context of these constructs, the researchers also read their descriptions in a reference book which described each of the 83 behavioural theories (Michie, West, Campbell, Brown, & Gainforth, 2014). The researchers then independently judged and double coded whether each construct

qualified as an MoA, according to the MoA Identification Guidance (see the final

version in Table 3-2) and additional practical guidance (see Appendix 3-2). For each

construct, the researchers categorised their judgements as 'MoA', 'Compound MoA',

'Not MoA' or 'Uncertain' and recorded their rationales using the identification

guidance's criteria. The task's main aim was to identify MoAs rather than differentiate

compound MoAs from MoAs. Therefore, researchers were advised to only code

'Uncertain' when they were unsure whether the theoretical construct qualified as an

MoA or not.

Table 3-2. Inclusion and exclusion criteria in the MoA Identification Guidance

Type of criteria	Criteria
Inclusion	Changes in momentary psychological and physiological states (e.g., fear, hunger or mood/arousal)
	Changes in manifestations of enduring psychological and physiological states or dispositions (e.g., cognitive ability, identity, or preparedness to change)
	Sequences of events transforming, or preventing transformation of states, stages or traits (e.g., habituation or associative learning)
	Changes in the physical and/or social environment where the theory specifies the influence on behaviour (e.g., physical/social opportunity, norm or interaction)
	Behaviours (e.g., avoidance behaviour)
Exclusion	A non-modifiable historical factor (e.g., prior experience or age)
	Only being changeable in a specific maturation period (e.g., tendency to respond to conflict physically which develops during maturation)
	Part of an intervention itself (e.g., a BCT)
	A target behaviour
	Including multiple processes and one or more of these are not mechanisms of action (e.g. process of teaching or acquiring knowledge, skills and values),

3.3.1.2.1 Monitoring inter-rater reliability of MoA identification

To monitor whether researchers used the MoA Identification Guidance similarly in sessions, the inter-rater reliability of researchers' judgements on identifying MoAs was assessed. The data for Sessions 1-2 and 3-5 were pooled to enable comparisons with the other sessions with 25-33 constructs. Judgements were recorded as nominal data. As the key aim was to calculate the reliability of identifying MoAs and not differentiating MoAs from compound MoAs, the codes for MoAs and compound MoAs were combined into one code ('MoA/Compound MoA').

To calculate the inter-rater reliability of researchers' judgements to identify MoAs, Krippendorff's alpha was selected (Krippendorff, 2004). This reliability coefficient can be used with nominal data, and it accounts for chance agreement, i.e., raters agreeing by chance which can lead to overestimating their agreement (Gisev, Bell, & Chen, 2013; Gwet, 2014; Krippendorff, 2004). This coefficient is also more resistant to some paradoxes seen in other commonly used coefficients, such as the penalising of high agreement in the Cohen's kappa statistic (Feinstein & Cicchetti, 1990; Gwet, 2014). Cohen's kappa has been shown to underestimate agreement between raters when agreement is above its expected agreement, meaning that in some cases the kappa value could be higher if raters disagreed more (Feinstein & Cicchetti, 1990). Krippendorff's alpha was computed with Hayes' macro code, applying bootstrapping for 10,000 iterations, on SPSS (Hayes & Krippendorff, 2007).

Krippendorff (2004) proposed that, when interpreting alpha, inter-rater reliability coefficients above 0.80 can be considered 'good', while coefficients between 0.67 and 0.80 can be seen as 'acceptable'. Coefficients below 0.67 can indicate that researchers

are applying MoA Identification Guidelines to the data differently (Krippendorff, 2004). The types of difficulties encountered in attaining Krippendorff's alpha of 0.80 informed refinements to the MoA Identification Guidance. This guidance was refined until no further issues were raised by researchers. It was anticipated that achieving the benchmark value, 0.80, was not feasible for most MoA identification sessions, as many included labels and definitions that were underspecified. Therefore, the benchmark for 'acceptable' inter-rater reliability ($\alpha = 0.67$) was used to evaluate whether researchers reliably identified MoAs.

When the MoA Identification Guidance was altered, the researchers identified constructs that were previously judged differently and asked experts to review them. The final guidance (see Table 3-2) was used for the last 36 MoA identification sessions. Additional practical guidance that was developed and used to identify MoAs is presented in Appendix 3-2.

3.3.1.3   *Reconciling researchers' judgments*

After each MoA identification session, the researchers compared their judgements on theoretical constructs. For the constructs they agreed on, they recorded their judgements as 'MoA', 'Compound MoA' or 'Not MoA.' For the remaining theoretical constructs, the researchers discussed their coding rationale based on the identification guidance, and the constructs' descriptions in Michie et al. (2014). Accordingly, the researchers reconciled and recorded their judgements on constructs. Theoretical constructs that were judged by one researcher as a compound MoA and the other as a MoA were recorded as 'MoA/Compound MoA' to be re-evaluated later.

3.3.1.4 Experts' reviews of judgements

If the researchers remained uncertain or disagreed on whether theoretical constructs qualified as MoAs, these constructs were resolved by the behavioural science experts. For constructs where issues stemmed from unclear labels or definitions, PS referred to the original theory descriptions to provide relevant information about the construct and facilitate the experts' judgments. The experts also reviewed the constructs that the current researchers judged differently from the TaT Project to reduce the likelihood of researchers agreeing by chance or developing shared misconceptions about the nature of MoAs.
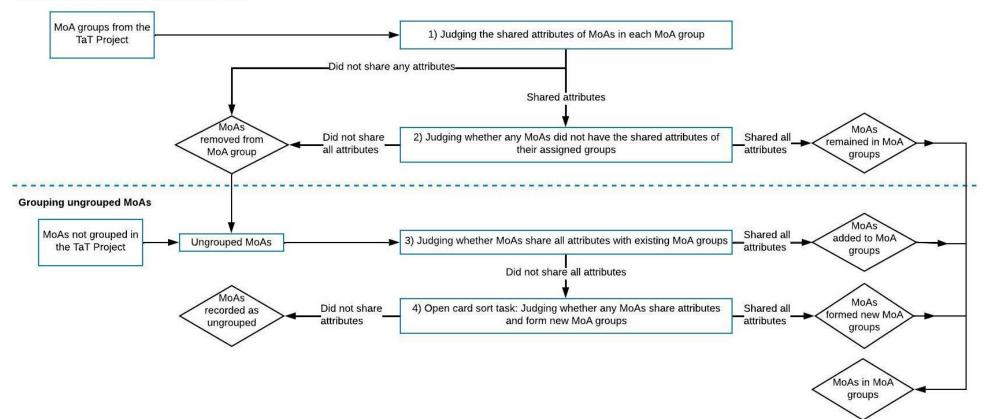
3.3.2   Step 2: Identifying compound MoAs

Drawing on examples of broad MoAs that could not be grouped (e.g., 'value system of the individual or society' or 'enabling factors'), the researchers and experts discussed a definition for 'compound MoA.' This definition was specified as 'a composite of MoAs that might work in different ways to bring about behaviour change.' After completing the MoA identification sessions, the researchers reviewed constructs that could potentially qualify as compound MoAs. These constructs included those recorded as (1) 'MoA/Compound MoA' or 'Compound MoA' by the researchers or (2) 'MoA' but flagged by PS as potentially qualifying as compound MoA following the expert reviews. The two researchers independently judged whether these constructs qualified as compound MoAs. The researchers then compared, discussed and reconciled their judgements, or consulted the experts for the final judgements on constructs with uncertainty.

At the end of Step 2, the TaT Project's 97 MoA groups were updated to reflect the results of the MoA and compound MoA identification exercise. The constructs judged to be compound MoAs or not MoAs were removed from their assigned MoA groups.

3.3.3   Step 3: Grouping MoAs

The researchers and experts judged the grouping of all MoAs from the 83 theories by reviewing the MoA groups from the TaT Project and attempting to group the ungrouped MoAs. This process to refine the grouping of MoAs is broadly outlined in Figure 3-3.

Reviewing 78 MoA groups from the TaT Project

MoA groups from the TaT Project → 1) Judging the shared attributes of MoAs in each MoA group

Did not share any attributes

Shared attributes

MoAs removed from MoA group ← Did not share all attributes ← 2) Judging whether any MoAs did not have the shared attributes of their assigned groups → Shared all attributes → MoAs remained in MoA groups

Grouping ungrouped MoAs

MoAs not grouped in the TaT Project → Ungrouped MoAs → 3) Judging whether MoAs share all attributes with existing MoA groups → Shared all attributes → MoAs added to MoA groups

Did not share all attributes

MoAs recorded as ungrouped ← Did not share attributes ← 4) Open card sort task: Judging whether any MoAs share attributes and form new MoA groups → Shared all attributes → MoAs formed new MoA groups

MoAs in MoA groups

Figure 3-3. Overview of procedure to group MoAs from the 83 behavioural theories

3.3.3.1 Reviewing the 78 MoA groups from the TaT Project

3.3.3.1.1 Judgements on attributes of MoA groups and their constituent MoAs

To review the MoA groups from the TaT Project and reduce the burden on researchers, they scrutinised these groups over 16 sessions. For each session, the MoA groups were randomly selected to give around 39-41 MoAs per session. As one MoA group had 48 constituent MoAs, its session also included 48 MoAs.

For each MoA group, the researchers judged (1) which attributes were shared by its constituent MoAs and (2) whether any MoA did not share all the attributes of its assigned group. To review an MoA group, two researchers (PS, & CM or EH) first read the labels and definitions of each MoA in the group. Then, they independently judged which attributes the group's MoAs shared, recording these in an open response task. If a researcher felt that the MoAs in a group did not all share attributes, they were asked to identify the attributes shared most frequently by the largest proportion of MoAs in the group.

To verify each MoA's grouping, the researchers were prompted to respond to the question 'Considering the attributes shared by the MoAs in this group, do any MoAs not share all of the attributes?' Researchers were instructed to mark MoAs judged not to share their group's attributes with a 'X' and mark MoAs that they were unsure about with a 'U'. For the MoAs marked with a 'X' or 'U', the researchers were also asked to record the attributes that they thought the MoAs did not share with their assigned group (see example in Figure 3-4).

	MoA label	MoA definition	Record the shared attributes of the MoAs in this group in first row of the group.	Considering the attributes shared by MoAs in this group, do any of the MoAs not share all attributes? Mark an "X" next to any MoA you think does not share all attributes in the column "MoA grouping" Mark a "U" next to any MoA that you're uncertain if it shares all attributes in the column "MoA grouping" If you have selected "X" or "U" for any MoA, please specify the attributes that they do not share with their group in the "MoA attributes" column.	
MoA group	Social interaction process	Process that involves reciprocal stimulation or response between two or more individuals.	Social encounters/interactions which influence behaviour		
	Association with non-delinquent peers	The act of associating with peer groups who do not violate social rules or conventions.		U	Is this an interaction/encounter or active choice of peers?
	Differential association	The balance of one's association with, or isolation from, criminal or non-criminal groups.			
	Social interaction	Social encounters with important others that may facilitate or hinder the behaviour.			
	Interpersonal situation	Social interaction that will either facilitate or make behaviour change difficult (e.g. peer interaction, communication with parents or teachers and drug-avoiding socialising).			
	Social Bonding	Process through which one establishes an affective relation between individuals.		X	Establishing relationships would be different from interactions with others

Figure 3-4. Example layout of the task to refine MoA groups

129

3.3.3.1.2 Reconciling judgements on MoA groups and their constituent MoAs

After each session to review MoA groups, the researchers compared and discussed their responses on the attributes shared by each group's constituent MoAs. When the researchers agreed, they recorded the MoA groups' attributes. Otherwise, the experts judged whether MoAs in a group shared attributes and, if so, which attributes were shared.

To determine which MoAs should remain in their assigned MoA groups, the researchers compared their judgments on whether each MoA shared all its group's attributes. The researchers discussed the labels, definitions and attributes of MoAs that they disagreed or remained uncertain about. Where researchers could not reach an agreement, they consulted the experts. When the researchers or experts agreed that an MoA did not to share all the attributes of its group, this MoA removed from the relevant group.

3.3.3.2 Grouping ungrouped MoAs

3.3.3.2.1 Assigning MoAs to MoA groups

The ungrouped MoAs included constructs identified as MoAs in Step 1 but not grouped, and MoAs removed from their previous MoA groups in Step 2. To check whether any ungrouped MoAs shared attributes with existing MoA groups, the researchers considered labels and definitions of approximately 41 randomly selected MoAs per session. After independently reading the MoAs' labels and definitions and the attributes of all MoA groups, the researchers (PS, & CM or EH) doubled coded whether any MoAs shared all the attributes of any group. The researchers compared and discussed their grouping judgements for each MoA and raised the MoAs that they were unsure

about with the experts. When the researchers or experts agreed that an MoA shared all the attributes of a group, the MoA was assigned to that group.

3.3.3.2.2 Open card sort task

For the remaining ungrouped MoAs, three researchers conducted an open card sort task. In this task, the researchers read the ungrouped MoAs' labels and definitions on printed cards. They discussed whether any MoAs shared attributes and, if so, grouped these MoAs together and recorded their perceived shared attributes. After this initial grouping, the researchers re-read each grouped MoAs' labels and definitions and re-visited their judgements on whether the MoAs in these groups shared attributes.

When researchers agreed an MoA could not be grouped, it was recorded as ungrouped for the remainder of the study. For the MoAs judged to share attributes, these attributes were recorded. In addition, group labels and definitions were developed, using the labels and definitions of their constituent MoAs and/or definitions from the American Psychological Association (APA) Dictionary (VandenBos, 2007) and Oxford Dictionary.

The experts judged all potential new MoA groups by considering their constituent MoAs and recorded attributes. Any new MoA group that experts disagreed with was removed and their constituent MoAs were recorded as ungrouped. When experts agreed with a new MoA group but disagreed with any of its constituent MoAs, these MoAs were removed from the group and recorded as ungrouped. At the end of this step, one researcher (PS) and expert (AW) reviewed and updated the labels and definitions of all MoA groups to ensure that they still reflect their constituent MoAs.

3.4 Results

3.4.1 Identified MoAs

3.4.1.1 Researchers judging theoretical constructs

The two researchers initially agreed on 1300 constructs, with 846 qualifying as MoAs

and 454 not. The Krippendorff's alpha values for the researchers' judgements is

presented in full in Appendix 3-3, while the values across MoA Identification Sessions

6 to 71 (with 25 constructs each) are shown in Figure 3-5. Across these sessions, the

lowest Krippendorff's alpha was 0.089 (95%CI, -0.236 to 0.414) in Session 7. The

highest Krippendorff's alpha was 0.927 (95%CI, 0.782 to 1.00) in Session 45. The

median values for Krippendorff's alpha were 0.596 (95%CI, 0.327 to 0.865) in Session

14 and 0.622 (95%CI, 0.319 to 0.924) in Session 58.
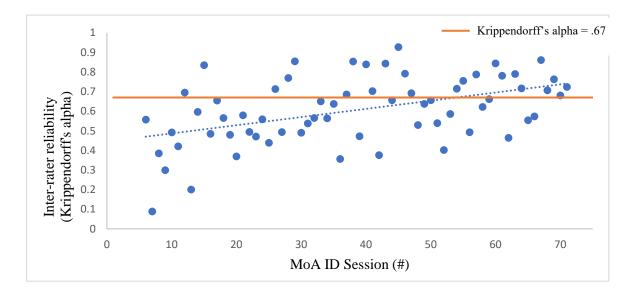
Figure 3-5. The inter-rater reliability of judgements on constructs across MoA
identification sessions

Krippendorff's alpha of 0.67 was selected as a benchmark for 'acceptable' inter-rater

reliability (Krippendorff, 2004). Of the 72 MoA Identification Sessions, 25 sessions had

a Krippendorff's alpha above 0.67 and eight sessions had a Krippendorff's alpha above

0.80. As Figure 3-5 demonstrates, the researchers' inter-rater reliability showed an

increasing trend over the sessions. In the final 36 MoA identification sessions, which used the final version of the MoA Identification Guidance, Krippendorff's alpha was above 0.67 for 20 sessions and above 0.80 for six of these.

In the early sessions, the most common types of disagreement were when one researcher thought a construct was an MoA but the other interpreted it as one of the following: a non-modifiable trait, a measure of the MoA, a stable aspect of the environment or part of the intervention (e.g., BCT). When using the identification guidance's final version, the most common types of disagreement reflected differing interpretations about the construct being a stable or modifiable aspect of the environment or part of the intervention.

3.4.1.2 *Resolving disagreements in researchers' judgments*

The results from the process to reconcile the judgements on identifying MoAs is summarised in Figure 3-6. Of the 1300 constructs the researchers agreed on, their judgements for 1126 constructs were recorded (781 as MoAs and 345 not qualifying as MoAs). The remaining 174 constructs were discussed with the experts, as researcher judgements were different from those in the TaT Project or the guidance on identifying MoAs was changed.

Of the 433 constructs researchers initially disagreed on, they reconciled their judgements on 136 constructs (84 MoAs and 52 not qualifying as MoAs) consistently with the TaT Project. The remaining 297 constructs were raised with the experts, because the researchers disagreed or remained uncertain about their judgements, or their

reconciled judgements differed from the TaT Project. In total, the experts judged 471

constructs, with 202 qualifying as MoAs and 269 not qualifying as MoAs.

After the expert judgments, of the 1733 constructs, 1067 had been judged to qualify as

MoAs, while 666 were judged not to qualify as MoAs. For instance, the construct

'social norm' (defined as 'Perception of others' beliefs about threat prevention') was

judged to be changeable psychological state that could influence behaviour and

therefore qualify as an MoA. However, the construct labelled as 'response' (defined as

'Starting, stopping or modifying actions') was judged to be a target behavioural and so

not to qualify as an MoA. In the later step to group MoAs (see Section 3.4.3), the

experts updated their judgements for five constructs, as these had been identified as

MoAs with an earlier version of the MoA Identification Guidance and no longer

qualified as MoAs. This change resulted in 1062 constructs qualifying as MoAs.
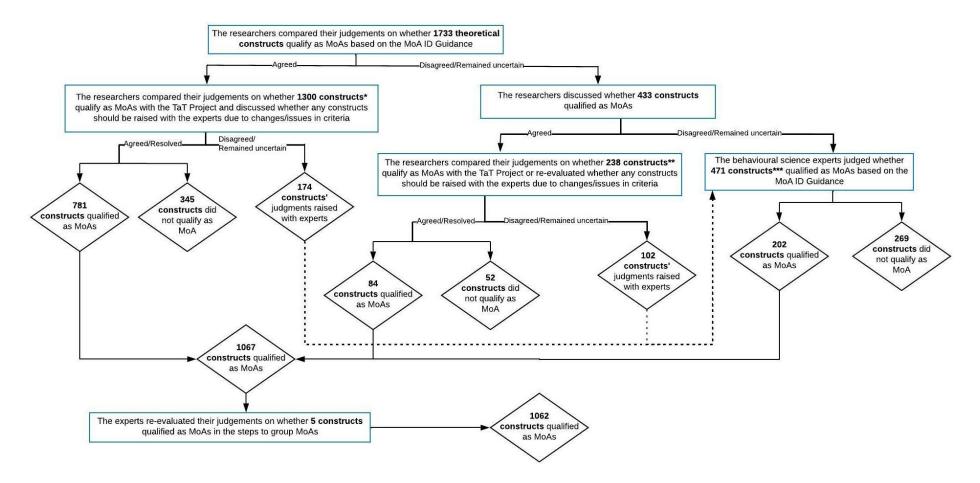
Figure 3-6. Overview of judgements to identify MoAs

Notes. *The researchers initially agreed that 846 theoretical constructs qualified as MoAs and 454 constructs did not qualify as MoAs.
**The researchers initially reconciled 238 constructs and disagreed or remained uncertain about 195 constructs.
***Of the 471 constructs raised with experts, 102 were reviewed in their original theory descriptions.

3.4.1.3 *Comparison with the TaT Project*

When the final judgements on theoretical constructs were compared to the 1723 constructs previously judged in the TaT Project, 337 constructs were judged differently (see cross-tabulation of judgements in Appendix 3-4). For 10 constructs this comparison could not be made, as their judgements were not found in the TaT Project's records. The reasons for these differences were mainly the stricter criteria developed for constructs to qualify as MoAs, such as those relating to the environment. For instance, the construct 'cultural environment' (defined as: 'The broad sociocultural or macro-environment') from the Theory of Triadic Influence (Flay & Petraitis, 1994) qualified as an MoA in the TaT Project. However, this construct did not qualify as an MoA in the current study, because its influence on behaviour was considered to be underspecified.

The TaT Project also generally included constructs labelled or defined as stages or values of stages as MoAs. 'Stages' can refer to MoAs that occur at certain timepoints in the behaviour change process, but also constructs that were judged not to qualify as MoAs in the current study. For instance, constructs part of 'stages of change' in the Transtheoretical Model of Behaviour Change (Prochaska & DiClemente, 1982), such as 'contemplation', were considered to be values of motivation to perform behaviour and, therefore not MoAs by themselves. Other stage constructs, such as 'action', were also not considered to qualify as MoAs, as they involve the target behaviour itself.

3.4.2 Identified compound MoAs

An overview of the judgements to identify compound MoAs is presented in Figure 3-7. The researchers initially recorded 137 constructs as potential compound MoAs, of which they judged 30 to qualify as MoAs and 97 as compound MoAs. They raised the

remaining 10 constructs with the experts, who judged three to qualify as MoAs and seven to qualify as compound MoAs. In addition, during expert reviews to judge whether constructs qualify as MoAs, the experts judged 30 constructs to qualify as compound MoAs. At the end of this step, 134 constructs were recorded as compound MoAs. However, as not all MoAs were re-evaluated on whether they qualified as compound MoAs, the experts judged additional 12 constructs to qualify as compound MoAs, during the steps to group MoAs (see Section 3.4.3).

Altogether, 146 compound MoAs were identified, and their labels and definitions are presented in Appendix 3-5. For instance, the MoA labelled 'inner containment' was judged to qualify as a compound MoA based on its definition: 'Factors involved in the regulation of the self, such as self-control, self-concept, the ability to tolerate frustration and resist diversions, etc.' This definition suggested that 'inner containment' included various factors related to regulation which could work differently to influence behaviour.

When identifying compound MoAs, the most common disagreement between researchers was based on constructs that had a label referring to a specific MoA but had a definition that included various processes. For instance, one construct was labelled 'script', which could suggest an MoA relating to an action script. However, this construct's definition was 'The complex set of strategies, commitments and evaluations that sum to progress action towards a goal; includes decisions to abandon or suspend action.' Based on the definition, the construct was interpreted to potentially include evaluations, decisions and planning for a behaviour, and thus was judged to qualify as a compound MoA.
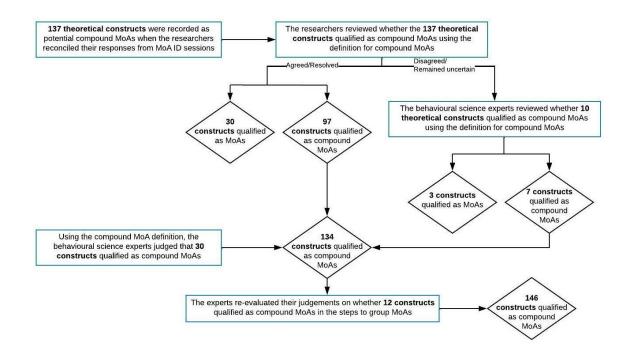
Figure 3-7. Overview of judgements to identify compound MoAs

After removing constructs that did not qualify as MoAs or qualified as compound MoAs in Steps 1 and 2, 644 MoAs remained in 78 MoA groups and 289 were recorded as ungrouped.

3.4.3 Grouping of MoAs

3.4.3.1 *Attributes shared by MoAs in each MoA group from the TaT Project*

The results from the process to specify the MoA group attributes are summarised in Figure 3-8. The researchers, with the help of the experts, specified the attributes of 72 MoA groups from the TaT Project. For instance, for an MoA group that had been labelled 'Act-related affect', the shared attributes were specified as 'emotional response related to any aspects of a behaviour'. For two other MoA groups, the experts judged that they had MoAs with two different types of attributes. As the MoAs with different

attributes also had similar frequencies, these groups were split into two, altogether forming four groups.

In total, the attributes for 76 MoA groups were specified. These attributes are presented in Table 3-4. When judging MoA groups' shared attributes, the most common disagreement was the specificity of these attributes, e.g., one researcher specifying a group's shared attributes as 'opportunity presented by service availability' and the other specifying them more broadly as 'environmental opportunity.

Four MoA groups were judged not to share sufficient attributes, and therefore, these groups were dissolved, and their 11 constituent MoAs were ungrouped. For instance, one MoA group labelled 'Cue' had two MoAs that were judged not to share attributes, as one MoA referred to an external stimulus and the other MoA referred to a stimulus 'arising from the person's cognitions and/or goals.'
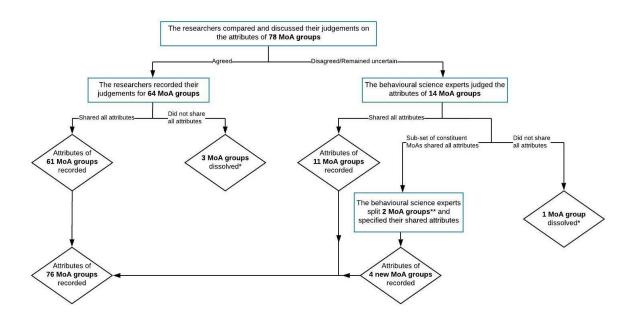
Figure 3-8. Overview of judgements on attributes of the MoA groups from the TaT Project

Notes. *Four MoA groups were judged not to share sufficient attributes and dissolved
**The two MoA groups had MoAs with two different attributes at similar frequencies and so were split

3.4.3.2 MoAs judged not share all the attributes of their assigned groups

An overview of the judgements on whether any of the 644 MoAs did not share all the attributes of their previously assigned 78 groups is presented in Figure 3-9. The researchers initially agreed on their judgements for 452 MoAs regarding whether these shared all the attributes of their MoA groups, with 441 sharing all the attributes and 11 not. Researchers' agreement on whether a constituent MoA shared its group's attributes was often contingent on them also agreeing on this group's shared attributes. When one researcher specified more granular attributes for an MoA group, they also judged that fewer constituent MoAs shared that group's attributes compared to the other researcher.

3.4.3.2.1 Resolving uncertainty or disagreements on whether MoAs shared all the attributes of their assigned groups

While researchers initially agreed on 452 MoAs' grouping, 55 of these MoAs needed to be re-evaluated, as the researchers had specified different attributes for their respective MoA groups. The researchers discussed these 55 MoAs, along with the 192 MoAs they had disagreed on or remained uncertain about. Following these discussions, the researchers agreed that 447 MoAs shared their groups' attributes, and 50 MoAs did not. The remaining 147 MoAs were raised with experts, who judged that 73 MoAs shared all attributes of their groups and 70 did not (including the 11 MoAs from the MoA groups that were dissolved). In addition, the experts judged three constructs to qualify as compound MoAs and one construct not to be an MoA. These four constructs were removed from the pool of MoAs to be grouped.

Altogether, 520 MoAs were judged to share the attributes of their previously assigned 76 MoA groups from the TaT Project. An example of a refined MoA group was labelled

'Commitment'. This group's attributes were specified as 'the cognitive state of feeling bound to achieve a goal'. While most of the group's constituent MoAs were judged to share all its attributes, one MoA was judged not to and therefore ungrouped. This ungrouped MoA was also labelled 'Commitment' but defined as 'an agreement or pledge to achieve a goal in the future, or the state or instance of being obligated or emotionally impelled to achieve a goal'. This definition was considered not to be limited to a 'cognitive state feeling bound to achieve a goal' but also include social agreements to act. Therefore, this MoA was added to the pool of ungrouped MoAs. In total, 120 MoAs were judged not to share their groups' attributes. The 120 MoAs, along with the 289 previously ungrouped MoA from Section 3.4.1 and the TaT Project, comprised 409 ungrouped MoAs.
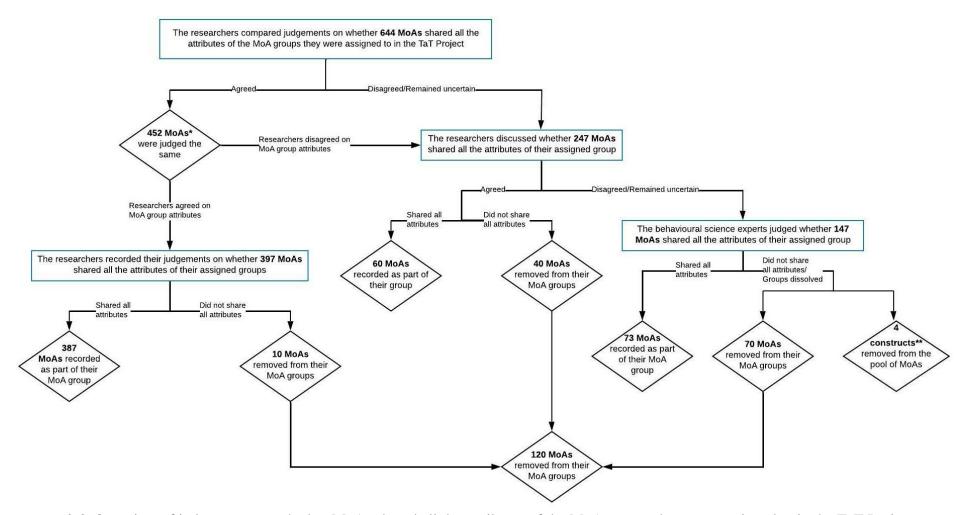
Figure 3-9. Overview of judgements on whether MoAs shared all the attributes of the MoA groups they were assigned to in the TaT Project

Notes. *Of the 452 MoAs initially agreed on, 55 MoAs needed to be re-evaluated, as researchers had recorded different attributes for their respective MoA groups

** As experts judged three MoAs to be compound MoAs and one construct not to be an MoA, these constructs were removed from the pool of MoAs for the grouping task

3.4.3.3 Grouping ungrouped MoAs

3.4.3.3.1 Assigning ungrouped MoAs to MoA groups from the TaT Project

The researchers and experts judged that 129 ungrouped MoAs shared all the attributes of 47 specific MoA groups from the TaT Project (for overview of judgements, see Appendix 3-6). In addition, the experts re-evaluated eight ungrouped MoAs to qualify as compound MoAs and one not to qualify as MoA. The remaining 271 ungrouped MoAs were included in a card sort task.

3.4.3.3.2 Open card sort task: Identifying ungrouped MoAs that share attributes to form new MoA groups

The three researchers grouped together 141 MoAs into 29 new potential MoA groups and documented their shared attributes. The experts agreed with the grouping of 102 MoAs in 28 MoA groups. Table 3-3 presents an example of a new group labelled 'Interpersonal dynamic' with its perceived attributes and constituent MoAs. All new MoA groups' labels and definitions are outlined in Table 3-4. During the card sort, the researchers and experts also judged that 12 MoAs shared all attributes of specific eight MoA groups from the TaT Project. Additionally, the experts amended their judgements for one construct as qualifying as a compound MoA and three as not qualifying as MoAs, leaving 153 MoAs ungrouped.

Table 3-3. Example of ungrouped MoAs sorted into new MoA groups

Group label	Attributes	MoA label	MoA definition
Interpersonal dynamic	Interactions in social relationships based on dispositions/inclinations	Interpersonal conflict	On-going or recent conflict in an interpersonal relationship such as a marriage or friendship
		Mutual accommodation	Inclination to mutually accommodate participants' schedules, preferences and commitments with others' in order to be able to engage in group action.
		Helping relationship	Relationship characterised by openness, trust and empathy, which is supportive with regard to the problem behaviour and health behaviour change

3.4.3.4 Finalised MoA groups

There were 763 MoAs in the final 104 MoA groups. The MoA groups with the most

constituent MoAs were: 'Self-efficacy', 'Need', 'Intention' and 'Knowledge'. The final

MoA groups' labels, definitions, shared attributes and number of constituent MoAs are

presented in Table 3-4. For 20 groups from the TaT Project, the labels and definitions

were revised. All the MoAs in the 104 groups are presented in Appendix 3-7 and

ungrouped MoAs are shown in Appendix 3-8.

Table 3-4. Final MoA groups' labels, definitions, shared attributes and number of constituent MoAs

No.	MoA group label	MoA group definition	MoA group attributes	No. MoAs in group	No. theories the group's MoAs were identified from	New group?
1	Self-efficacy	Belief about personal capabilities to perform task or engage in a behaviour.	Cognitive assessment of self, controllability of outcomes relating to behaviour	49	37	
2	Need	Objective that people strive to achieve in order to improve or maintain their wellbeing or quality of life.	The state of requiring particular conditions for oneself	34	8	
3	Intention	A conscious decision to perform a behaviour.	Conscious cognitive process related to performing behaviour, involving commitment to act	24	20	
4	Knowledge	Information and understanding of a specific topic or the world in general, usual acquired through experience and/or learning.	Process/state of being aware of facts/information about something, based on learning/experience, stored/retrievable information	23	17	
5	Attitude towards behaviour	A favourable or unfavourable evaluation or appraisal of a behaviour.	Personal evaluative attitude towards behaviour	21	18	
6	Goal	The end state towards which one is striving.	Aim/intended end state of outcomes relating to behaviour, cognitive process	20	10	

No.	MoA group label	MoA group definition	MoA group attributes	No. MoAs in group	No. theories the group's MoAs were identified from	New group?
7	Skill	Ability or proficiency acquired through training and practice required to engage in a behaviour.	Possession and level of an ability to achieve an end state	18	16	
8	Outcome expectancy (no explicit evaluation)	Belief about the consequences of behaviour which are not explicitly appraised.	Perceived outcomes of behaviour without explicit evaluation	17	13	
9	Outcome expectancy (likelihood)	Belief about whether a certain behaviour will lead to desired outcomes (also response efficacy).	Perception regarding likelihood behaviour will lead to an outcome	16	16	
10	Psychological capability	A psychological ability, talent, or facility that a person can put to constructive use.	Psychological capability	16	11	
11	Belief	An association of some characteristic or attribute, usually evaluative in nature, with an attitude object.	Cognitive propositional representation	15	13	
12	Normative belief	An individual's perceived belief of others regarding performing a behaviour.	Perception relating to what others do or think should be done	15	14	
13	Reflective thinking	A type of thinking in which decisions are made (e.g., about complex problems) slowly and deliberately (i.e., not impulsively).	Cognitive process, deliberate decision-making processes, involves reflection, consideration and consolidation	14	8	

No.	MoA group label	MoA group definition	MoA group attributes	No. MoAs in group	No. theories the group's MoAs were identified from	New group?
14	Self-image	One's own view or concept of oneself.	Evaluation of self, psychological process	14	9	
15	Motivation	The impetus that gives purpose or direction to behaviour.	Psychological state that gives drive to a behaviour	12	9	
16	Social influence	The impact or influence others have on thoughts, feelings or behaviours.	Social influence of others on the behaviour	12	6	
17	Evaluated outcome expectancy	The outcome (e.g., cognitive or emotional) associated with specific end states.	Perception of evaluated outcome	12	10	✓
18	Perceived importance	The significance one ascribes to the achieving an end state.	Importance one attributes to an end state	11	9	
19	Perceived influence	The perceived influence of others on one's behaviour.	Perception of social influences	11	11	
20	Goal pursuit	The action of striving towards goal achievement or engagement in goal directed behaviours.	Processes involved in pursuing a goal	10	5	
21	Perceived severity	Perception of how serious or severe a threat or health risk is.	Perception about the severity/importance of a threat	10	9	

No.	MoA group label	MoA group definition	MoA group attributes	No. MoAs in group	No. theories the group's MoAs were identified from	New group?
22	Perceived susceptibility	Perception of vulnerability to the threat.	Belief about the degree of one's vulnerability to a threat/outcome	10	9	
23	Value	A moral, social or aesthetic principle accepted by an individual or society as a guide to what is good, desirable or important.	The levels of valence or importance placed on a principle	10	7	
24	Choice and decision making	The cognitive process of choosing between two or more alternatives.	Cognitive process, appraisal and selection involving two or more alternatives	9	6	
25	Drive	A generalised state of readiness precipitating or motivating an activity or course of action.	Motivational state of readiness to perform a behaviour	9	5	
26	Injunctive norm	A standard that describes how people should behave in a given situation, irrespective of how people typically behave in the setting.	Injunctive norms: what others' think should be done	9	7	
27	Act-related affect	A feeling about or arising from a behaviour.	Emotional response related to any aspects of a behaviour	8	5	
28	Descriptive norm	A standard that describes how people typically behave in a given situation.	Descriptive norms: what other's actually do	8	6	

No.	MoA group label	MoA group definition	MoA group attributes	No. MoAs in group	No. theories the group's MoAs were identified from	New group?
29	Social learning	A process by which thoughts, feelings, and motivational states observed in others are internalised and replicated without the need for conscious awareness.	Social learning process involving imitation/copying of behaviours, thoughts or information	8	6	
30	Motivation to comply	The extent to which one is willing to exert physical or mental effort to act in accordance with others.	Motivational response in a social context	8	7	
31	Planning	The process by which detailed specifications of how to perform an intended behaviour are formed.	Creation of a formal representation/specification of an intended behaviour	8	6	
32	Arousal	A state of alertness and readiness for action.	Preparatory psychological state, readiness for action	7	7	
33	Feeling	An affective state that includes emotions and desires.	Affective state experienced in response to some stimuli	7	7	
34	Future-oriented negative feeling	Negative affective state associated with anticipated events.	Future-oriented negative states	7	6	
35	Group identity	Processing of information about self based on social identify (e.g., group membership).	Processing of identity-related information based on social group	7	3	
36	Perceived context	Perception of the environment/context.	Perception related to the environment one is in	7	7	

No.	MoA group label	MoA group definition	MoA group attributes	No. MoAs in group	No. theories the group's MoAs were identified from	New group?
37	Self-regulation and control	The process by which people regulate their behaviour; a process whereby intentions are enacted in the face of desires or impulses arising from other sources.	Cognitive process, involving self-regulation of behaviour	7	4	
38	Social interaction	A set of social encounters with important others that may facilitate or hinder the behaviour.	Social encounters/interactions which influence behaviour	7	7	
39	Associative learning	A process whereby patterns of brain activity representing perceptions, emotions or response organization become linked so that when a particular pattern occurs, another is made more likely to occur.	A learned process through which a stimulus affects the likelihood of a particular response	6	4	
40	Attention	The extent to which one attends to information.	Process involved in directing one's focus on a stimulus	6	5	
41	Attributional process	A process relating to assigning causality for events which may include internal/external attribution.	Cognitive perception, relating to the causes of events/circumstances	6	4	
42	Memory	The process of retaining content such that it can be recalled.	Process of retaining information, can be recalled	6	3	
43	Perceived barriers	Belief about the negative aspects of taking health protective action.	Beliefs about barriers and costs to performing a behaviour	6	6	

No.	MoA group label	MoA group definition	MoA group attributes	No. MoAs in group	No. theories the group's MoAs were identified from	New group?
44	Perceived threat	Perception of the threat posed by a disease or a health problem, based on one's perceived susceptibility to, and the perceived severity of a disease or health problem.	Cognitive perception, represents the perceived severity and susceptibility of a risk/threat (future negative event)	6	5	
45	Perception	The process or result of becoming consciously aware of something by means of the senses.	Cognitive process, related to the sensation and interpretation of stimuli	6	6	
46	Reinforcement	A process in which the frequency or probability of a response is increased by a dependent relationship or contingency with a stimulus or circumstance.	Process in which the likelihood of a behaviour is changed as a result of stimuli which follow it	6	6	
47	Self-esteem	The degree to which the qualities and characteristics contained in one's self-concept are perceived to be positive.	Evaluative perception about positive aspects of oneself	6	6	
48	Social opportunity	The affordance of the social environment in which people live.	The influence of the social environment on an individual, relating to opportunity in the social environment	6	5	
49	Support from social network	The response of acceptance, encouragement or approval from others for an individual's behaviour.	Support from social network for behaviour	6	3	

No.	MoA group label	MoA group definition	MoA group attributes	No. MoAs in group	No. theories the group's MoAs were identified from	New group?
50	Subjective decisional balance	The value the individual associates with engaging in a behaviour.	Perception as to whether the outcome/consequences of a behaviour are valuable	6	5	
51	Appraisal of alternatives	The cognitive evaluation of the nature and significance of two or more options.	Appraisal of two or more options	6	5	✓
52	Commitment	A cognitive agreement or pledge to attain a goal in the future.	The cognitive state of feeling bound to achieve a goal	5	5	
53	Introjected regulation	The drive to perform a behaviour out of a sense of guilt or obligation or a need to prove something.	Perception that one is obligated to perform an action, feeling of responsibility to act, assigning responsibility to self	5	2	
54	Locus of causality	Mental representation of the degree to which one's behaviour is regulated by one's true self.	Cognitive assessment of behavioural control, attribution of control to self	5	5	
55	Sensation	A feeling arising from senses or imagined experiences, without interpretation of meaning.	Experience in response to sensory stimuli	5	3	
56	Reference value	A specified level of an end state that is compared to the level of the current state.	Standard for comparison	5	2	✓

No.	MoA group label	MoA group definition	MoA group attributes	No. MoAs in group	No. theories the group's MoAs were identified from	New group?
57	Self-administered strategy	A program of action that the individual imposes on themselves to achieve a goal.	Strategy directed by the individual to change behaviour	5	5	✓
58	Socially shared norm	A standard or a set of standards that is consensual and is held by a social group.	Socially shared norms	5	4	✓
59	Addiction	A chronic condition involving a repeated powerful motivation to engage in a rewarding behaviour, acquired as a result of engaging in that behaviour that has significant potential for unintended harm.	Complex cognitive/emotional process, based on repeated process, relating to a continuous state with motivational basis	4	3	
60	Awareness	A consciousness of something.	Perception/awareness of internal/external events, no explicit evaluation, cognitive process	4	4	
61	Desire	A feeling of want or need (e.g., to engage in the behaviour).	Affective state relating to want	4	3	
62	Positive feeling	A positive affective state.	Positive affective state, sensations experienced, conscious process	4	3	
63	Financial availability	The extend that one has the financial means to make the behaviour possible or facilitate it.	Opportunity presented by financial availability, influence one's ability to engage in a behaviour	4	3	

No.	MoA group label	MoA group definition	MoA group attributes	No. MoAs in group	No. theories the group's MoAs were identified from	New group?
64	Intention formation	The process by which a conscious decision is made to perform a behaviour.	Cognitive process resulting in an intention	4	4	
65	Monitoring	The evaluation of chosen methods for goal achievement, and consideration of whether additional methods should be used.	Cognitive reflective process, includes evaluating one's own behaviours or plan, with respect to goal attainment	4	4	
66	Rule	Specific guideline or standard that determine how a person behaves in a specific situation.	Rule about own behaviour	4	4	
67	Urge	Impulse to engage in an action.	Relatively automatic psychological process, push towards response	4	2	
68	Capability	The possession of able qualities to carry out a behaviour.	Ability to change behaviour	4	4	✓
69	Discrepancy resolution	A psychological process of settling a perceived incompatibility between two cognitive states.	Psychological strategy to resolve cognitive discrepancies	4	3	✓
70	Heuristic	An experience-based strategy for solving a problem or making a decision that often provides an efficient means of finding an answer.	Heuristic, cognitive process	4	3	✓
71	Learning	The acquisition of novel information, behaviours or abilities based on experience.	Learning	4	4	✓

No.	MoA group label	MoA group definition	MoA group attributes	No. MoAs in group	No. theories the group's MoAs were identified from	New group?
72	Physical opportunity	The affordance of a physical environment that allows people to carry out a particular behaviour.	Physical affordance	4	3	✓
73	Social embeddedness	The extent to which a person is linked to the social environment.	Social integration	4	4	✓
74	Stimulus	Any agent, event, or situation—internal or external—that elicits a behaviour from an individual.	Stimulus that elicits behavioural response	4	4	✓
75	Temporal orientation	The tendency to focus on short- or long-term outcomes.	Temporal orientation	4	1	✓
76	Expectation about social relatedness	A belief about whether the individual will achieve a certain connection with the social environment.	Expectations about attaining social relatedness	3	1	
77	Feedback mechanism	A process whereby current behaviour is compared against an emotional or behavioural standard in order to modify subsequent goal-directed behaviour.	Cognitive process of comparing one's behaviour against a standard or goal state	3	3	
78	Image	A mental representation of objects or events.	Cognitive representation of sensations	3	2	
79	Learning associated with presented pattern	The acquisition of novel information, emotions, behaviours, or abilities based on the exposure to stimuli that is presented in a particular pattern.	Learning based on pattern-presentation	3	3	

No.	MoA group label	MoA group definition	MoA group attributes	No. MoAs in group	No. theories the group's MoAs were identified from	New group?
80	Perceived health	Perception/belief regarding the current state of one's health.	Belief about one's health	3	2	
81	Satisfaction	Sensation of contentment or fulfilment.	Affective state, contentment	3	3	
82	Selection of peers	The selection of people within one's social network.	Association with individuals based on perception about oneself	3	2	
83	Action script	The mental road map of an end state which contains basic actions, and their temporal and causal relations.	Cognitive structures directing behaviour	3	2	✓
84	Categorisation	The process by which objects, events, people, or experiences are grouped into classes on the basis of (a) characteristics shared by members of the same class and (b) features distinguishing the members of one class from those of another.	Cognitive categorisation	3	3	✓
85	Energy state	The state of internal resources that give strength and vitality to pursue and achieve an end state.	Energy level available to pursue an end state	3	3	✓
86	False belief about social groups	A mental proposition about beliefs and behaviours in social groups that is asserted but lacks a basis in reality.	False assumptions relating to social groups	3	1	✓

No.	MoA group label	MoA group definition	MoA group attributes	No. MoAs in group	No. theories the group's MoAs were identified from	New group?
87	Feeling towards stimulus	Any experience of affect about a perceived agent, event or situation.	Affective response directed at a stimulus	3	2	✓
88	Interpersonal dynamic	Set of ongoing interactions/exchanges among people that can be supportive or disruptive.	Interactions in social relationships based on dispositions/inclinations	3	3	✓
89	Schema	A collection of basic knowledge about a concept or entity that serves as a guide to perception, interpretation, imagination, or problem solving.	Cognitive framework	3	2	✓
90	Communication	The transmission of information between people.	Transmission of information: one-to-one or one-to-many	2	2	
91	Comprehension	The act of understanding something, especially the meaning of a communication.	Cognitive process through which information is understood	2	2	
92	Feedback	A process whereby behaviour sustains or modifies subsequent behaviour.	Repeated process, experiences that provide information and influence an end state	2	2	
93	Habit	A well learned behaviour or automatic sequence of behaviours that is independent of cognitive influence.	Relatively automatic behaviours performed with minimal cognitive effort	2	2	

No.	MoA group label	MoA group definition	MoA group attributes	No. MoAs in group	No. theories the group's MoAs were identified from	New group?
94	Self-monitoring	A process involving self-observation and self-control with the aim of maintaining situation-appropriate behaviour.	Reflective cognitive process of observing one's own behaviour in respect to some standard	2	2	
95	Service availability	The extend one can access services that make the behaviour possible or facilitate it.	Opportunity presented by service availability, which influence one's ability to engage in a behaviour	2	2	
96	Temporal constraint	The availability of time to engage in a behaviour.	Temporal restrictions, features of the environment restricting or constraining capacity to act	2	2	
97	Behavioural option	Perception of behaviours that are available as another choice instead of the planned or currently engaged behaviour.	Alternative behavioural option, intruding consciousness	2	1	✓
98	Inference	The process to reach a conclusion by evaluating an earlier premise according to specific rules.	Rule-based reasoning process	2	2	✓
99	Interdependent script	A state in which two or more people have interlinked sequences of behaviour that rely on or react with one another such that one cannot change without affecting the other.	Socially shared script	2	1	✓
100	Motivational orientation	A state that directs the perception of specific valence of outcomes (positive or negative).	Motivational orientation for evaluating outcomes	2	1	✓

No.	MoA group label	MoA group definition	MoA group attributes	No. MoAs in group	No. theories the group's MoAs were identified from	New group?
101	Present negative feeling	An emotional state of unhappiness, ranging in intensity from mild to extreme.	Current negative affective state	2	1	✓
102	Observation of others	The process of watching someone else's behaviour.	Observing others' behaviours	2	2	✓
103	Perceived availability of behavioural options	Awareness of alternative behaviours that could be carried out.	Perception of available behaviours	2	1	✓
104	Repression of information	The process of restricting, restraining or subduing aspects of information that is presented.	Process of filtering specific aspects of information	2	2	✓

3.5 Discussion

To build a basis for the MoA Ontology, the current study aimed to develop a preliminary ontological structure that contains MoAs reliably identified from behavioural theories and grouped together based on their share attributes. The researchers and experts identified 1062 MoAs from 1733 theoretical constructs, of which 146 were compound MoAs. The inter-rater reliability of researchers' judgements on whether theoretical constructs qualified as MoAs was low at the beginning of the study but showed an increasing trend with the updates to the MoA Identification Guidance. Using this guidance's final version, the researchers achieved 'acceptable' inter-rater reliability for 55% of the 36 final sessions. These findings suggest that reliably judging whether theoretical constructs qualify as MoAs is a challenge. However, the inter-rater reliability may increase when researchers have more experience judging whether constructs qualify as MoAs and use the final MoA Identification Guidance.

In the current study, the attributes that MoAs shared within 104 MoA groups were specified. Based on these group attributes, 120 MoAs were removed from their previously assigned groups, and 141 MoAs were added to groups. Thereby, this study provided an explicit rationale for the MoA groupings which comprise the preliminary ontological structure for MoAs. By forming 28 new MoA groups, this study also increased the comprehensiveness of MoA groups, compared to the TaT Project (Michie et al., 2018).

3.5.1 MoA identification challenges

Authors of behavioural theories sometimes underspecify their constructs, creating challenges for understanding these constructs (e.g., Hale et al., 2020; West et al., 2019). Consistently, in this study, theoretical constructs' labels and definitions were often unclear, which had an adverse effect on inter-rater reliability. For instance, the Needs-Opportunities-Abilities Model did not label or define the construct 'economic' as a need (MoA), although this construct was categorised under needs within the model (Gatersleben & Vlek, 1998). Some definitions were particularly difficult to interpret and required considering the construct's role within a theory. The influence of theoretical constructs on behaviour often depends on other constructs within that theory (Johnston et al., 2018; Michie & Johnston, 2012). While the researchers referred to a key reference book specifying the theories and, if needed, the original theories, it remained challenging to judge whether constructs should qualify as MoAs when their influence on behaviour is underspecified or very indirect (via other MoAs). Finally, many theory authors did not specify the processes of change for their constructs (e.g., 'change in belief') that would lead to behaviour change. Therefore, changeable constructs (e.g., 'belief') were judged to qualify as MoAs under the assumption that that theory authors referred to 'changes in these constructs'.

3.5.2 MoA grouping: Progress in building a 'gold standard' MoA Ontology and limitations

By drawing on 83 behavioural theories and extending the findings of the TaT Project (Michie et al., 2018), the developed ontological structure extensively captured MoAs in the behaviour change field. In line with the principles for developing 'gold standard' ontologies (Smith et al., 2007; OBO Foundry, 2019f), the MoA Ontology's scope was

specified by defining MoAs. For this ontology, preliminary content that aligns with its scope was identified and organised into a two-level hierarchical structure, i.e., MoA groups and their constituent MoAs. However, the current study did not evaluate whether the identified content (MoA groups and constituent MoAs) overlapped with the classes in other ontologies. Such classes need to be reused in the MoA Ontology to ensure that this ontology does not replicate work and is interoperable with other ontologies (OBO Foundry, 2019b)

By specifying the MoA groups' attributes, the current study ensured that the decisions about grouping MoAs were explicit. However, a key challenge was deciding on the appropriate level of granularity for MoA groups. There were some overlaps between the MoAs groups from the TaT Project and the new MoA groups. For instance, the MoA group labelled 'Learning associated with presented pattern' could be part of the new MoA group labelled 'Learning'. In addition, some constituent MoAs had more specific attributes than their groups, and so might need to be captured as unique classes in the MoA Ontology. The ungrouped MoAs, which have unique attributes that differentiate them from MoA groups, are also currently not included in the initial hierarchical structure. While the current methodology did not allow MoAs to be organised hierarchically beyond two-levels, the MoA Ontology needs to include unique classes that are structured more logically (OBO Foundry, 2019e; Wright et al., 2020).

3.5.3 Implications

As noted above, some theoretical constructs' labels and definitions are incomplete. An implication is that theory authors need to define proposed constructs more clearly. By synthesising construct labels and definitions from different theories, the MoA Ontology

could become a resource for theory authors to define their constructs clearly and consistently with other theories, enabling comparisons across these theories. To develop such an ontology, the current groupings of MoAs will be used as a preliminary ontological structure.

3.5.4   Future research

As the ontological structure developed by grouping MoAs includes some overlapping content (i.e., MoA groups that overlap with one another), the next step to develop the MoA Ontology will need to identify unique classes for the ontology. To organise the ontology's content more logically, these classes will also need to be hierarchically structured by building on the initial two-level hierarchy. Finally, to avoid replicating the work of other ontologies and be compatible with these ontologies, the MoA Ontology will need to reuse their content where relevant (OBO Foundry, 2019b). For instance, the next step to develop an ontology of MoAs will need to consider whether any classes in other ontologies could be reused to capture any MoA groups.

3.5.5   Conclusion

To advance our understanding about why interventions work in various contexts, researchers need better means to communicate and synthesise the evidence about MoAs. The current study aimed to develop a preliminary ontology structure for MoAs by identifying and grouping MoAs from different behavioural theories. This structure will be used to build the first draft of the MoA Ontology. Through further refinements, the MoA Ontology will provide a useful tool to learn about MoAs from behaviour change interventions reports.

4 Chapter 4: Development of a Mechanism of Action Ontology as part of the Behaviour Change Intervention Ontology (Study 3)

4.1 Abstract

Rationale: Ontologies should include classes (entities represented in the ontology) with clear labels and definitions, reuse classes from other ontologies where relevant, and specify relationships between classes. To begin developing an ontological structure of mechanisms of action (MoAs) of behaviour change interventions, Study 2 identified and grouped putative MoAs from behavioural theories.

Aim: To develop the first version of the MoA Ontology with clearly labelled and defined, hierarchically organised classes

Methods: Classes were selected from MoA groups, their MoAs and ungrouped MoAs and supplemented by classes from other relevant ontologies or by developing new classes to complete the hierarchical structure. The classes were labelled, defined and hierarchically structured, based on their attributes, by a researcher and a behavioural science expert. To ensure that these classes and their structure were clear and comprehensible, they were reviewed by other behavioural science and ontological experts from the Human Behaviour-Change Project. Any uncertainties and suggested refinements to the ontology were discussed.

Results: The first version of the MoA Ontology consists of eight hierarchical levels with 412 classes. Examples of upper-level classes are 'mental process', 'mental disposition' and 'interpersonal process'. The issues flagged during the expert review relate to the complexity of the hierarchy, the usability and comprehensiveness of the ontology and the labels and definitions of some classes.

Conclusions and implications: This first version of the MoA Ontology provides the basis for an expert review to examine the usability, comprehensiveness and coherence of the ontology.

4.2 Introduction

The Mechanism of Action (MoA) Ontology is being developed in line with principles for developing 'gold standard' ontologies (see Chapter 1), which were proposed by the Open Biological and Biomedical Ontology (OBO) Foundry (2019i). One of these principles requires ontologies to have a specified scope and content that aligns with this scope (OBO Foundry, 2019f). To address this principle, the MoA Ontology's scope was specified by defining MoAs of behaviour change interventions in Study 2 (see Chapter 3). By drawing on 83 theories of behaviour and behaviour change (Davis, Campbell, Hildon, Hobbs, & Michie, 2015), Study 2 also identified 1062 MoAs. Of these MoAs, 763 were sorted into 104 groups, 153 were ungrouped and 146 were categorised as too unspecified to be grouped (compound MoAs). The MoA groups and ungrouped MoAs were candidates for becoming the classes (i.e., entities represented in the ontology) in the MoA Ontology.

4.2.1 Developing a 'gold standard' MoA Ontology: following OBO Foundry Principles

To usable and comprehensible, the MoA Ontology needed to include unique ontological classes, which have clear labels and textual definitions (OBO Foundry, 2019d, 2019g). Ontological classes also needed to be logically and hierarchically structured (Michie, West, & Hastings, 2019; Seppälä, Ruttenberg, & Smith, 2017). In addition, the ontology needed to be developed in line with the OBO Foundry principle for commitment to collaboration, reusing classes and relationships from other ontologies where relevant (OBO Foundry, 2019b; Wright et al., 2020).

4.2.1.1 *Providing appropriate textual definitions for ontology classes*

In an ontology, each class should have a single and unique label and textual definition (OBO Foundry, 2019d, 2019g; see Chapter 1). A 'good' ontological definition for a class consists of: (1) its parent class and (2) the attributes that distinguish the defined class from other members of its parent class (i.e., its differentiae) (Michie et al., 2019; Seppälä et al., 2017). For instance, in the Ontology for General Medical Science, an injury is defined as 'a disorder that involves some structural damage that is immediately caused by a catastrophic external force' (Goldfain & Jain, 2015). In this definition, the parent class of injury is 'disorder', while the attribute that distinguishes an injury from other disorders is that it 'involves some structural damage that is immediately caused by a catastrophic external force.'

By specifying the parent term of a class in its definition, ontology developers clearly specify what type of entity that class is. A definition's differentia should only include the essential attributes of the defined class and avoid listing clarifications, detail, subclasses or examples of that class (Seppälä et al., 2017). Additional information about a class can be included as 'comments' for that class in the ontology.

To disambiguate the meanings of terms in a scientific domain, an ontology's classes should have definitions that are clearer and simpler than the terms they define (Arp, Smith, & Spear, 2015; Michie et al., 2019; Seppälä et al., 2017). A definition also needs to avoid circularity, meaning that its label or synonyms should not be used to define a class (Michie et al., 2019; Seppälä et al., 2017). An example of a circular definition is for 'inspiring' in the Oxford Online Dictionary: 'having the effect of inspiring someone' (Inspiring, 2020). Additional guidelines about writing definitions for ontologies,

including good practice, conventions for formatting and punctuation, are presented in Appendix 4-1.

4.2.1.2 *Specifying logical hierarchical relationships between classes*

For humans and computers to make inferences about classes in an ontology, the relationships between these classes need to be logical and clearly specified (OBO Foundry, 2019e; see details in Chapter 1). A taxonomy is often used as a backbone to structure ontologies: each class in the ontology is linked to the backbone with an 'is_a' (parent-child class) relationship, forming a hierarchy (Smith & Ceusters, 2010). In a parent-child class relationship, the child class shares all of its parent class's attributes but has one or more differentiating attributes from its parent. For instance, the class 'injury' shares all the attributes of its parent class 'disorder' but also 'involves some structural damage that is immediately caused by a catastrophic external force', differentiating it from other types of disorders (Goldfain & Jain, 2015). Additional examples of relationships are presented in Table 4-1. One of these relationships is 'has_part', which helps specify the parts (components) that make up an entity (Gene Ontology Consortium, n.d.). For instance, as water is made of hydrogen and oxygen (National Center for Biotechnology Information, 2022), the relationship between water and hydrogen would be 'water has part hydrogen'.

Table 4-1. Examples of ontological relationships and their descriptions

Ontological relationship	Description of the relationship	Example of relationship usage
has_part	This relationship is used to represent part-whole relationships. A has part B means that the existence of A suggests the existence of B (Gene Ontology Consortium, n.d.).	Water has part hydrogen: the existence of water suggests the existence of hydrogen.

has_occurrent_part_some	This relationship is similar to the 'has_part' relationship but is specifically used to represent the relationship between two occurents (i.e., entities that develop over time and are made up of temporal parts, such as processes) (Barton, Rosier, Burgun, & Ethier, 2014).	Mental process has occurent part some consciousness: the existence of a mental process implies the existence of consciousness (Otte et al., 2021c).
has_participant_at_all_times	The relationship specifies that a continuant (i.e., entities that exist as a whole at a given time, such as objects and locations) is in some way always involved in a process (Relation Ontology, n.d.).	Interpersonal process has participant at all times minimum two people: At least two people will always be in some way involved in an interpersonal process (Hastings, Ceusters, Jensen, Mulligan, & Smith, 2012).

4.2.1.3 *Commitment to collaboration with other ontologies*

By reusing relevant content from other ontologies, ontology developers avoid replicating work and ensure their ontology is interoperable (i.e., compatible) with other ontologies (Arp et al., 2015; Masci et al., 2009; OBO Foundry, 2019b; see details in Chapter 1). Ontology developers can reuse content from other ontologies by importing relevant ontological classes, labels, definitions and relationships and/or specifying parent classes from other ontologies (Arp et al., 2015; Smith & Ceusters, 2010; OBO Foundry, 2019b). When a class and its definitions are reused from another ontology, these should be referenced by using Uniform Resource Identifiers (URIs) (Norris, Finnerty, Hastings, Stokes, & Michie, 2019). For instance, the class 'belief' in the Mental Functioning Ontology (Hastings et al., 2012) has the following URI: 'MF:0000041'. Therefore, when reusing the 'belief' class, an ontology would reference the URI 'MF:0000041' to indicate which ontology this class was imported from.

As introduced in Chapter 1, Basic Formal Ontology (BFO) is an upper level and domain-neutral ontology that categorises entities into two main classes: 'continuants' and 'occurrents' (Arp et al., 2015; Norris et al., 2019). Continuants (e.g., objects and

spatial regions) are entities that exist as a whole throughout their existence (Arp et al., 2015). For instance, as long as a certain book exists, it will exist as that book. In contrast, occurrents (e.g., processes) develop over time and consist of temporal parts (Arp et al., 2015). For instance, the process of writing a book unfolds over time and has temporal parts, such as writing its first chapter.

To structure ontologies, many developers draw on BFO, as this supports interoperability with other OBO Foundry ontologies (Arp et al., 2015; Norris et al., 2019). The domain-neutral classes of BFO can be specified as parent classes for ontologies in various scientific domains. For instance, 'process' is used as the parent class of 'diagnostic process' in the Mental Disease Ontology (Goldfain, 2011) and of 'behaviour' in the Gene Ontology (Lomax, 2012). By having shared parent classes, different ontologies' classes can be clearly linked to one another, which can facilitate data integration across these ontologies (Masci et al., 2009).

Using a parent class from BFO enables ontology developers to disambiguate potentially similar classes in their ontology (Hastings, Ceusters, Smith, & Mulligan, 2011; Hastings et al., 2012). As illustrated in Chapter 1, drawing on BFO, the Emotion Ontology distinguishes between the different uses of the term 'anger', i.e., disposition or process (Hastings et al., 2011). Anger as a process is labelled as 'anger' and defined as a negative emotional process (Hastings, Mulligan, Smith, Wright, & Schenk, 2021), while disposition to become angry is labelled as 'irascibility' and defined as 'a mental disposition to frequent or easily incited outbursts of anger' (Otte et al., 2021b).

4.2.2 Developing an ontology of MoAs: Identifying, labelling and defining ontological classes and hierarchically structuring these classes

Having created MoA groups in Study 2, a number of tasks were required to create the MoA Ontology. To respect the principle of reusing classes from existing ontologies where appropriate, the MoA Ontology classes needed to be identified from other ontologies. Where a suitable class from an existing ontology was identified for an MoA group, this class (including its URI, label and definition) needed to be reused in the MoA Ontology. For MoA groups that did not overlap with classes in other ontologies, a necessary step was to develop unique classes, as some groups had overlap. For instance, MoA groups related to outcome expectancy contained MoAs (i.e., MoAs derived from theories) with overlapping labels and definitions. Two of such groups, one labelled 'Subjective decisional balance' and the other labelled 'Evaluated outcome expectancy', each contained MoAs defined as the evaluations of behavioural outcomes' desirability.

There was also a need to systematically check whether any MoA group's MoAs had sufficient differentiating attributes from the other MoAs in that group to suggest the existence of a subclass. Otherwise, these MoAs would qualify as 'instances' (examples) of their class. In addition, each MoA left ungrouped in Study 2 needed to be reviewed in terms of whether it suggested the existence of an additional ontological class or was an instance (example) of an existing MoA class. Finally, to structure the classes in the MoA Ontology, the most appropriate parent class for each class needed to be considered by drawing on other ontologies, including BFO.

4.2.3 Aims and research questions

The current study aimed to develop the MoA Ontology from the MoA groups, and ungrouped MoAs identified in Study 2, such that the MoA Ontology: (1) reused classes from other ontologies or developed novel classes, (2) provided clear labels and definitions for all classes and (3) had a clear, mostly hierarchical structure where subclasses inherited all attributes of the relevant parent class. Figure 4-1 outlines studies reported in this thesis to develop the MoA Ontology and highlights the current study. To achieve its aim, this current study addressed the following research questions:

1. Which MoA groups from Study 2 can be represented in the MoA Ontology by reusing classes from other ontologies?

2. Which MoA groups from Study 2 should be represented by novel classes in the MoA Ontology, and what are the parent classes of these novel classes?

3. Which MoAs from MoA groups have differentiating attributes such that they should be represented as subclasses of the relevant parent class?

4. Which ungrouped MoAs have differentiating attributes from classes in the MoA Ontology such that they should be added as classes to the ontology?

5. What classes should be developed, or included from BFO and other existing ontologies to provide the MoA Ontology with appropriate structure?

6. What hierarchical relationships should be specified between classes in the MoA Ontology?
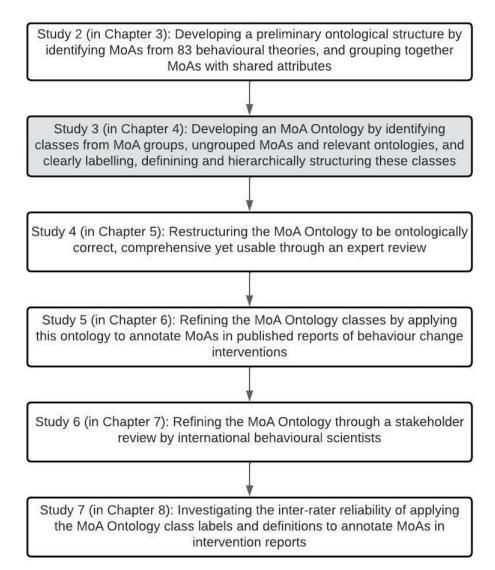
Figure 4-1. Studies used to develop the MoA Ontology in this thesis, with the current study highlighted

4.3 Methods

To select and structure classes in the MoA Ontology, a researcher (PS, the author of this thesis) and behavioural science expert (AW) followed six steps: (1) identified and imported classes from other ontologies that overlapped with MoA groups from Study 2; (2) developed novel ontology classes based on the remaining MoA groups; (3) reviewed MoAs contained in each MoA group to identify possible subclasses; (4) reviewed ungrouped MoAs from Study 2 to judge whether these qualified as classes; (5) imported or developed classes to structure the MoA Ontology; and (6) specified the hierarchical

relationships between classes to structure the MoA Ontology. To refine the ontology's class labels, definitions and relationships, these were then reviewed by three behavioural science experts (FL, SM & RW) and an ontology expert (JH).

4.3.1 Step 1: Importing classes that overlap with MoA groups from other ontologies

The current study started with the assumption that each MoA group from Study 2 would become a class in the MoA Ontology, unless proven otherwise. To judge whether any classes from other ontologies should be imported to the MoA Ontology, the researcher and expert AW checked whether any MoA groups overlapped with classes in other ontologies. Only ontologies that drew on BFO were considered.

To identify candidate classes in these ontologies, they searched online specialist ontology databases for key terms relating to the MoA groups (e.g., their labels or synonyms). These databases included the Ontology Lookup Service (European Bioinformatics Institute, 2019) and Bioportal (National Center for Biomedical Ontology, 2019). For instance, by searching for synonyms of an MoA group's label, 'Attention', in the Ontology Lookup Service, the class 'attending' in the Mental Functioning Ontology could be identified (Hastings et al., 2012). This class is defined as 'A mental process whereby relevant aspects of our mental experience are focused on specific targets' (Otte et al., 2021a).

The researcher and expert decided whether a candidate class should be imported from another ontology to represent an MoA group. These decisions were made by judging whether two or more MoAs in the MoA group shared all attributes of the candidate

class, based on that class's definition. If so, the candidate class was recorded as a class of the MoA Ontology. For instance, if most MoAs of the MoA group 'Attention' (see examples in Table 4-2) could be judged to share all attributes of the class 'attending' in the Mental Functioning Ontology (Hastings et al., 2012), this class would be imported. Where the researcher and expert disagreed on importing a candidate class, they discussed and reconciled their judgements.

When two or more MoAs of an MoA group fit the candidate class's definition, but other MoAs did not, the expert removed those that did not fit from the group, adding them to the pool of ungrouped MoAs. To illustrate this step, as shown in Table 4-2, the 'Attention' MoA group has three MoAs. Based on their definitions, two MoAs, also labelled 'attention', could be judged to share all the attributes of the class 'attending'. However, a third MoA labelled 'directive function' has a broader definition, including effort to achieve a goal. If this MoA was judged not to share all the attributes of the class 'attending', this MoA would be added to the pool of ungrouped MoAs.

Table 4-2. Example MoA group 'Attention' and its MoAs' labels and definitions

MoA label	MoA definition
Attention	The process by which executive processes become engaged with stimuli.
Attention	The extent to which people attend to the information being presented.
Directive function	The process by which goals direct attention and effort towards goal-relevant activities and away from goal-irrelevant activities.

To structure the classes in the MoA Ontology in later steps, the parent classes of all imported classes were recorded in a spreadsheet up to BFO-level. For instance, the immediate parent class of 'attending', 'mental process' from the Mental Functioning

Ontology, and the parent class of 'mental process' from BFO, 'process', would be recorded (Hastings et al., 2012).

4.3.2   Step 2: Developing novel classes based on MoA groups

For MoA groups that did not overlap with classes from other ontologies, the researcher and expert created novel classes for use in the MoA Ontology. To develop these classes, the researcher and expert first read the definitions of all MoAs in an MoA group and judged whether these MoAs shared sufficient attributes to be represented by a single class. The groups where MoAs were judged not to share sufficient attributes were dissolved and these MoAs were added to the set of ungrouped MoAs.

For the MoA groups where MoAs were judged to share sufficient attributes, the researcher and expert adapted the group's label and definition from Study 2 to fit with the guidance on writing ontological definitions (Michie et al., 2019; Seppälä et al., 2017; see Appendix 4-1). For these definitions, parent classes were identified from other ontologies, including BFO, or classes already in the MoA Ontology. For instance, the MoA group 'Motivation' (defined as 'the impetus that gives purpose or direction to behaviour') could be developed into a class with the same label. By identifying its parent class as 'mental process' from the Mental Functioning Ontology, the 'motivation' class could be defined as 'a mental process that energises and directs behaviour.'

Based on the updated ontological definitions, the researcher and expert judged whether each MoA group had differentiating attributes from the others, and therefore qualified

as a novel class in the MoA Ontology. Those without differentiating attributes were dissolved, and their MoAs were recorded as ungrouped.

There were some MoA groups that had differentiating attributes from other classes in the MoA Ontology but did not align with the relationships of classes imported from other ontologies. For instance, the MoA group 'Future oriented negative emotion' could qualify as a subclass of the class 'emotion process' imported from the Emotion Ontology (Hastings et al., 2011). However, this group had two MoAs, 'anxiety' and 'fear', that could also be captured by 'emotion process' subclasses in the Emotion Ontology, also labelled 'anxiety' and 'fear'. For such MoA groups, the researcher and expert discussed and judged whether the MoA groups should be represented as novel classes or dissolved to avoid contradicting the structure of other ontologies.

For the MoA groups converted into novel classes, the groups' MoAs were recorded as MoA instances (examples) of these classes. However, based on the definitions of the novel classes, the researcher and expert judged whether the classes' MoA instances still shared all their attributes. The instances that did not share all the attributes of their class were added to the pool of ungrouped MoAs.

4.3.3   Step 3: Identifying subclasses from MoA instances

The researcher and expert judged whether the instances of MoA classes (i.e., the instances that had not been ungrouped) qualified as subclasses of their class by having a differentiating attribute from that class. The MoA instances judged not to qualify as subclasses remained instances of their respective class and were recorded as 'examples'

for the remainder of the study. For each MoA instance that the researcher and disagreed on, they discussed and reconciled their judgements.

When the researcher and expert judged that a class, imported from another ontology, had instances with distinguishing attributes, they investigated whether relevant subclasses existed in this ontology. Where relevant, they recorded such subclasses' labels and definitions, and discussed whether these candidate classes should be reused as subclasses in the MoA Ontology. For instance, an MoA instance labelled 'stress' under the class 'emotion process' had a differentiating attribute from that class. As the class 'emotion process' had a subclass labelled 'stress' in the Emotion Ontology (Hastings et al., 2011), this subclass could be reused in the MoA Ontology.

For all MoA instances judged to be subclasses, the researcher and expert refined the subclasses' labels and definitions according to ontological principles or imported classes from other ontologies where relevant. The hierarchical relationships between all subclasses and their respective parent classes were recorded.

4.3.4   Step 4: Reviewing ungrouped MoAs to select classes in the MoA Ontology

In this step, the assumption was that each ungrouped MoA would need to be represented by a class in the MoA Ontology, unless proven otherwise. This assumption was based on ungrouped MoAs having attributes that differentiated them from the MoA groups formed in Study 2 or the classes identified in the current study's previous steps.

For each ungrouped MoA, the researcher and expert checked whether classes from other ontologies could be reused by searching for key terms in online ontology databases (see

details in Step 1). If an appropriate class was found in another ontology, this class was recorded for reuse in the MoA Ontology. Next, they judged whether the remaining ungrouped MoAs qualified as an instance (example) of any existing class in the MoA Ontology. If not, they recorded the ungrouped MoA as a class and specified the parent class from the MoA Ontology or other ontologies. For instance, if they judged that the ungrouped MoA labelled 'mental segregation' (defined as 'a process by which the riskless component is separated from the risky component') was a class, the parent class could be specified as 'mental process' from the Mental Functioning Ontology (Hastings et al., 2011). When the researcher and expert disagreed on any judgements regarding ungrouped MoAs, they discussed and reconciled their judgements.

For ungrouped MoAs that qualified as a class, the researcher and expert wrote labels and definitions in line with ontological principles or imported their labels and definitions from other ontologies, as appropriate. For instance, the class 'mental segregation' could be defined as 'a mental process that simplifies decision-making by separating elements of alternative options that involve risk from those that do not involve risk.' The labels of some classes were also updated to better reflect their definitions.

Some ungrouped MoAs had clear definitions but mismatching labels. For instance, the ungrouped MoA 'exposure' was defined as 'the action of noticing the information in a message.' As ontological definitions, rather than labels, are considered key for understanding classes in ontologies (Michie et al., 2019), the ungrouped MoAs with clear definitions but mismatching labels were included in the ontology by changing their labels to better reflect their definitions.

179

Ungrouped MoAs were not included in the ontology when their definitions were underspecified, and their labels did not provide sufficient information to define these MoAs as classes. For instance, the ungrouped MoA 'conventional behaviour structure' was defined as 'interconnected set of conventional behaviours.' In addition, ungrouped MoAs judged to qualify as compound MoAs or not qualify as MoAs were excluded from the MoA Ontology.

4.3.5   Step 5: Importing or developing classes to structure the MoA Ontology

To structure the MoA Ontology, the parent classes recorded from BFO or other ontologies were imported into the ontology. For classes that shared attributes, the researcher and expert judged whether they had sibling relationships (i.e., having a shared parent class). They developed a parent class for such sibling classes. For instance, as the classes 'decision simplification by disregarding shared components' and 'decision simplification by identifying clearly better or worse options' could qualify as sibling classes, a parent class could be developed for these two classes.

The expert also judged whether additional child classes or classes with other key relationships (e.g., 'has_part' relationships) should be imported from other ontologies. To limit the MoA Ontology's size, child classes were only imported from other ontologies when their parent class already had child classes identified in Step 3. For instance, the class 'emotion process' included child classes (e.g., 'happiness') that were identified and imported from the Emotion Ontology (Hastings et al., 2011) in Step 3. The direct sibling classes (e.g., 'anger' and 'boredom') of such child classes in the Emotion Ontology could be imported to represent classes more comprehensively in the MoA Ontology.

4.3.6 Step 6: Hierarchically structuring the classes in the MoA Ontology

To create a hierarchical structure for the MoA Ontology, the parent-child relationships recorded between classes in Steps 1-5 were used. For instance, the class 'motivation' could be organised under its previously specified parent class 'mental process' (see Step 2). The researcher and expert discussed and re-evaluated whether all parent-child relationships between classes imported from other ontologies should be kept, recording their decisions.

4.3.7 Step 7: Review of MoA Ontology by behavioural science experts and an ontology expert

To refine the labels, definitions and structure of the MoA Ontology, two behavioural science experts (FL, SM & RW) and an ontology expert (JH) from the Human Behaviour-Change Project (Michie et al., 2017) were presented with a spreadsheet including all class labels and definitions (see an excerpt in Figure 4-2). They were also given a diagram outlining the relationships of these classes (see an excerpt Figure 4-3), which was prepared using Lucidchart, an online diagramming application (www.lucidchart.com). The experts were asked whether the class labels and definitions were clear and comprehensible, and whether the relationships between classes were sensible. They were also prompted to suggest changes to the class labels, definitions or relationships where necessary.

Upper Level	Sub-Level 1	Sub-Level 2	Sub-Level 3	Sub-Level 4	Sub-Level 5	Sub-Level 6	Definitions
				01. Judging as potential peer			Judging whether an individual or individuals should be considered as a person of the same status or rank.
					01. Judging as peer of similar status or ability		Judging whether an individual or individuals should be considered as a person of the same status or rank in terms of ability
					02. Judging as peer influential to one's behaviour or self-evaluation		Judging whether an individual or individuals should be considered as a person of the same status or rank who influences one's behaviour or self-evaluation
			13. Learning				Any process in an organism in which a relatively long-lasting adaptive behavioural change occurs as the result of experience.

Figure 4-2. Excerpt of spreadsheet presenting the MoA Ontology's class labels and definitions

After reviewing the labels, definitions and diagram, the experts and authors of the MoA Ontology's first draft (AW & PS) had a meeting to discuss the MoA Ontology's classes and structure. Based on the experts' feedback, the changes that needed to be made to labels, definitions and structure of the ontology were outlined and the next steps to develop the MoA Ontology were specified.
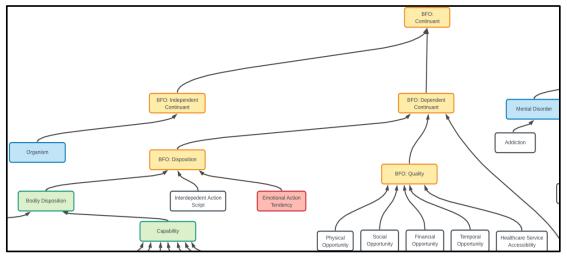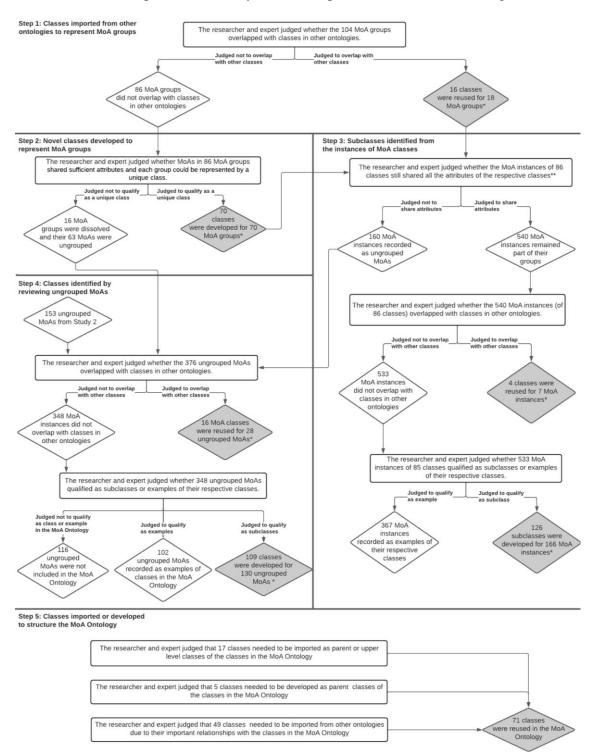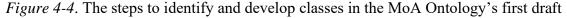
Figure 4-3. Excerpt of diagram presenting class labels and relationships in the MoA Ontology

4.4   Results

The results from Steps 1-5 to identify and develop classes are outlined in Figure 4-4.

Figure 4-4. The steps to identify and develop classes in the MoA Ontology's first draft

Notes. *For MoA groups, MoA instances or ungrouped MoAs that shared distinguishing attributes, the same classes were imported or developed.
**Judgements on whether MoA instances still shared all the attributes of their respective imported (Step 1) or novel classes (Step 2) were summarised for brevity.

4.4.1 Step 1: Classes imported from other ontologies to represent MoA groups

For 14 of the 104 MoA groups from Study 2, 14 classes were imported from other ontologies. For instance, from the Emotion Ontology (Hastings et al., 2011), a class labelled 'affective processes' (defined as 'any process that has positive or negative valence.') was imported for the MoA group 'Feeling', which had been defined as: 'An affective state that includes emotions and desires'. As two MoA groups, 'Observation of others' and 'Social learning', had overlapping definitions (see Table 4-3), the same class ('observational learning') was imported from the Gene Ontology (Osumi-Sutherland, 2014b) to represent both MoA groups. Similarly, the class 'perception' was imported from the Mental Functioning Ontology (Hastings et al., 2012) for the MoA groups 'Perception' and 'Sensation' (see definitions in Table 4-3).

In total, 16 classes were imported from other ontologies to represent 18 MoA groups (see Appendix 4-2). Examples of these MoA groups and the classes imported from other ontologies to represent them are shown in Table 4-3. After the labels and definitions for the 16 classes were imported, the researcher and expert judged that the 22 MoA instances no longer shared all their classes' attributes, and these instances were added to the pool of ungrouped MoAs.

Table 4-3. The labels and definitions of selected MoA groups and the classes imported from other ontologies based on these groups

MoA group label	MoA group definition	Imported class label (URI)	Imported class definition
Belief	An association of some characteristic or attribute, usually evaluative in nature, with an attitude object.	Belief MF:000004 1	A disposition to mental processes that represent some proposition X to be true.

MoA group label	MoA group definition	Imported class label (URI)	Imported class definition
Choice and decision making	The cognitive process of choosing between two or more alternatives.	Judging MF:000000 6	A mental process during which a decision is made and the outcome of which is a belief or opinion.
Observation of others	The process of watching someone else's behaviour.	Observation al learning* GO:009859 7	Learning that occurs through observing the behaviour of others.
Social learning	A process by which thoughts, feelings, and motivational states observed in others are internalized and replicated without the need for conscious awareness.		.
Perception	The process or result of becoming consciously aware of something by means of the senses.	Perception* MF:000001 9	A mental process which is a) produced by a causal process (for example involving light rays or air vibrations) involving a part of the environment of the organism, and b) is experienced by the organism as being so caused, and c) in which the relevant part of the environment is thereby represented to the organism.
Sensation	A feeling arising from senses or imagined experiences, without interpretation of meaning.		

Notes. * Classes that were added to the MoA Ontology to represent more than one MoA group

4.4.2 Step 2: Novel classes developed to represent MoA groups

For 70 of the 104 MoA groups from Study 2 that could not be represented by importing

classes from other ontologies, 70 new classes were developed for the MoA Ontology

(see Appendix 4-2). Examples of these MoA groups and the classes developed to

represent them are presented in Table 4-4. For instance, the MoA group 'Reflective

thinking' (defined as: 'a type of thinking in which decisions are made [e.g., about

complex problems] slowly and deliberately [i.e., not impulsively]') became a class with

the same label in the MoA Ontology. The definitions of the 70 new classes were refined

by identifying their parent classes in the MoA Ontology or other ontologies that drew

on BFO. For instance, as the parent class of 'reflective thinking' was specified as

185

'thinking' from the Mental Functioning Ontology (Hastings et al., 2012), its definition was updated to read as: 'Thinking that involves generation of inferences based on syllogistic reasoning or decision making based on the evaluation of anticipated consequences or the construction of propositional representations.'

For some classes, their labels were refined to better reflect their definitions. For instance, the MoA group 'Discrepancy resolution' (defined as 'a psychological process of a settling a perceived incompatibility between two cognitive states.') was identified as a novel class for the MoA Ontology. This class's parent class was specified as 'mental process' in the Mental Functioning Ontology (Hastings et al., 2012) and defined as 'a mental process through which a perceived inconsistency between two concurrently held cognitive representations is reduced.' To better match this definition, the class's label was changed to 'dissonance reduction process'.

Based on the definitions of the novel classes, the researcher and expert judged that 138 MoA instances no longer shared all their classes' attributes. Therefore, these instances were added to the pool of ungrouped MoAs.

Table 4-4. The labels and definitions of selected novel classes developed based on MoA groups

MoA group label	MoA group definition	Class label	Class definition
Awareness	A consciousness of something.	Awareness	A mental disposition to be conscious of events, objects or sensory patterns.
Descriptive norm	A standard that describes how people typically behave in a given situation.	Descriptive norm	A belief regarding the prevalence of performance of a given behaviour by people within a group.

MoA group label	MoA group definition	Class label	Class definition
Discrepancy resolution	A psychological process of a settling a perceived incompatibility between two cognitive states.	Dissonance reduction process	A mental process through which a perceived inconsistency between two concurrently held cognitive representations is reduced.
Self-efficacy	Belief about personal capabilities to perform task or engage in a behaviour.	Self-efficacy	A belief about one's capabilities to engage in a behaviour.
Reflective thinking	A type of thinking in which decisions are made (e.g., about complex problems) slowly and deliberately (i.e., not impulsively).	Reflective thinking	Thinking that involves generation of inferences based on syllogistic reasoning or decision making based on the evaluation of anticipated consequences or the construction of propositional representations.

4.4.2.1 MoA groups that could not be developed into novel classes

For 16 of the 104 MoA groups from Study 2, novel classes could not be developed and, therefore these groups were dissolved (see the labels and definitions of these groups in Appendix 4-3). Their 63 MoAs were recorded as ungrouped. Of the 16 groups, five groups were not developed into separated classes because their respective MoAs were judged not share sufficient attributes. For instance, the group 'Expectation about social relatedness' had three MoAs, 'expectation for academic achievement', 'expectation for affection' and 'expectation for independence'. These MoAs shared some attributes, as they were defined as beliefs about the likelihood of certain experiences. However, the expert judged that the MoAs did not strictly refer to the likelihood of social relatedness, i.e., the attributes based on which they were grouped together in Study 2. Therefore, a separate class for this MoA group was not developed. Another five groups had instances that were judged to be captured by classes already in the MoA Ontology. For example, some instances from 'Subjective decisional balance' could be captured by the class 'belief about the desirability of consequences of behaviour'. In addition, six MoA groups were dissolved because they were considered incompatible with the structure of

other ontologies from which the MoA Ontology imported classes. For instance, the MoA group 'positive feeling' included MoAs, such as 'happiness' and 'pleasure', which overlapped with subclasses of 'emotion process' in the Emotion Ontology (Hastings et al., 2011). To avoid contradicting the Emotion Ontology's hierarchical structure, these groups were dissolved.

At the end of this step, of the 104 MoA groups identified in Study 2, 88 were now represented by 86 classes. In total, 540 instances were still recorded under these 86 classes. Sixteen MoA groups had been dissolved. With the 63 MoAs from the dissolved groups and the 160 instances removed from classes (see Steps 1 and 2) being added to the list of 153 ungrouped MoAs from Study 2, there were 376 ungrouped MoAs.

4.4.3   Step 3: Subclasses identified from the instances of MoA classes

4.4.3.1   Subclasses created by importing classes from other ontologies

Of the 540 MoA instances that were still recorded under a class, two instances overlapped with two subclasses in other ontologies and therefore these subclasses were imported. For example, the 'affective process' class had an instance labelled as 'stress' (defined as: 'negative emotion state caused by events [e.g., divorce, bereavement]'). This instance overlapped with the class 'stress' (defined as 'a negative emotion in response to a stressful elicitor.') in the Emotion Ontology (Hastings et al., 2011). Therefore, this class was reused in the MoA Ontology (see Table 4-5). In addition, two instances 'ascription of responsibility' and 'internal attribution' were judged to share distinguishing attributes with the class 'appraisal as caused by self' (see definitions in Table 4-5) from the Mental Functioning Ontology (Hastings et al., 2012). Therefore, this class was reused to represent both these instances. Similarly, as the instances

'copying', 'imitation' and 'modelling' were judged to share distinguishing attributes with the class 'imitative learning' from the Gene Ontology (see definitions in Table 4-5), this class was imported for the three instances (Osumi-Sutherland, 2014a). In total, four classes were reused from other ontologies for seven MoA instances that qualified as subclasses (see Appendix 4-4).

Table 4-5. The labels and definitions of selected MoA instances and the subclasses imported from other ontologies to represent these instances

MoA class label	MoA instance label	Definition	Subclass label (URI)	Subclass definition
Affective process		Any process that has positive or negative valence.		
	Stress	Negative emotion state caused by events (e.g., divorce, bereavement).	Stress MFOEM:000029	A negative emotion in response to a stressful elicitor.
Appraisal of causal agency		An appraisal that represents an evaluation of who or what caused an event.		
	Ascription of responsibility	The belief that one's own actions have contributed to, or could alleviate, negative consequences to others.	Appraisal as caused by self* MFOEM:000076	An appraisal that represents an evaluation that an event was caused by the self.
	Internal attribution	Attributing discrepancies (between the information about one's own behaviour gathered during the self- monitoring stage and one's standards for that behaviour) to an aspect of the individual.		
Observationa l learning		Learning that occurs through observing the behavior of others.		
	Copying	Form of imitation that occurs when an observer seeks to optimize the accuracy of his/her behaviour to that of a model, whereby one brings one's behaviour to approximate that of a model and where one knows that this act is an acceptable replication of the model act; includes contingent rewards based on sameness and differences cues which are based on the closeness of the match between a model's and an observer's behaviour.	Imitative learning* GO:0098596	Learning in which new behaviours are acquired through imitation.
	Imitation	The process of copying the behaviour of another person, group, or object, intentionally or unintentionally.		
	Modelling	The process by which one or more individuals or other entities serve as examples that others will emulate.		

Notes. * Classes that were added to the MoA Ontology to represent more than one MoA instances

4.4.3.2 Subclasses created by developing novel ontology classes

The researcher and expert judged that 99 MoA instances qualified as subclasses of their respective class, but no appropriate class could be imported from another ontology to represent these instances. Therefore, these instances were used to develop and define 99 new subclasses. For instance, the MoA instance 'gain goal' (defined as 'goal relating to the improvement and protection of one's resources') qualified as a subclass of the class 'Goal' (see definition in Table 4-6). Drawing on its label and definition from Study 2, this new class's label and definition were refined to read as 'Gain-related goal (label): A goal related to improving and protecting one's resources (definition).' Additional 66 instances were judged to share the same distinguishing attributes with one or more instances. Based on these instances, 25 new classes were developed to represent more than one instance. For example, the class 'temporal orientation to the present' (defined as 'a mental disposition to focus more on present than future outcomes') was developed to represent the instances 'myopia' and 'present-oriented' (see definitions in Table 4-6). Moreover, as the MoA instance 'need for health' (defined as 'need for good health and adequate, accessible healthcare') clearly captured as two separate subclasses of 'need', the expert used this instance to develop two new classes: 'need for health' and 'need for healthcare' (see definitions in Table 4-6).

In total, 166 MoA instances of 44 MoA classes were judged to qualify as subclasses for which no appropriate class could be imported from another ontology. As some of these instances shared the same distinguishing attributes, 126 new classes were developed. These 166 instances and the subclasses developed based on them are shown are outlined in Appendix 4-4.

The remaining 367 MoA instances were judged to qualify as examples of their relevant classes and are presented in Appendix 4-5. For some MoA instances, the researcher and expert had challenges deciding whether they qualified as novel subclasses or examples of a class. For example, 'computer self-efficacy' (defined as 'one's perception of whether one is capable of performing a task using the technology') was judged to be an example of the class 'self-efficacy' (defined as 'a belief about one's capabilities to engage in a behaviour'). This was because 'performing a task using the technology' was judged to specify a particular behaviour, which did not qualify as a differentiating attribute from the class.

At the end of this step, 173 instances had been judged to qualify as subclasses of their respective 45 MoA classes (see Appendix 4-4). To represent these instances, altogether, 130 subclasses were added to the MoA Ontology by reusing classes from other ontologies or developing new classes.

Table 4-6. The labels and definitions of selected MoA instances and the novel subclasses developed to represent these instances

MoA class label	MoA instance label	Definition	Subclass label	Subclass definition
Goal		A cognitive representation of the end state to which one is striving.		
	Gain goal	Goal relating to the improvement and protection of one's resources	Gain-related goal	A goal related to improving and protecting one's resources.
Temporal orientation		A mental disposition to focus more on present or future outcomes.		
	Myopia	Near-sightedness such that one is more present-focused than future-oriented	Temporal orientation to the present*	A mental disposition to focus more on present than future outcomes.
	Present-oriented	An attitude characterised by a focus on short-term benefits and outcomes	Temporal orientation to the present*	A mental disposition to focus more on present than future outcomes.
Need		A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining a particular state.		
	Need for health**	Need for good health and adequate, accessible healthcare	Need for health	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining good health.
			Need for healthcare	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining access to appropriate healthcare.

Notes. * Classes that were added to the MoA Ontology to represent more than one MoA instances
** Two classes were developed from the 'Need for health' MoA instance

4.4.4 Step 4: Classes identified by reviewing ungrouped MoAs

4.4.4.1 Classes created from ungrouped MoAs by importing classes from other ontologies

Of the 376 ungrouped MoAs, the researcher and expert judged that 10 ungrouped MoAs overlapped with 10 classes in other ontologies, and so imported these classes into the MoA Ontology. For instance, the class 'vigilance' from the Emotion Ontology (Hastings et al., 2011) was imported to represent the ungrouped MoA 'vigilance' (see definitions in Table 4-7). As 18 ungrouped MoAs were judged to share differentiating attributes with one or more ungrouped MoAs, only six classes were imported to represent these ungrouped MoAs. For instance, the class 'fear' from the Mental Functioning Ontology (Hastings et al., 2012) was imported for the ungrouped MoAs labelled 'fear' and 'fear arousal', as both were defined as emotions experienced in response to a threat (see definitions in Table 4-7). Altogether, 16 classes were imported from other ontologies for 28 ungrouped MoAs (see Appendix 4-6).

Some judgements on whether ungrouped MoAs overlapped with classes in other ontologies involved uncertainty, particularly when the MoAs shared labels with classes in other ontologies but were defined differently. For instance, the ungrouped MoAs 'liking' shared its label with 'liking' in the Neuro Behavior Ontology (Gkoutos, 2011). However, their definitions differed: The ungrouped MoA specified a positive emotion about something, while the class 'liking' was specified as affection felt towards someone. Based on this ungrouped MoA's definition, the MoA was judged to overlap more closely with the class 'positive emotion' from the Emotion Ontology (Hastings et al., 2011) and so this class was imported (see definitions in Table 4-7).

Table 4-7. The labels and definitions of selected ungrouped MoAs that qualified as classes, and the relevant classes imported from other ontologies

Ungrouped MoA label	Ungrouped MoA definition	Imported class label	Imported class definition	Parent class
Vigilance	The action or state of the executive directing attention to ensure that appropriate actions are undertaken when required.	Vigilance MF:0000060	The ability to maintain attention and alertness over prolonged periods of time.	Attending
Fear	A negatively valanced emotion that is accompanied by a high level of arousal and elicited by a threat that is perceived to be significant and personally relevant.	Fear* MFOEM:000026	An activated, aversive emotion that motivates attempts to cope with events that provide threats to the survival or well-being of organisms.	Emotion process
Fear arousal	The elicitation of fear caused by the detection of an imminent threat.			
Liking	Feeling positive about something.	Positive emotion MFOEM:000211	A positive emotion is an emotion that has a positive valence.	Emotion process

4.4.4.2 *Classes created from ungrouped MoAs by developing novel classes*

From 91 ungrouped MoAs that were judged to qualify as classes but did not overlap with classes in other ontologies, 91 new classes were developed. For instance, the ungrouped MoA 'identity', defined as 'the action of noticing the information in a message', was developed into a class with the same label and defined as 'a cognitive representation relating to how one perceives oneself' (see Table 4-8). In addition, from 38 ungrouped MoAs that shared distinguishing attributes with one or more ungrouped MoAs, 16 classes were developed. For instance, the class 'belief about social support' (defined as 'a belief about whether others will provide assistance or comfort to help the person cope with a variety of stressors') was developed from the two instances: 'perceived social support' and 'social support' (see definitions in Table 4-8). Based on the definition of one ungrouped MoA 'self- and partner- reinforcement' (defined as 'the

ability to reinforce oneself or one's sexual partner's safe sex practices'), the expert also developed two new classes with distinct attributes, 'close other reinforcement capability' and 'self-reinforcement capability' (see definitions in Table 4-8). In total, 109 new classes were developed to represent 130 ungrouped MoAs that did not overlap with classes in other ontologies (see Appendix 4-7).

At the end of Step 4, based on 158 ungrouped MoAs that had been judged to qualify as classes in the MoA Ontology, 125 classes were added to the MoA Ontology. Of the ungrouped MoAs that did not qualify as classes, 102 were recorded as examples of 55 classes previously included in the ontology (see Appendix 4-8), while 116 were excluded from the MoA Ontology (see Appendix 4-9).

Table 4-8. The labels and definitions of selected ungrouped MoAs and the novel classes developed based on these MoAs

Ungrouped MoA label	Ungrouped MoA definition	Imported class label	Imported class definition	Parent class
Identity	Mental representations of the self as one is or aspires to be and feelings associated with these	Identity	A cognitive representation relating to how one perceives oneself.	Cognitive representation
Perceived social support	One's perception of the provision of assistance or comfort from others to help them cope with a variety of biological, psychological and social stressors; can be practical, informational or emotional	Belief about social support*	A belief about whether others will provide assistance or comfort to help the person cope with a variety of stressors.	Belief
Social support	Perceived emotional encouragement and practical support from others for a behaviour	Belief about social support*	A belief about whether others will provide assistance or comfort to help the person cope with a variety of stressors.	Belief

Ungrouped MoA label	Ungrouped MoA definition	Imported class label	Imported class definition	Parent class
Self- and partner-reinforcement**	The ability to reinforce oneself or one's sexual partner's safe sex practices	Self-reinforcement capability	A bodily disposition that is realised by the bearer being able to reward themselves for performing an intended behaviour.	Capability
		Close other reinforcement capability	A bodily disposition that is realised by the bearer being able to reward a friend or partner for performing an intended behaviour.	Capability

4.4.5 Step 5: Classes imported or developed to structure the MoA Ontology

4.4.5.1 Classes imported from other ontologies to help hierarchically structure the MoA ontology

From other ontologies, 17 classes were imported as parent or upper-level classes in order to link classes in the MoA Ontology to the level of BFO. For instance, to link 'awareness' to BFO, its parent class 'mental disposition' in the Mental Functioning Ontology (Hastings et al., 2012) and the next three upper-level classes, 'bodily disposition', 'disposition' and 'specifically dependent continuant', were imported (see definitions in Table 4-9). All classes imported from other ontologies to hierarchically structure the ontology, and their example subclasses are shown in Appendix 4-10. For one class, 'bodily feeling', no definition was found in the Emotion Ontology (Hastings et al., 2011). As the researcher and expert did not have the expertise to develop a definition for this class, this class was imported without a definition being developed for it.

Table 4-9. The labels and definitions of selected classes imported to hierarchically structure classes in the MoA Ontology

Class label (URI)	Class definition
Specifically dependent continuant BFO:0000020	b is a specifically dependent continuant = Def. b is a continuant & there is some independent continuant c which is not a spatial region and which is such that b s-depends_on c at every time t during the course of b's existence
Disposition BFO:0000016	b is a disposition means: b is a realizable entity & b's bearer is some material entity & b is such that if it ceases to exist, then its bearer is physically changed, & b's realization occurs when and because this bearer is in some special physical circumstances, & this realization occurs in virtue of the bearer's physical make-up.
Bodily disposition MF:0000032	A disposition that inheres in some extended organism.
Mental disposition MF:0000033	A bodily disposition that is realized in a mental process.

4.4.5.2 *Novel classes developed from other ontologies to help hierarchically structure the MoA Ontology*

Further five new classes were developed to hierarchically structure the MoA Ontology (see Appendix 4-10). For instance, the class 'decision simplification' was developed to hierarchically organise classes that shared attributes, such as 'decision simplification by identifying clearly better or worse options' and 'decision simplification through rounding' (see definitions in Table 4-10). Through this shared parent class, these classes were linked more logically to the upper-level class 'mental process'.

Table 4-10. The labels and definitions of selected classes for which a parent class was developed in the MoA Ontology, and the respective parent class

Class label	Subclass label	Definition
Decision simplification		A mental process that simplifies decision making.
	Decision simplification by identifying clearly better or worse options	A mental process that simplifies decision making by editing information to identify any clearly superior or inferior options.
	Decision simplification through rounding	A mental process that simplifies decision making by rounding probabilities or outcomes associated with alternative options, or by disregarding options with extremely unlikely outcomes.

4.4.5.3   *Additional classes imported from other ontologies to help structure the MoA Ontology*

To comprehensively represent the classes 'emotion process' and 'appraisal' in the MoA Ontology, the expert also judged that all 17 subclasses of the 'emotion process' and 26 subclasses of the 'appraisal' classes should be imported from the Emotion Ontology (Hastings et al., 2011). For instance, 'amusement' and 'anger' were added as subclasses of 'emotion process' in the MoA Ontology (see definitions in Table 4-11). As some classes had not been defined in the Emotion Ontology (e.g., 'amusement'), the researcher and expert developed definitions for these.

The expert judged that six additional classes had important relationships with classes in the MoA Ontology and therefore needed to be represented (see definitions in Table 4-11). Firstly, the Mental Functioning Ontology specified that the class 'mental process' 'has_occurrent_part_some' (relationship) 'consciousness' (Hastings et al., 2012). This relationship implied that people have some form of consciousness during all mental processes. To include this relationship in the MoA Ontology at a later stage, the class 'consciousness' and its parent class 'process profile' were imported (see definitions in

Table 4-11). Next, 'appraisal process' (see definition in Table 4-11) was imported from the Emotion Ontology (Hastings et al., 2011) to capture the process of forming an 'appraisal', a class that was already in the MoA Ontology. The remaining three classes were imported due to their relationships to the class 'emotion process'. The Emotion Ontology (Hastings et al., 2011) indicated that 'emotion process' 'has_part' some 'emotional behavioural process' and 'physiological response to emotion process' (see definitions in Table 4-11). These relationships implied that emotion processes involve some behavioural processes (e.g., facial expressions) and physiological responses (e.g., neurological activity). To capture these processes as are part of the emotion process, they were added to the MoA Ontology. Another class labelled 'emotional action tendency' was defined as a 'disposition to behaviour that inheres in an organism by virtue of the physical changes brought about by an emotion process' in the Emotion Ontology (Hastings et al., 2011). As this class was considered important to link the 'emotion process' to behaviour, the class was also imported.

In total, 49 classes were imported from other ontologies (see Appendix 4-11), because the expert judged that these had important relationships with classes in the MoA Ontology. An issue with importing some classes was that their definitions did not align with the principles of 'good' ontological definitions. For instance, the class 'contempt', which was imported from the Emotion Ontology (Hastings et al., 2011), was defined as 'a negative emotion generally elicited by the negative evaluation of others and their actions.' This definition included a generalising statement (i.e., 'generally elicited'), which is advised against in ontological definitions (Seppälä et al., 2017).

Table 4-11. The labels and definitions of selected classes imported from other ontologies to help structure the MoA Ontology

Class label (URI)	Class definition	Parent class
Amusement MFOEM:000169	A positive emotion that is experienced when a person finds something funny and entertaining.	Emotion process
Anger MFOEM:000009	A negative emotion, characterised by feelings of unpleasantness and high arousal, in the form of antagonistic feelings and action tendencies.	Emotion process
Process profile BFO:0000144	b is a process_profile =Def. there is some process c such that b process_profile_of c.	Process
Consciousness MF:0000017	That part of the mental process that confers a subjective perspective, a phenomenology, an experience of the mental process of which it is a part; and intends the object or event that the mental process is about, should such exist; it confers intentionality on the mental process.	Process profile
Appraisal process MFOEM:000002	An appraisal process is a mental process that gives rise to an appraisal.	Mental process
Emotional behavioural process MFOEM:000004	An emotional behavioural process is the behaviour of the organism in response to the appraisal, which includes the characteristic facial expressions for particular emotion types.	Behaviour
Physiological response to emotion process MFOEM:000003	A physiological response to emotion process is a bodily process which encompasses all the neurophysiological changes caused by the appraisal, which take place in the central nervous system (CNS), neuro-endocrine system (NES) and autonomous nervous system (ANS).	Bodily process

4.4.6 Step 6: Hierarchical relationships specified between classes in the MoA Ontology

Drawing on the hierarchical relationships recorded from other ontologies and the additional hierarchical classes developed, MoA Ontology's classes were structured into eight hierarchical levels. For one subclass of 'learning' the relationships were not adopted from other ontologies. In the Gene Ontology, the class 'operant conditioning' is not a subclass of 'associative learning' (Ashburner et al., 2000). However, in PRIME Theory, which synthesised theories of habits, emotions, self-control, choice and drives, 'operant conditioning' is a type of 'associative learning' (West & Brown, 2013). As the relationship proposed in the Gene Ontology misaligned with the psychological theory, the class 'operant conditioning' was classified as a subclass of 'associative learning'.

In total, the MoA Ontology draft, generated by PS and AW, had 412 classes organised into eight hierarchical levels. Of these classes, 102 were reused from other ontologies, while 310 were developed for the MoA Ontology. Appendix 4-12 presents the hierarchically structured MoA Ontology.

4.4.7 Step 7: Results of expert review of the MoA Ontology

The feedback from the behavioural science and ontology experts (FL, SM, RW & JH) revealed that many important semantic features of putative MoAs were captured by the drafted ontology. However, the review also outlined several concerns with the usability and comprehensibility of the structure the MoA Ontology, and some of its classes and definitions. An overview of these concerns is provided in Table 4-12. To address these concerns and develop a more usable version of the MoA Ontology, the experts recommended further iterative expert reviews and discussion.

Table 4-12. The concerns raised and solutions proposed by the behavioural science and ontology experts to develop the MoA Ontology

Theme	Concern	Example classes	Proposed solution
Accurately capturing the nature of MoAs	The classes in the MoA Ontology, e.g., 'attending' and 'happiness', are only MoAs when these classes are potentially active in bringing about the intervention's effect on behaviour. For instance, when 'attending' brings about an intervention's effect, it qualifies as an MoA. However, people can attend to stimuli more generally, i.e., not only in an intervention. The MoA Ontology's structure needs to capture that MoAs work through entities, e.g., 'attending''.	Attending and happiness	The MoA Ontology needs to be restructured through discussion between experts to capture the nature of MoAs more accurately.
Usability and comprehensibility of the MoA Ontology's structure	While linking classes in the MoA Ontology to classes in BFO was considered important, the experts did not find the MoA Ontology's structure user friendly for behavioural scientists who are unfamiliar with BFO classes.	Specifically dependent continuant	Further discussions between the behavioural experts and the ontology expert could help reformulate the MoA Ontology's upper levels. BFO classes could be used to define and structure classes, but not be presented in a user-friendly version of the MoA Ontology, thus reducing potential confusion.
Usability: Granularity of the MoA Ontology	Some classes in the ontology were considered too detailed. These classes added to the complexity of the ontology's structure without specifying features of MoAs that would be often targeted in behaviour change interventions.	Cleanliness injunctive norm, some subclasses of capability and belief	Judgements on which classes to include in the MoA Ontology needed to be re-evaluated more critically. The level of detail needed to be limited to develop a more useable ontology.
Reuse of classes from another ontology	The ontology expert explained that the classes 'cognitive representation' and 'appraisal' were used differently in the MoA Ontology to the manner intended by the Emotion and Mental Functioning Ontologies. The authors of the MoA Ontology's first draft interpreted 'cognitive representation' as neural pathways that can represent complex concepts when activated.	Cognitive representation and appraisal	Discussions between the behavioural science experts and the ontology expert were necessary to clarify on how to reuse the classes 'cognitive representation' and 'appraisal' in the MoA Ontology. Their subclasses

Theme	Concern	Example classes	Proposed solution
	Therefore, they organised complex classes, such as 'plan' and 'identity', as the subclasses of 'cognitive representation'. However, the ontology expert explained that 'cognitive representation' refers to activated representations of a mental disposition, such as a belief, in the Mental Functioning Ontology. For instance, a person can generally hold a belief about the environment. When this belief is activated, the person has a specific cognitive representation about the environment. In the Emotion Ontology, the class 'appraisal' was also only intended to capture evaluations in the context of emotions, whereas the MoA Ontology draft used this class for evaluations more generally.		in the MoA Ontology also needed to be re-evaluated to judge their appropriate parent class.
Relationships of some classes	A structural concern was that the MoA Ontology defined 'opportunity' as a quality, but did not specify where this quality inheres in. According to BFO, a quality needs to inhere in (i.e., belong to) an independent continuant (e.g., a person or a setting). This meant that the MoA Ontology needed to clearly specify whether opportunity was a quality of the person or environment.	Opportunity and the subclasses of opportunity	The decision on how to conceptualise the class 'opportunity' required further expert discussions.
Missing entities	The experts identified that several classes that needed to be in the MoA Ontology were missing. For instance, classes for bodily structure, environmental systems and roles were considered important classes for the MoA Ontology but were currently not included.		The experts suggested that the classes that should be added to the MoA Ontology needed to be judged after the structure of this ontology was revised.

4.5   Discussion

To develop a draft of the MoA Ontology that aligned with OBO Foundry principles, the current study aimed to identify classes for the ontology, develop clear labels and definitions for these classes and arrange them in a logical hierarchical structure. Drawing on the MoA groups and ungrouped MoAs from Study 2 and classes in other ontologies, the preliminary MoA Ontology included 412 classes organised on eight hierarchical levels. Of these classes, 102 were imported from other ontologies, such as the Gene Ontology, the Mental Functioning Ontology and the Emotion Ontology. The remaining 310 classes were developed specifically for the MoA Ontology.

The expert review suggested that this version of the ontology needed to be reorganised, in order to reduce the ontology's complexity (e.g., limit the specificity of classes). The experts also suggested that the ontology's structure needed to capture the nature of MoAs more accurately. In addition, closer collaboration between the behavioural science and ontology experts was proposed to better align the MoA Ontology's structure and definitions with relevant ontologies. These improvements to the MoA Ontology required a separate study consisting of iterative expert reviews to refine the ontology.

To develop the MoA Ontology, the current study needed to flexibly apply different OBO Foundry principles due to the limitation of other ontologies or disagreements with the definitions or structure of other ontologies. By reusing the classes from other ontologies, the researchers aimed to increase the interoperability of the MoA Ontology with other ontologies in line with the principle 'Commitment to collaboration' (Arp et al., 2015; Masci et al., 2009; OBO Foundry, 2019b). According to this principle, the

definitions and labels were also imported. However, some class labels and definitions were very complex or did not comply with the principles for writing 'good' ontological definitions (Arp et al., 2015; Michie et al., 2019; Seppälä et al., 2017; OBO Foundry, 2019g). For these class labels and definitions to be clear and usable, they might need to be refined at a later stage of the MoA Ontology's development.

This study revealed that the previous definition for MoAs ('processes that are potentially causally active in bringing about the impact of a behaviour change intervention on the outcome behaviour') had a too limited scope to account for classes that needed to be represented in the MoA Ontology. In Study 2, constructs had been identified as potential MoAs, when they were defined as a process of change or changeable entity. Changeable entities (e.g., a belief) were included under the premise that they could be represented as changes in these entities. For instance, 'belief' was included as an MoA under the assumption that respective theories were referring to 'change in a belief.' However, ontologies, such as the Mental Functioning Ontology, revealed complex relationships between continuants (e.g., 'belief') and processes (e.g., 'judging'). For instance, judging was defined as 'a mental process during which a decision is made and the outcome of which is a belief or opinion' (Hastings et al., 2012). Therefore, both continuants (e.g., 'belief') and the processes that they participate in (e.g., 'judging') need to be included in the MoA Ontology.

As other ontology developers have emphasised, the same terms (e.g., anger) can be used to refer to dispositions and processes (Hastings et al., 2011). By identifying separate classes from some MoA groups from Study 2, the current study showed that the distinctions between different uses of terms were previously insufficiently considered

when grouping MoAs. For instance, from instances organised under the MoA group 'Choice and decision-making', two separate classes could be identified: 'judging' (the process during which a decision can be formed) and 'decision' (an outcome of judging).

4.5.1 Challenges developing the MoA Ontology

As some MoAs derived from theories were labelled and/or defined ambiguously, a challenge when developing classes for the MoA Ontology was judging their parent class in other ontologies. Some MoAs' definitions used terms that could be verbs or nouns, making it difficult to understand whether these MoAs referred to processes or continuants. For example, the MoA 'propositional categorisation' was defined as 'categorisation through which semantic concepts emerge from the impulsive system'. 'Categorisation' could indicate the process of mentally categorising information or the mental disposition to categorise information a certain way. The ambiguity in labels and definitions of theoretical constructs meant that the judgements on selecting classes and judging their parent classes involved subjectivity.

As the current study attempted to represent all unique MoAs identified from behavioural theories, the MoA Ontology became too complex and difficulty to use. The current study's methodology did not sufficiently balance the comprehensiveness of the ontology with its usability. In addition, it was challenging to accurately reuse classes from other ontologies, as the developers of the MoA Ontology's current version did not have the domain expertise to interpret certain classes. By collaborating more closely with experts involved in updating the Mental Functioning Ontology and Emotion Ontology, these ontologies can be used more appropriately or updated to align with thinking in the behaviour change field.

4.5.2 Implications

The current study implied that the previous 'MoA' definition as 'process' used in this thesis needed to be reconsidered, as MoAs work through continuants (e.g., dispositions) and processes. Another implication was that when drawing on other ontologies, MoA Ontology developers need to critically evaluate whether the relevant classes are clearly defined and comprehensible for potential ontology users. As suggested by the OBO Foundry (2019b), these classes and how they are defined should also be negotiated with other ontology developers.

More generally, as many theoretical constructs (e.g., anger) can be conceptualised as processes, or dispositions, behavioural theories need to carefully use terms to define these constructs. By drawing on theoretical constructs to develop clearly differentiated classes, the MoA Ontology could support theory authors and intervention designers in labelling, defining and reporting MoAs. For instance, by specifying a 'belief' as an outcome of 'judging', the MoA Ontology can provide a more precise language to describe these constructs. The class 'belief' would specify a mental disposition that needs to be changed or manifested in order to change behaviour, while 'judging' would specify the process through which changes in the 'belief' occur.

4.5.3 Future research

To refine the preliminary MoA Ontology to be ontologically correct, extensive yet usable, it needs to be iteratively reviewed and revised by behavioural science and ontology experts. The ontology expert working with the Human Behaviour-Change Project (Michie et al., 2017) is also a developer of the Mental Functioning and the Emotion Ontologies, and thereby can help better align the MoA Ontology's with these

ontologies. Following the development of the MoA Ontology's next version, the clarity of the ontology's labels and definitions needs to be investigated by applying them to annotate (i.e., code) hypothesised MoAs in the literature. In addition, a wider range of behavioural and social experts need to be consulted to improve the ontology's usability.

4.5.4   Conclusion

To develop an MoA Ontology that is useful to social and behavioural scientists and that is interoperable with other ontologies, this ontology needs to be logically structured, have 'good' ontological definitions and align with other relevant ontologies. By drawing on candidate classes from the MoA groups and ungrouped MoAs identified in Study 2 and other ontologies, the preliminary version of the MoA Ontology includes and defines classes that capture an extensive range of MoAs. This version also specified the hierarchical relationships between these classes. As the feedback from the expert review revealed that this version of the ontology was too complex to be useful, the MoA Ontology's structure needs to be reorganised. Therefore, the ontology will be refined through more active feedback from behavioural science experts and an ontology expert.

5 Chapter 5: Developing a version of the Mechanisms of Action Ontology that is ontologically correct, comprehensive and usable (Study 4)

5.1 Abstract

Rationale: In Study 3 reported in Chapter 4, ontological classes were developed for each unique mechanism of action (MoA) identified from behavioural theories. The resulting ontology was judged to be too large, complex and granular to be usable.

Aim: To develop a version of the MoA Ontology that is ontologically correct, comprehensive and yet not too large to be usable.

Methods: Drawing on the classes in the previous version of the MoA Ontology, three experts (two behavioural science experts and an ontology expert) selected broad classes that comprehensively captured MoAs to be the upper-level classes of the new version of the ontology, MoA Ontology version 1.2 (v1.2). These classes were then structured, labelled and defined. Next, a researcher and another behavioural science expert judged which lower-level classes in the ontology's previous version captured important distinctions in behavioural theories and behaviour change interventions. These classes were added to the MoA Ontology v1.2. To ensure that the ontology was comprehensively structured, new classes were added, labelled and defined where necessary. The experts judged whether any classes in the MoA Ontology v1.2 should be added or removed by considering the ontology's usability, comprehensiveness, and parsimony. They also judged whether any class labels and definitions were unclear or difficult to understand, and suggested changes where relevant. Accordingly, the ontology was updated.

Results: The MoA Ontology v1.2 has seven hierarchical levels with 202 classes. The upper-level classes shown to ontology users include classes, such as 'MoA through

anatomical structure', 'MoA through personal role' and 'MoA through bodily disposition'.

Conclusions and implications: There are fewer and more parsimonious classes in the MoA Ontology v1.2 than in the previous version. Therefore, the resulting ontology is more coherent and usable for annotations (i.e., coding) of the MoAs in behaviour change intervention reports.

5.2 Introduction

The preliminary version of the Mechanism of Action (MoA) Ontology (v1.1), developed in Study 3 (see Chapter 4), attempted to capture all the unique MoAs identified from 83 behavioural theories in Study 2 (see Chapter 3). However, the resulting ontology was considered too complex and excessively granular for potential users. Moreover, Study 3 revealed that while MoAs had been defined as processes in the Behaviour Change Intervention Ontology (BCIO), not all the classes in the MoA Ontology v1.1 could be conceptualised as processes. For instance, 'belief' (a mental disposition) needed to be included in the MoA Ontology but is not a process. Therefore, the definition for 'mechanism of action' itself needed to be updated to capture different aspects of an MoA. Finally, to ensure the MoA Ontology appropriately reused classes from other ontologies, classes in this ontology needed to be reviewed by and negotiated with a developer of the Emotion and Mental Functioning Ontologies (Hastings, Ceusters, Smith, & Mulligan, 2011; Hastings, Ceusters, Jensen, Mulligan, & Smith, 2012)

5.2.1 Usability and Coherence of Ontologies

The MoA Ontology should include a wide range of classes relevant to MoAs in behaviour change interventions. However, the MoA Ontology also needs to be usable and coherent, to promote its uptake by intervention developers, practitioners and policymakers (Gómez-Pérez, 2001; Vigo, Bail, Jay, & Stevens, 2014). The MoA Ontology should not unnecessarily add to the complexity of the behaviour change field (see Chapter 1). There needs to be balance in producing an ontology that is comprehensive and sufficiently complete while still being understandable and of a usable size. An ontology is considered 'complete' if it contains all the classes and

relationships that are needed for its intended purpose (Gómez-Pérez, 1995). The intended purpose of the MoA Ontology is to facilitate the synthesis of knowledge about MoAs in behaviour change interventions across various target behaviours and contexts. If others find that classes with greater levels of granularity are needed to apply the MoA Ontology in their particular context, these classes can be added to the ontology at a later date (Open Biological and Biomedical Ontology [OBO] Foundry, 2019b, 2019c).

5.2.2 Representing the nature of MoAs accurately in the MoA Ontology

MoAs were defined as 'processes that are potentially causally active in bringing about the effect on an intervention on the outcome behaviour' in Study 2. Therefore, a construct only qualifies as an MoA when it is potentially active in producing the impact of an intervention on behaviour. For instance, 'happiness' is an MoA when an intervention changes or maintains a person's happiness level and thereby behaviour. In contrast, happiness experienced due to witnessing a beautiful naturally occurring phenomenon, such as a spectacular sunset, would not meet the definition of an MoA. In the case of the example intervention, the MoA works through 'happiness.' Therefore, the MoA Ontology's structure needed to clearly represent MoAs in terms of the entities that they work through (e.g., MoA works through entity x).

The previous definition for MoAs ('processes that are potentially causally active in bringing about the impact of a behaviour change intervention on the outcome behaviour') implied that all subclasses of MoAs needed to be processes. However, in Study 3, this definition proved too limited to capture all the entities that MoAs can work through. For instance, MoAs could work through mental dispositions, such 'beliefs.' While a 'belief' would not qualify as an MoA by itself, it could be part of the process

that changes a behaviour. As described in Study 3, many theories do not distinguish between mental dispositions (defined as: 'A bodily disposition that is realized in a mental process'), such as 'belief', and the processes that change these dispositions (e.g., 'judging'). However, the MoA Ontology should represent a wide range of entities MoAs work through. Therefore, the formal definition of an MoA needed to be broadened to capture that MoAs can work through processes as well as other types of entities (e.g., dispositions).

5.2.3   Collaborating with developers of other relevant ontologies

To increase the MoA Ontology's interoperability with existing ontologies, MoA Ontology v1.1 reused some classes from the Emotion Ontology and Mental Functioning Ontologies, even when the classes' definitions did not reflect principles for 'good' ontological definitions (Michie, West, & Hastings, 2019; OBO Foundry, 2019b, 2019g; Seppälä, Ruttenberg, & Smith, 2017). Therefore, there was a need to discuss potential revisions to these classes with a developer of the Emotion and Mental Functioning Ontologies. In addition, to ensure that classes from these ontologies were appropriately reused, some reused classes' labels and definitions were flagged as requiring further clarification from the ontology expert (JH). For instance, the ontology expert (JH) noted that 'cognitive representation' was used differently in the MoA Ontology v1.1 than the manner that she and her co-developers intended in the Mental Functioning Ontology (Hastings et al., 2012).

5.2.4   Developing the MoA Ontology v1.2

To develop an ontologically correct, comprehensive, and usable MoA Ontology v1.2, the MoA Ontology v1.1 needed to be reorganised with a top-down approach. Firstly, the

ontology's structure needed to reflect that MoAs are viewed as working through the ontology's classes. Next, appropriate upper-level classes for the MoA Ontology v1.2 needed to be identified from the MoA Ontology v1.1 or new classes needed to be created if required. For upper-level classes reused from the Emotion and Mental Functioning Ontologies, their definitions needed to be discussed with a developer of those two ontologies to ensure the classes were reused correctly or to revise the classes' definitions in the Mental Functioning or Emotion Ontologies.

The lower-level classes for the MoA Ontology v1.2 then needed to be selected from the classes in the MoA Ontology v1.1, by judging which of these classes captured important distinctions between MoAs in behavioural theories or behaviour change interventions. Additional lower-level classes needed to be created to ensure that the MoA Ontology was sufficiently comprehensive. Finally, when the parent classes of lower-level classes had changed, the lower-level classes' definitions needed to be updated to reflect the new parent classes.

5.2.5   Aims and research questions

To develop an ontologically correct, comprehensive and yet usable MoA Ontology, the current study aimed to identify appropriate upper-level classes, include lower-level classes from the MoA Ontology v1.1 judged as important in behavioural theories or intervention reports and create new classes where necessary. Figure 5-1 presents an outline of the studies to develop the MoA Ontology in this thesis, with the current study highlighted. In order to achieve this study's aims, the following research questions were investigated:

1. What are the appropriate upper-level classes in the MoA Ontology v1.2 for this ontology to be ontologically correct, comprehensive yet usable?

2. Given the revised upper-level classes, which lower-level classes should be retained unchanged from the MoA Ontology v1.1?

3. Given the revised upper-level classes, which lower-level classes from MoA Ontology v1.1 require updated definitions?

4. Given the revised upper-level classes, what lower-level classes should be created to complete a comprehensive yet usable MoA Ontology v1.2?
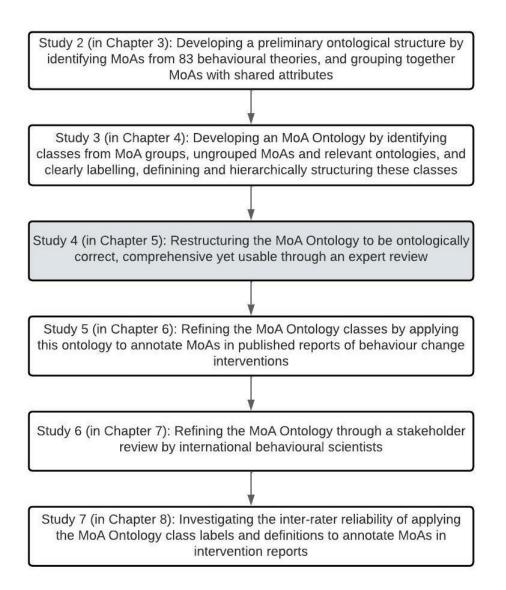
Figure 5-1. Studies used to develop the MoA Ontology in this thesis, with the current study highlighted

5.3   Methods

Developing the MoA Ontology v1.2 involved two broad steps: first identifying, defining
and structuring the upper-level classes and then the lower-level classes of the ontology.
These steps were carried out by a researcher with MSc level qualification relevant to
behaviour change (the author of this thesis, PS), three behavioural science experts (AW,
SM & RW) and an ontology expert (JH). The ontology expert was also involved in
developing the Emotion and Mental Functioning Ontologies.

5.3.1   Step 1: Identifying, defining and structuring upper-level classes of the MoA Ontology v1.2

The behavioural science and ontology experts discussed whether the definition for an
'MoA' should be refined and recorded any changes to the definition. The experts also
discussed how to conceptualise the classes in the MoA Ontology as being entities
through which the MoA process works. Each entity was considered ontologically as
'MoA through [name of entity].' In other words, when we refer to 'MoA through X',
this is taken to mean 'MoA in which the causal influence occurs by influencing X.' This
enables the MoA Ontology to be ontologically correct, while also dealing with the fact
that people often refer to things other than processes when talking about MoAs. Any
kind of entity can be included in this scheme because the MoA is defined as working
through the entity – regardless of whether the entity itself is a process, an object or a
disposition (i.e., an attribute that is expressed through a process when appropriate
triggers are encountered).

The next task was to identify a small set of classes that could serve as the highest
domain-specific level of the MoA Ontology. Three experts (JH, SM & RW) reviewed

the classes in version 1.1. The experts judged which classes would help broadly and comprehensively capture the MoAs of behaviour change interventions in the ontology. The experts also judged whether any new upper-level classes needed to be added to the MoA Ontology v1.2 to comprehensively capture the different pathways by which MoAs can operate.

In the next step, the researcher and one expert (AW) developed definitions for the new upper-level classes, following good practice in creating ontological definitions (Michie et al., 2019). All definitions for the upper-level classes in the MoA Ontology v1.2 were next reviewed by experts SM, RW and JH. They judged whether each class's definition adequately captured the intended meaning, suggested revisions to definitions if required and specified an appropriate parent class for each class. The ontology was revised accordingly. For classes from the Emotion and Mental Functioning Ontologies identified as potentially suitable for reuse in the upper level of MoA Ontology v1.2, the experts AW, SM and RW judged whether their definitions needed to be modified. If so, they negotiated definitions with ontology expert (JH). The relevant classes, together with their new definitions, formed the domain specific upper level for MoA Ontology v1.2.

To structure these upper-level classes and link them to the Basic Formal Ontology (BFO; Arp, Smith, & Spear, 2015), their parent classes were recorded up to the BFO level. These parent classes were considered necessary to structure the upper-level MoA Ontology v1.2 but too broad to be conceptualised as entities that MoAs would work through. Therefore, these classes were not presented as part of the MoA Ontology v1.2's domain specific upper level.

5.3.2 Step 2: Identifying, defining and structuring lower-level classes of the MoA Ontology v1.2

To select lower-level classes that should be prioritised for inclusion in the MoA Ontology v1.2, the researcher and the expert AW reviewed each class in the MoA Ontology v1.1. To judge whether a class should be included in the MoA Ontology v1.2, they used the following iteratively developed principles:

1. As upper-level ontology classes capture broader entities, classes from levels 1-6 of the eight hierarchical levels in MoA Ontology v1.1 were included, unless:

   a. The class definition had insufficient differentiating attributes from its parent or another class in the ontology

   b. The class differed from its parent class only by specifying that that the class was about a specific aspect of behaviour, the environment or the self (e.g., 'belief about task difficulty')

   c. The class differed from its parent class by defining a specific application or use of the parent class (e.g., 'decision simplification by combining probabilities of identical outcomes' and 'certainty effect heuristic process')

   d. The class was different from another class only by specifying the topic to which the other class was applied (e.g., 'perceived importance of X')

   e. The class was not identified from the 83 behavioural theories and did not serve as parent class of other classes in the MoA Ontology (e.g., some subclasses of 'emotion process')

   f. The class was a process described only in terms of its aim, where it was impossible to determine from the definition how the process occurred (e.g., 'searching for solutions to health risks')

2. Classes that would be excluded under criteria 1(a) – 1(f) could be retained in the ontology if they were judged to be frequently investigated in studies of behavioural theories or behaviour change interventions (based on the research team's knowledge of the evidence), and thereby useful to potential ontology users

3. To avoid introducing excessive granularity, classes from levels 7 and 8 of the MoA Ontology v1.1 were excluded, unless the distinction between the class and its parent class was judged to be important in behaviour theories (based on team's knowledge of relevant evidence)

Working separately, the researcher and expert decided whether each class should be included or excluded from MoA Ontology v1.2. When they were uncertain about or excluded a class, they recorded the reasons for their uncertainty or the exclusion. For included or uncertain classes, the researcher and expert also suggested an appropriate parent class in the MoA Ontology v1.2. Next, they discussed and reconciled their judgements on each class, creating the first draft of the MoA Ontology 1.2. Where necessary, classes' definitions were updated to reflect changes in their parent classes, and these classes were reorganised in the ontology accordingly. For transparency and for future reference, a list was kept of all the classes from the MoA Ontology v1.1 that were removed.

5.3.2.1 *Review of draft MoA Ontology v1.2 classes by behavioural science experts and an ontology expert*

The draft MoA Ontology v1.2 was presented to experts JH, SM and RW for review. The experts were prompted to consider whether each included class met the criteria

described above. They also reviewed whether any classes that the researcher and expert AW were uncertain on should be included in the MoA Ontology v1.2. For classes included in the MoA Ontology v1.2, the three experts also reviewed whether their labels and definitions were clear and met the standards for good ontological definitions (Michie et al., 2019; OBO Foundry, 2019g; Seppälä et al., 2017). If not, the experts suggested improvements. To provide additional information for certain classes, the experts could suggest synonyms for their labels. Finally, the experts were asked to add new classes to the ontology if they thought these were needed to make the ontology more comprehensive.

The three experts discussed their feedback with the researcher and expert AW. Based on these discussions, the MoA Ontology v1.2's classes, labels and definitions were updated. In addition, the hierarchical relationships between classes were specified by drawing on the relationships recorded in the MoA Ontology v1.1. The ontology structure was refined as described at the start of this Methods section. For any questions regarding the hierarchical relationships in the Mental Functioning and Emotion Ontologies, the ontology expert was consulted.

5.4 Results

5.4.1 Upper-level classes in the MoA Ontology v1.2

The definition of 'MoA' was specified as an 'attribute of the process by which a behaviour change intervention influences the behaviour' in order to capture that MoAs work through various types of entities, including processes and dispositions. A process attribute refers to a selected aspect of a process that is not the full process. To capture classes in the MoA Ontology as entities through which the MoA process works, the experts also decided to present the ontology's upper-level classes as 'MoA works through entity x', as shown in Figure 5-2. For instance, an MoA working through the class (entity) 'belief' can be captured as 'MoA works through belief'. However, to simplify the MoA Ontology v1.2's presentation, only the classes (entities) that MoAs work through are shown in the ontology's final version.
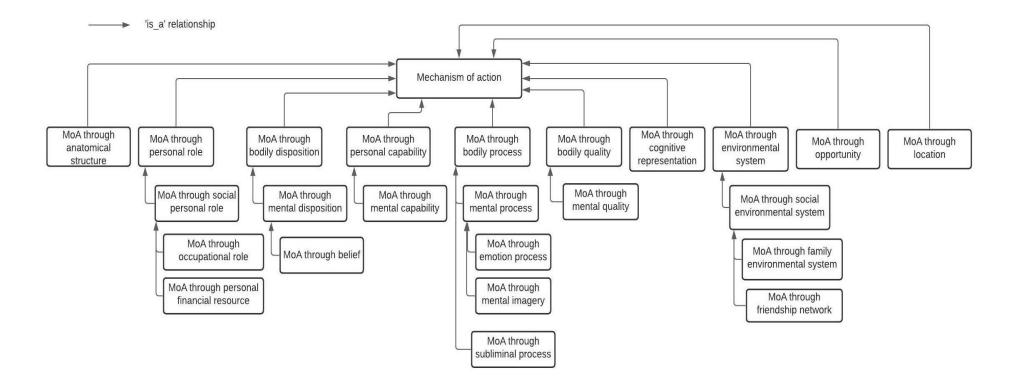
Figure 5-2. Representation of upper-level MoAs in the MoA Ontology

Ten classes were selected from the MoA Ontology v1.1 as upper-level classes in the MoA Ontology v1.2, because experts judged these classes to broadly capture a wide range of MoAs. For instance, 'mental disposition' and its parent class 'bodily disposition' were selected as upper-level classes. Following the expert review, some class labels and definitions were refined to be clearer, reflect changes in the ontology or align with other ontologies. For instance, the experts decided that the class 'psychological capability' in the MoA Ontology overlapped with the 'mental capability' class in the Mental Functioning Ontology (Hastings et al., 2012). To align more closely with Mental Functioning Ontology, the class 'mental capability' was reused for the 'psychological capability' class, and its label and definition were updated accordingly. A record of the changes made to the labels and definitions of classes selected from the MoA Ontology v1.1 is presented in Appendix 5-1.

To comprehensively capture MoAs, three classes from other ontologies, which had not been included in the MoA Ontology v1.1, were reused in the v1.2. These classes were 'bodily quality' and 'mental quality' from the Mental Functioning Ontology (Hastings et al., 2012) and 'anatomical structure' from the Uber-anatomy Ontology (Mungall, Torniai, Gkoutos, Lewis, & Haendel, 2012). In addition, 11 new classes were developed as upper-level classes for the MoA Ontology v1.2. For instance, the class 'location' was added to the ontology to capture that an MoA can work through a person's location relative to an aspect of the intervention. One new class 'environmental system' was inspired by the class 'environmental system' in the Environment Ontology, which was defined as 'a system which has the disposition to environ one or more material entities' (Buttigieg et al., 2013). However, the definition of the class was simplified to read as 'a system which has the disposition to *surround and interact* with one or more material

entities' in the MoA Ontology. Some of these classes, such as 'family environmental system', were adapted from classes in the MoA Ontology v1.1 (e.g., 'family social influence process'). Two of the new classes, 'mental imagery' and 'subliminal process,' were developed with expert JH and subsequently added to the Mental Functioning Ontology (Hastings et al., 2012).

Altogether, 24 classes were identified as upper-level classes in the MoA Ontology v1.2. The labels and definitions of these upper-level classes and their ontologically precise formulations ('MoA works through entity x') are presented in Table 5-1.

Table 5-1. The 24 classes selected as domain-specific upper-level classes of the MoA Ontology v1.2

Level 1	Level 2	Level 3	MoA definition	Label of the class the MoA works through	Definition of the class the MoA works through
MoA through anatomical structure			MoA in which the causal influence occurs by influencing the bodily structure.	Anatomical structure UBERO:000006 1	A material anatomical entity that is a single connected structure with inherent 3D shape generated by coordinated expression of the organism's own genome.
MoA through personal role			MoA in which the causal influence occurs by influencing a personal role.	Personal role	A role that inheres in a human being by virtue of their social and institutional circumstances.
	MoA through personal social role		MoA in which the causal influence occurs by influencing a social role.	Personal social role	A personal role that is realised in human social processes.
		MoA through occupation al role	MoA in which the causal influence occurs by influencing an occupational role.	Occupational role	A social role that involves the person's occupation.
	MoA through personal financial resource		MoA in which the causal influence occurs by influencing a personal financial resource.	Personal financial resource	A personal role in which the individual has access to a material or an immaterial entity which may confer economic benefits.
MoA through bodily disposition			MoA in which the causal influence occurs by influencing a bodily disposition.	Bodily disposition MF:0000032	A bodily disposition is a disposition that inheres in some extended organism.
	MoA through mental disposition		MoA in which the causal influence occurs by influencing a mental disposition.	Mental disposition MF:0000033	A mental disposition is a bodily disposition that is realized in a mental process.
		MoA through belief	MoA in which the causal influence occurs by influencing a belief.	Belief MF:0000041	A belief is a disposition to mental processes that represent some proposition X to be true.

Level 1	Level 2	Level 3	MoA definition	Label of the class the MoA works through	Definition of the class the MoA works through
MoA through personal capability			MoA in which the causal influence occurs by influencing personal capability.	Personal capability MF:0000043	A disposition inhering in an organism whose realization in the normal case brings benefits to an organism or group of organisms, where "in the normal case" means not only in the normal range on the scale, but also in a context which is normal for the group to which the bearer or user belongs.
	MoA through mental capability		MoA in which the causal influence occurs by influencing mental capability.	Mental capability MF:0000048	A capability that necessarily includes mental processes in its realisation.
MoA through bodily process			MoA in which the causal influence occurs by influencing a bodily process.	Bodily process OGMS:0000060	A process in which at least one bodily component of an organism participates.
	MoA through mental process		MoA in which the causal influence occurs by influencing a mental process.	Mental process MF:0000020	A bodily process that is of a type such that it can of itself be conscious.
		MoA through emotion process	MoA in which the causal influence occurs by influencing an emotion process.	Emotion process MFOEM:000001	A mental process that involves a complex aggregate of constituent processes, is valanced and has an object.
		MoA through mental imagery	MoA in which the causal influence occurs by influencing imagery.	Mental imagery MF:0000083	A mental process that evokes the visual representation of objects or events when these are not immediately present to the senses.
	MoA through subliminal process		MoA in which the causal influence occurs by influencing a subliminal process.	Subliminal process MF:0000088	A bodily process that involves neuronal activity in response to a sensory stimulus but which is not the subject of consciousness.
MoA through bodily quality			MoA in which the causal influence occurs by influencing a bodily quality.	Bodily quality MF:0000074	A quality that inheres in some extended organism.
	MoA through mental quality		MoA in which the causal influence occurs by influencing a mental quality.	Mental quality MF:0000075	A bodily quality that inheres in those structures of the extended organism that are essential for mental functioning.

Level 1	Level 2	Level 3	MoA definition	Label of the class the MoA works through	Definition of the class the MoA works through
MoA through cognitive representation			MoA in which the causal influence occurs by influencing a cognitive representation.	Cognitive representation MF:0000031	A representation which specifically depends on an anatomical structure in the cognitive system of an organism.
MoA through environmental system			MoA in which the causal influence occurs by influencing an environmental system or an aspect of this system.	Environmental system	A system which has the disposition to surround and interact with one or more material entities.
	MoA through social environmental system		MoA in which the causal influence occurs by influencing a social environmental system or an aspect of this system.	Social environment system	An environmental system that consists of people, social and cultural institutions and processes involving these that influence the life of people and social groups.
		MoA through family environment system	MoA in which the causal influence occurs by influencing a family environment or an aspect of this environment.	Family environment system	A social environmental system that consists of persons related as members of a domestic group, or a number of domestic groups linked through descent from a common ancestor, marriage, or adoption.
		MoA through friendship network	MoA in which the causal influence occurs by influencing a friendship network or an aspect of this network.	Friendship network	A social environmental system that consists of persons who share a bond of mutual affection and are in contact or communication among which transmission of knowledge, behaviour, values or of an infectious agent is possible.
MoA through opportunity			MoA in which the causal influence occurs by influencing an opportunity.	Opportunity	A quality of a person's environmental system that makes a behaviour possible or facilitates it.
MoA through location			MoA in which the causal influence occurs by influencing the location of people or objects.	Location	A spatial quality inhering in a bearer by virtue of the bearer's spatial location relative to other objects in the vicinity.

To structure these 24 upper-level classes, eight classes were added to serve as parent classes up to BFO level (Arp et al., 2015). For instance, the BFO class 'role' was recorded as parent class for 'personal role' in the MoA Ontology. To avoid adding complexity to the ontology, the granular parent classes of 'anatomical structure' and 'environmental system' (e.g., 'system') were not added to the ontology. Instead, to serve as a more general parent class for these two classes, the BFO class 'independent continuant' was recorded. At the end of this step, 32 classes were added to the MoA Ontology v1.2 (see Table 5-2).

5.4.2   Lower-level classes in the MoA Ontology

From the MoA Ontology v1.1, 88 classes were retained unchanged for the MoA Ontology v1.2, as these classes captured clear distinctions between MoAs and had appropriate parent classes. For instance, 'awareness', 'social influence process' and 'motivational orientation' were reused with the same definitions from the ontology's previous version. These 88 classes also included some lower-level classes, which specified important theoretical distinctions between potential MoAs. For instance, the classes 'perceived descriptive norm' and 'perceived injunctive norm' differentiated between types of normative beliefs specified in interventions and behavioural theories (Deutsch & Gerard, 1955; West & Brown, 2013).

An additional 65 classes were retained from the MoA Ontology v1.1, but their labels and/or definitions were updated following experts' feedback. For instance, one class label was change from 'perceived regulatory fit process' to 'experiential rightness of goal pursuit', because the updated label would be easier to understand for researchers unfamiliar with behavioural theories. The label 'perceived regulatory fit process' was

recorded as a synonym for the class. Some class labels and/or definitions were also updated to reflect changes in their parent classes. For instance, following the ontology experts' feedback, the parent class of 'identity' was changed from 'cognitive representation' to 'mental disposition'. To reflect this change, the definition of 'identity' was updated from 'a cognitive representation relating to how one perceives oneself' to 'a mental disposition relating to perceptions of oneself.' To keep an account of the changes to these classes, their labels and definitions from v1.1 and v1.2 are presented in Appendix 5-1.

The definitions of the classes reused from the Emotion and Mental Functioning Ontologise, 'judging', 'communication', 'thinking' and 'anxiety', were revised so that these classes could be successfully reused in the MoA Ontology. For instance, to simplify the 'communication' definition, it was changed to be 'an interpersonal process that involves the transmission of information between two organisms' from 'an interpersonal process that involves as participant at least two linguistically capable organisms, one of whom produces an utterance that is well-formed in a given language and the other of whom perceives and understands that utterance by virtue of their recognition of the meaning of the utterance through their knowledge of the language.' As no definition could be found for 'bodily feeling' in the Emotion Ontology, a definition for this class was also added with the help of the relevant expert (JH): 'An affective process involving sensory experience of physiological stimuli.'

For the MoA Ontology v1.2 to capture MoAs more comprehensively, 17 new classes were created. For instance, 'semantic memory', 'procedural memory' and 'iconic memory' were added as the subclasses of 'memory' to capture different types of

memory. Some of new classes were inspired by classes in the MoA Ontology v1.1. For instance, the classes 'social skill', 'physical skill' and 'mental skill' were created based on the class labelled as 'skill' in the MoA Ontology v1.1. The three new classes became the subclasses of, respectively, 'social capability', 'physical capability' and 'mental capability.' The experts judged that these more specific classes would help better distinguish the different types of skills reported in behaviour change interventions.

At the end of this step, 170 classes were added to the ontology, bringing the total number of classes to 202 on seven hierarchical levels (see Table 5-2). For nine classes, synonyms were also added to provide potential ontology users with more guidance when applying these classes (see Appendix 5-2).

Table 5-2. The classes included in the MoA Ontology v1.2

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Purpose of selected class	New or changed from MoA Ontology v1.1?
Independent continuant BFO:017-002							b is an independent continuant = Def. b is a continuant which is such that there is no c and not such that b s-depends_on c at t.	Structure ontology	New
	Anatomical structure UBERON:0000061						A material anatomical entity that is a single connected structure with inherent 3D shape generated by coordinated expression of the organism's own genome.	Upper-level class	New
	Environmental system						A system which has the disposition to surround and interact with one or more material entities.	Upper-level class	New
		Social environment system					An environmental system that consists of people, social and cultural institutions and processes involving these that influence the life of people and social groups.	Upper-level class	New
			Family environment system				A social environmental system that consists of persons related as members of a domestic group, or a number of domestic groups linked through descent from a common ancestor, marriage, or adoption.	Upper-level class	New
			Friendship network				A social environmental system that consists of persons who share a bond of mutual affection and are in contact or communication among which transmission of knowledge, behaviour, values or of an infectious agent is possible.	Upper-level class	New
Specifically depende							b is a specifically dependent continuant = Def. b is a continuant & there is some independent continuant c which is not a spatial region and which is such that b s-	Structure ontology	Retained

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Purpose of selected class	New or changed from MoA Ontology v1.1?
nt continuant BFO:000 0020							depends_on c at every time t during the course of b's existence.		
	Dispositio n BFO:00000 16						b is a disposition means: b is a realizable entity & b's bearer is some material entity & b is such that if it ceases to exist, then its bearer is physically changed, & b's realization occurs when and because this bearer is in some special physical circumstances, & this realization occurs in virtue of the bearer's physical make-up.	Structure ontology	Retained
		Bodily disposition MF:0000032					A disposition that inheres in some extended organism.	Upper-level class	Retained
			Personal capability MF:0000043				A disposition inhering in an organism whose realization in the normal case brings benefits to an organism or group of organisms, where "in the normal case" means not only in the normal range on the scale, but also in a context which is normal for the group to which the bearer or user belongs.	Upper-level class	Label updated
				Mental capability MF:0000048			A capability that necessarily includes mental processes in its realisation.	Upper-level class	Label and definition updated
					Mental skill		A mental capability acquired through training and practice.	Lower-level class	New
					Self-regulation capability		A mental capability that involves processes that modulate the frequency, rate or extent of a response to external or internal stimuli and that are instigated by the person themselves.	Lower-level class	New
						Behaviour al self-	A behaviour undertaken to modulate the frequency, rate or extent of a different behaviour, the specific actions or	Lower-level class	Label and definition updated

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Purpose of selected class	New or changed from MoA Ontology v1.1?
						regulation capability	reactions of an organism in response to external or internal stimuli, and that is instigated by the organism itself.		
						Cognitive self-regulation capability	A self-regulation capability to modulate one's cognitive processes.	Lower-level class	New
						Emotional self-regulation capability	A self-regulation capability to modulate one's emotions.	Lower-level class	Label and definition updated
				Physical capability			A capability to perform a behaviour by virtue of muscular-skeleton attributes or psychomotor control	Lower-level class	Definition updated
					Physical skill		A physical capability acquired through training and practice.	Lower-level class	New
				Social capability			A capability to engage in interpersonal processes that influence ability to perform a behaviour, when appropriate circumstances occur.	Lower-level class	Definition updated
					Social skill		A social capability acquired through training and practice.	Lower-level class	New
			Mental disposition MF:0000033				A bodily disposition that is realized in a mental process.	Upper-level class	Retained
				Addiction ADDICTO:0000349			A chronic acquired mental disorder involving repeated abnormally powerful motivation to engage in a behaviour despite risk or experience of harm.	Lower-level class	Retained
				Alienation			A mental disposition to perceive or experience oneself as isolated from and not meaningfully involved in social groups.	Lower-level class	Definition updated
				Awareness			A mental disposition to be conscious of events, objects or sensory patterns.	Lower-level class	Retained

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Purpose of selected class	New or changed from MoA Ontology v1.1?
				Behavioural intention			A mental disposition that is a commitment to enact or not enact a behaviour.	Lower-level class	Definition updated
				Belief MF:0000041			A disposition to mental processes that represent some proposition X to be true.	Upper-level class	Retained
					Belief about barriers		A belief about the extend to which factors exist that could restrict or impede the person from engaging in a behaviour.	Lower-level class	Definition updated
					Belief about conformity to behavioural norms		A belief about the extent to which one's own behaviour is similar to that of referent others.	Lower-level class	Label and definition updated
					Belief about consequences of behaviour		A belief about the outcomes resulting from a behaviour.	Lower-level class	Retained
						Belief about social consequences of behaviour	A belief about the outcomes of a behaviour in terms of social processes or attributes.	Lower-level class	Definition updated
					Belief about consequences of goal attainment		A belief about the outcomes resulting from achieving a goal.	Lower-level class	Retained
					Belief about control over one's future		A belief about the extent to which one can direct what happens in one's future.	Lower-level class	Retained
					Belief about gain		A belief about the existence of an increase from an initial reference point.	Lower-level class	Retained

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Purpose of selected class	New or changed from MoA Ontology v1.1?
					Belief about likelihood of consequences of behaviour		A belief about the likelihood a particular behaviour will result in particular outcomes.	Lower-level class	Retained
						Belief about likelihood of health consequences of behaviour	A belief about the likelihood of a behaviour resulting in a change in a threat to health and wellbeing.	Lower-level class	Retained
					Belief about likelihood of potential outcomes		A belief about the probability that a given event or state will occur in the future.	Lower-level class	Definition updated
					Belief about loss		A belief about the existence of a decrease from an initial reference point.	Lower-level class	Retained
					Belief about message relevance		A belief regarding whether the content of a verbal, written or recorded communication is relevant to oneself.	Lower-level class	Retained
					Belief about one's environment		A belief about the nature of the immediate physical and social settings in which people live, including culture and the people and institutions with whom they interact.	Lower-level class	Retained
					Belief about severity of an outcome		A belief about how serious the harm associated with an outcome could be.	Lower-level class	Label updated
					Belief about susceptibility to a threat		A belief about how vulnerable one is to a threat.	Lower-level class	Label updated

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Purpose of selected class	New or changed from MoA Ontology v1.1?
					Belief about the desirability of consequences of behaviour		A belief about the desirability or worth of the outcomes of a behaviour.	Lower-level class	Retained
					Belief about the timing of the consequences of behaviour		A belief about whether how long after the performance of behaviour particular consequences will occur.	Lower-level class	Definition updated
					Belief about voluntariness of behaviour		A belief about the extent to which one is free to choose whether to perform the behaviour.	Lower-level class	Definition updated
					Evaluation of self		A belief about the qualities and characteristics in one's self concept.	Lower-level class	Label and definition updated
						Positive evaluation of self	A belief about the positive qualities and characteristics in one's self concept.	Lower-level class	New
						Negative evaluation of self	A belief about the negative qualities and characteristics in one's self concept.	Lower-level class	New
					Evaluative belief		A belief about whether the consequences of the behaviour are positive or negative.	Lower-level class	New
					Perceived norm		A belief about what is typical for people who belong to a particular social group.	Lower-level class	Label and definition updated

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Purpose of selected class	New or changed from MoA Ontology v1.1?
						Perceived descriptive norm	A belief about the prevalence of performance of a given behaviour by people within a group.	Lower-level class	Label and definition updated
						Perceived injunctive norm	A belief about whether a behaviour is appropriate and correct for people who belong to a particular social group.	Lower-level class	Label and definition updated
						Normative belief	A belief about whether important others think one should perform a behaviour.	Lower-level class	Retained
					Self-efficacy		A belief about one's capabilities to enact a behaviour.	Lower-level class	Definition updated
						Situational self-efficacy	A belief about one's capabilities to enact a behaviour in a particular situation.	Lower-level class	Definition updated
				Cognitive schema			A mental disposition about an entity that guides perception, thought or behaviour.	Lower-level class	Definition updated
					Action schema		A cognitive schema that guides a sequence of behaviours.	Lower-level class	Label and definition updated
				Decision			A mental disposition to represent one proposition as preferred from at least two.	Lower-level class	Retained
					Behavioural decision		A decision that one behaviour is preferred from at least two behavioural options.	Lower-level class	Label and definition updated
				Goal			A mental disposition to strive towards an end state.	Lower-level class	Definition updated
				Identity			A mental disposition relating to perceptions of oneself.	Lower-level class	Definition updated
					Social identity		Identity that is associated with the sense of belonging to a social group.	Lower-level class	Definition updated
				Knowledge			A mental disposition to understand the nature of the world, or a specific aspect of the world, that corresponds to the	Lower-level class	Definition updated

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Purpose of selected class	New or changed from MoA Ontology v1.1?
							actual state of the world and is acquired through experience or learning.		
					Knowledge regarding a behaviour		Knowledge regarding a particular set of actions.	Lower-level class	Retained
					Knowledge regarding an innovation		Knowledge regarding a novel invention or way of doing something.	Lower-level class	Retained
					Knowledge regarding a threat		Knowledge regarding a potential harm.	Lower-level class	Retained
					Knowledge regarding treatment		Knowledge regarding a therapy or medication for a health problem.	Lower-level class	Retained
				Learned stimulus-response association			A mental disposition to respond in a particular way to an event in a person's environment, which is acquired through an associative learning process.	Lower-level class	Definition updated
				Mental image disposition			A mental disposition to represent a mental image.	Lower-level class	Label and definition updated
				Willingness to comply			A mental disposition to be inclined to act in accordance with the likely approval of others	Lower-level class	Label and definition updated
				Motivational orientation			A mental disposition for motivation to be guided by a focus on the presence or absence of outcomes of a certain valence.	Lower-level class	Retained
					Prevention focused		A mental disposition for motivation to be guided by a focus on the presence or absence of positive outcomes.	Lower-level class	Retained

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Purpose of selected class	New or changed from MoA Ontology v1.1?
					motivational orientation				
					Promotion focused motivational orientation		A mental disposition for motivation to be guided by a focus on the presence or absence of negative outcomes.	Lower-level class	Retained
				Personal value			A mental disposition regarding what is fundamentally important in life and which informs standards for behaviour.	Lower-level class	Retained
				Psychological need			A mental disposition of a person to act to obtain or maintain a particular state due to this state's importance to the person's wellbeing.	Lower-level class	Label and definition updated
					Autonomy need		A psychological need to have a sense of personal agency and initiative	Lower-level class	Definition updated
					Need for self-esteem		A psychological need to have a positive evaluation of oneself and one's qualities and characteristics.	Lower-level class	Definition updated
					Need for sense of security		A psychological need to feel safe from threats.	Lower-level class	Definition updated
					Need for social relatedness		A psychological need to have caring relationships with other people.	Lower-level class	Definition updated
					Need to feel competent		A psychological need to experience oneself as able and effective.	Lower-level class	Definition updated
				Mental plan			A mental disposition to form a representation of a behaviour, the conditions under which it will be enacted and an intention to enact the behaviour under those conditions.	Lower-level class	Label and definition updated
				Self-concept			A mental disposition to represent oneself as having particular qualities and characteristics.	Lower-level class	Definition updated

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Purpose of selected class	New or changed from MoA Ontology v1.1?
				Stereotype			A mental disposition to represent attributes of members of a social group as shared by the virtue of their group membership.	Lower-level class	Definition updated
					Risk stereotype		A stereotype of a person who enacts a problem behaviour.	Lower-level class	Label and definition updated
				Social embeddedness			A mental disposition to experience a feeling of being connected by social attachments.	Lower-level class	Definition updated
				Subjective need			A mental disposition to experience a feeling of anticipated relief from, or avoidance of, mental or physical discomfort.	Lower-level class	New
				Temporal orientation			A mental disposition to focus more on present or future outcomes.	Lower-level class	Retained
		Emotional action tendency MFOEM:000007					An emotional action tendency is a disposition to behaviour that inheres in an organism by virtue of the physical changes brought about by an emotion process.	Lower-level class	Retained
	Representation MF:0000030						A dependent continuant which is about a portion of reality.	Structure ontology	Retained
		Cognitive representation MF:0000031					A representation which specifically depends on an anatomical structure in the cognitive system of an organism.	Upper-level class	Retained
			Appraisal MFOEM:000005				An appraisal is a cognitive representation which represents an evaluation of the relevance of some triggering object or event to the organism.	Lower-level class	Retained

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Purpose of selected class	New or changed from MoA Ontology v1.1?
				Appraisal of causal agency MFOEM:000075			An appraisal that represents an evaluation of who or what caused an event.	Lower-level class	Retained
					Appraisal as caused by self MFOEM:000076		An appraisal that represents an evaluation that an event was caused by the self.	Lower-level class	Retained
					Appraisal as caused by factors external to the person		An appraisal that represents an evaluation that an event was caused by factors external to the person.	Lower-level class	Retained
				Appraisal of dangerousness MFOEM:000103			An appraisal which represents an evaluation of the dangerousness of an object or situation.	Lower-level class	Retained
				Appraisal of expectedness MFOEM:000060			An appraisal that represents an evaluation of whether an event was expected to occur.	Lower-level class	Retained
				Appraisal of obligation to act			An appraisal that represents an evaluation of how much one is personally obliged to respond to an event or person in need.	Lower-level class	Retained
			Desired standard				A cognitive representation of a reference level that an individual wishes to obtain.	Lower-level class	Definition updated

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Purpose of selected class	New or changed from MoA Ontology v1.1?
			Mental image				A cognitive representation of the visual appearance of some objects or events when these are not immediately present to the senses.	Lower-level class	New
	Role BFO:0000023						b is a role means: b is a realizable entity & b exists because there is some single bearer that is in some special physical, social, or institutional set of circumstances in which this bearer does not have to be& b is not such that, if it ceases to exist, then the physical make-up of the bearer is thereby changed.	Structure ontology	New
		Personal role					A role that inheres in a human being by virtue of their social and institutional circumstances.	Upper-level class	New
			Personal social role				A personal role that is realised in human social processes.	Upper-level class	New
				Occupational role			A social role that involves the person's occupation.	Upper-level class	New
			Personal financial resource				A personal role in which the individual has access to a material or an immaterial entity which may confer economic benefits.	Upper-level class	New
	Quality PATO:0000001						A dependent entity that inheres in a bearer by virtue of how the bearer is related to other entities.	Structure ontology	Retained
		Bodily quality MF:0000074					A quality that inheres in some extended organism.	Upper-level class	New
			Mental quality MF:0000075				A bodily quality that inheres in those structures of the extended organism that are essential for mental functioning.	Upper-level class	New
		Location					A spatial quality inhering in a bearer by virtue of the bearer's spatial location relative to other objects in the vicinity.	Upper-level class	New
		Opportunity					A quality of a person's environmental system that makes a behaviour possible or facilitates it.	Upper-level class	Definition updated

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Purpose of selected class	New or changed from MoA Ontology v1.1?
			Financial opportunity				An opportunity regarding whether the person has sufficient financial resources to enact a behaviour.	Lower-level class	Definition updated
			Healthcare service accessibility				An opportunity regarding how easy it is for a person to approach and use a healthcare service.	Lower-level class	Definition updated
			Physical opportunity				An opportunity of the physical environmental system that makes a behaviour possible or facilitates it.	Lower-level class	Definition updated
			Social opportunity				An opportunity of the social environment system that influences performance of a behaviour.	Lower-level class	Definition updated
			Temporal opportunity				An opportunity regarding whether the person has sufficient time to enact a behaviour in the social and physical environment.	Lower-level class	Definition updated
Process BFO:000 0015							An occurrent that has temporal proper parts and for some time t, p s-depends_on some material entity at t.	Structure ontology	Retained
	Bodily process OGMS:000 0060						A process in which at least one bodily component of an organism participates.	Upper-level class	Retained
		Bodily behavioural cue					A stimulus that arises from bodily processes and serves to elicit or guide behaviour.	Lower-level class	Label and definition updated
			Mental behavioural cue				A stimulus that arises from mental processes and serves to elicit or guide behaviour.	Lower-level class	Label updated
		Individual human behaviour BCIO:036000					Individual human activity that involves co-ordinated contraction of striated muscles controlled by the brain.	Lower-level class	Label and definition updated

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Purpose of selected class	New or changed from MoA Ontology v1.1?
			Normative behaviour				An individual human behaviour that is commonly enacted by people that are part of a social environmental system.	Lower-level class	New
		Goal pursuit process					A bodily process in which attempts are made to achieve a desired end state.	Lower-level class	Retained
		Interpersonal process MF:0000021					A process in which at least two human beings are agents.	Lower-level class	Retained
			Communication MF:0000040				An interpersonal process that involves the transmission of information between two organisms.	Lower-level class	Definition updated
				Linguistic communication MF:0000086			A communication process in which the information that is communicated is encoded in language.	Lower-level class	New
				Non-linguistic communication MF:0000089			A communication process in which information is transmitted without being encoded in the meaning units of any language.	Lower-level class	New
				Interpersonal reciprocal communication			Communication that is mutual between two or more people.	Lower-level class	Label and definition updated
					Behaviour-influencing social interaction process		An interpersonal process in which one person's reciprocal communication with one or more others may facilitate or hinder the person's behaviour.	Lower-level class	Retained

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Purpose of selected class	New or changed from MoA Ontology v1.1?
			Social influence process				An interpersonal process where one or more person exerts an influence on the behaviour of another.	Lower-level class	Retained
		Internal reward for a response					A process by which the person experiences an internally-generated positive physical or psychological state subsequent to a response.	Lower-level class	Retained
		Experiential rightness of goal pursuit					A process by which the manner in which one attempts to achieve a goal creates an experiential sense of rightness associated with pursuing the goal, which in turn increases task engagement.	Lower-level class	Label updated
		Physiological response to emotion process MFOEM:000003					A physiological response to emotion process is a bodily process which encompasses all the neurophysiological changes caused by the appraisal, which take place in the central nervous system (CNS), neuro-endocrine system (NES) and autonomous nervous system (ANS).	Lower-level class	Retained
		Plan enactment					A process by which a person attempts to follow the steps in a plan.	Lower-level class	Retained
		Self-regulation of behaviour					A bodily process that modulates the frequency, rate or extent of behaviour, the specific actions or reactions of an organism in response to external or internal stimuli and that is instigated by the organism itself.	Lower-level class	Retained
			Behavioural self-regulation of behaviour				A behaviour undertaken to modulate the frequency, rate or extent of a different behaviour, the specific actions or reactions of an organism in response to external or internal stimuli, and that is instigated by the organism itself.	Lower-level class	Retained
			Introjected self-regulation				Self-regulation undertaken to manage a sense of guilt, anxiety or obligation.	Lower-level class	Retained

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Purpose of selected class	New or changed from MoA Ontology v1.1?
			Self-reinforcing self-regulation				A bodily process that modulates the frequency, rate or extent of behaviour through self-administering a reward for performing an intended behaviour.	Lower-level class	Retained
			Value-congruent self-regulation				Self-regulation undertaken to achieve congruence between one's values and the behaviour performed.	Lower-level class	Retained
		Mental process MF:0000020					A mental process is a bodily process that is of a type such that it can of itself be conscious.	Upper-level class	Retained
			Affective process MFOEM:000195				Any process that has positive or negative valence.	Structure ontology	Retained
				Bodily feeling MFOEM:000202			An affective process involving sensory experience of physiological stimuli.	Lower-level class	Definition added
					Pain MFOEM:000203		A bodily process in an organism S, involving two integrated levels: (a) activation of the nociceptive system and associated emotion generating brain components of S, and (b) a simultaneous aversive sensory and emotional experience on the part of S, where (b) is phenomenologically similar to the sort of aversive experience involved in pain with concordant tissue damage.	Lower-level class	Retained
				Emotion process MFOEM:000001			A mental process that involves a complex aggregate of constituent processes, is valanced and has an object.	Upper-level class	Definition updated

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Purpose of selected class	New or changed from MoA Ontology v1.1?
					Anger MFOEM:0000009		A negative emotion, characterised by feelings of unpleasantness and high arousal, in the form of antagonistic feelings and action tendencies.	Lower-level class	Retained
					Anxiety MFOEM:0000028		An emotion that is negative, aversive and provoked by the prospect of distal future threat.	Lower-level class	Definition updated
					Disgust MFOEM:0000019		A negative emotion which guards the body against dangerous foods and microbial infections.	Lower-level class	Retained
					Fear MFOEM:0000026		An activated, aversive emotion that motivates attempts to cope with events that provide threats to the survival or well-being of organisms.	Lower-level class	Retained
					Happiness MFOEM:0000042		A positive emotion which is experienced in reaction to a positive experience or event.	Lower-level class	Retained
					Pleasure MFOEM:0000035		A positively experienced emotion which is sought out (approached) and is associated with happiness, enjoyment, and satisfaction.	Lower-level class	Retained
						Sexual pleasure MFOEM:000040	A positively experienced emotion which is sought out (approached) and is associated with happiness, enjoyment, and satisfaction as a result of sexual activities.	Lower-level class	Retained
					Sadness MFOEM:0000056		A negative emotion felt when an event is appraised as unpleasant, obstructive to one's goals and concerns, and one feels unable to cope with it or modify it.	Lower-level class	Retained
					Shame MFOEM:0000055		A negative emotion that is distressing and occurs when one appraises one's behaviour or circumstance as wrong, dishonourable, immodest or indecorous.	Lower-level class	Retained
					Surprise		A neutral emotion caused by encountering unexpected events of all kinds.	Lower-level class	Retained

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Purpose of selected class	New or changed from MoA Ontology v1.1?
					MFOEM:0000 32				
				Subjective emotional feeling MFOEM:000 006			A (fiat) part of the emotion process by which the organism experiences its own emotion.	Lower-level class	Retained
					Cognitive dissonance		An unpleasant subjective emotional feeling experienced due to perceived inconsistency between two concurrently held cognitive representations.	Lower-level class	Retained
					Feeling an urge		A subjective emotional feeling that arises when an impulse to enact a behaviour is activated but not immediately acted upon.	Lower-level class	Definition updated
			Appraisal process MFOEM:000 002				An appraisal process is a mental process that gives rise to an appraisal.	Lower-level class	Retained
			Arousal MF:0000012				A physiological and psychological state of being awake or reactive to stimuli.	Lower-level class	Retained
			Attending MF:0000018				A mental process whereby relevant aspects of our mental experience are focused on specific targets.	Lower-level class	Retained
			Cognitive process MF:0000008				A mental process that creates, modifies or has as participant some cognitive representation.	Lower-level class	Retained
				Comprehens ion			A cognitive process that creates a representation of the meaning and significance of a communication, object, event or situation.	Lower-level class	Retained
				Decision simplificatio n			A cognitive process that simplifies decision making.	Lower-level class	Definition updated

249

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Purpose of selected class	New or changed from MoA Ontology v1.1?
				Thinking			A cognitive process that involves the manipulation of mental language and/or mental images.	Lower-level class	Definition updated
					Reflective thinking		Thinking that involves generation of inferences based on syllogistic reasoning or decision making based on the evaluation of anticipated consequences or the construction of propositional representations.	Lower-level class	Retained
			Dissonance reduction process				A mental process through which a perceived inconsistency between the two concurrently held cognitive representations is reduced.	Lower-level class	Retained
			Goal setting process				A mental process that establishes a cognitive representation of the end state to which one is striving.	Lower-level class	Label updated
			Heuristic process				A mental process that uses simple rules and associations learnt from experience to make judgements.	Lower-level class	Retained
			Judging MF:0000006				A mental process during which evidence is evaluated, the outcome of which is a belief or opinion.	Lower-level class	Definition updated
				Decision-making			Judging during which a decision is created.	Lower-level class	New
				Judging consequences of behaviour			Judging during which a belief about the consequences of a behaviour is created or modified.	Lower-level class	Definition updated
				Social comparison process			Judging oneself or one's social group in relation to the qualities or characteristics of another person or social group.	Lower-level class	Definition updated
			Learning GO:0007612				Any process in an organism in which a relatively long-lasting adaptive behavioural change occurs as the result of experience.	Lower-level class	Retained
				Associative learning			Learning associations or disassociations between two or more stimuli or between a stimulus and a response.	Lower-level class	Definition updated

250

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Purpose of selected class	New or changed from MoA Ontology v1.1?
					Classical conditioning		Associative learning that occurs when the pairing of a conditioned and unconditioned stimulus leads to the conditioned stimulus producing a response that would otherwise have only been produced by the unconditioned stimulus.	Lower-level class	Retained
					Discriminati on learning		Associative learning process in which people learn to distinguish between appropriate responses to similar but different stimuli depending on whether a generalised response is rewarded or not.	Lower-level class	Retained
					Extinction in classical conditioning		Associative learning process in which the strength of a conditioned response is reduced because its conditioned stimulus is presented without being accompanied by the unconditioned stimulus.	Lower-level class	Definition updated
					Extinction in operant learning		Associative learning process in which the rate of behavioural response in the presence of a discriminative stimulus is reduced because the response is no longer followed by a positive reinforcer.	Lower-level class	Definition updated
					Generalisati on (learning)		Process in which the effects of conditioning on behaviour spread to stimuli that differ in certain aspects from the stimulus present during the original conditioning.	Lower-level class	Retained
					Operant conditioning		Associative learning in which the likelihood of a particular behavioural response is influenced by the past consequences associated with performing that behaviour.	Lower-level class	Retained
				Non-associative learning GO:0046958			A simple form of learning whereby the repeated presence of a stimulus leads to a change in the probability or strength of the response to that stimulus. There is no association of one type of stimulus with another, rather it is a generalized response to the environment.	Lower-level class	Retained
					Habituation GO:0046959		A decrease in a behavioural response to a repeated stimulus.	Lower-level class	Retained

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Purpose of selected class	New or changed from MoA Ontology v1.1?
					Sensitization GO:0046960		An increase in a behavioural response to a repeated stimulus.	Lower-level class	Retained
				Observation al learning GO:0098597			Learning that occurs through observing the behaviour of others.	Lower-level class	Retained
					Imitative learning GO:0098596		Learning in which new behaviours are acquired through imitation.	Lower-level class	Retained
			Memory GO:0007613				The activities involved in the mental information processing system that receives (registers), modifies, stores, and retrieves informational stimuli.	Lower-level class	Retained
				Associative memory			The activities involved in the mental information processing system that receives (registers), modifies, stores, and retrieves informational stimuli regarding the set of entities associated with a particular object or event.	Lower-level class	Retained
				Episodic memory			The activities involved in the mental information processing system that receives (registers), modifies, stores, and retrieves informational stimuli regarding a personally experienced event at a particular time or place.	Lower-level class	Retained
				Semantic memory			The activities involved in the mental information processing system that receives (registers), modifies, stores, and retrieves meanings, understandings, and conceptual facts about the world	Lower-level class	New
				Procedural memory			The activities involved in the mental information processing system that receives (registers), modifies, stores, and automatically retrieves informational stimuli regarding how to perform a complex activity without conscious awareness	Lower-level class	New
				Iconic memory			The activities involved in the mental information processing system that receives (registers), modifies, stores, and retrieves very brief sensory memory of some visual stimuli	Lower-level class	New

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Purpose of selected class	New or changed from MoA Ontology v1.1?
			Mental categorising				A mental process in which objects, events, people, or experiences are grouped into classes, on the basis of features shared by members of the same class and features distinguishing the members of one class from those of another.	Lower-level class	Retained
			Mental imagery MF:0000083				A mental process that evokes the visual representation of objects or events when these are not immediately present to the senses.	Upper-level class	New
			Mentally comparing against a standard				A mental process in which current conditions are compared against a particular reference level.	Lower-level class	Retained
			Motivation				A mental process that energises and directs behaviour.	Lower-level class	Retained
				Automatic motivation			A mental process that energises and directs behaviour via emotions and impulses that arise from associative learning or innate dispositions.	Lower-level class	Retained
				Extrinsic motivation			Motivation in order to attain some external goal or externally imposed constraint.	Lower-level class	Retained
				Intrinsic motivation			Motivation due to the behaviour itself being interesting or enjoyable.	Lower-level class	Retained
			Perception MF:0000019				A mental process which is a) produced by a causal process (for example involving light rays or air vibrations) involving a part of the environment of the organism, and b) is experienced by the organism as being so caused, and c) in which the relevant part of the environment is thereby represented to the organism.	Lower-level class	Retained
			Planning MF:0000027				A mental process that involves mentally manipulating representations of steps in an imagined process which has some objective, e.g. to bring about a desired state of affairs.	Lower-level class	Retained

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Purpose of selected class	New or changed from MoA Ontology v1.1?
							The outcome of this mental process is a plan which has the potential to be followed to bring about the desired outcome.		
			Self-monitoring				A mental process in which one observes and evaluates one's own behaviour.	Lower-level class	Retained
			Wanting MF:0000045				A mental process that involves thinking about a state of affairs that does not yet obtain together with a desire for that state of affairs to obtain.	Lower-level class	Retained
		Subliminal process MF:0000088					A bodily process that involves neuronal activity in response to a sensory stimulus but which is not the subject of consciousness.	Upper-level class	New
	Process profile BFO:0000144						b is a process_profile =Def. there is some process c such that b process_profile_of c.	Lower-level class	Retained
		Consciousness MF:0000017					That part of the mental process that confers a subjective perspective, a phenomenology, an experience of the mental process of which it is a part; and intends the object or event that the mental process is about, should such exist; it confers intentionality on the mental process.	Lower-level class	Retained

5.4.2.1 *Classes from the MoA Ontology v1.1 that were not included in v1.2*

In total, 243 classes from the MoA Ontology v1.1 were not included in the v1.2 to limit the excessive granularity in the ontology (see principles for excluding classes in Methods section Step 2). Classes were often excluded when the researcher and experts considered that these (1) were not to be sufficiently differentiated from other classes in the ontology and (2) did not capture important distinctions between MoAs in behaviour change interventions. For instance, the subclasses of 'decision simplification' were only distinguished from their parent class by describing a specific way in which decisions were mentally simplified (e.g., 'decision simplification by disregarding shared components'). Therefore, these subclasses were excluded from the MoA Ontology v1.2, and only their parent class 'decision simplification' was kept. In another case, to limit the number of subclasses of 'emotion process', only the emotions identified from behavioural theories or well-established emotional processes (e.g., basic emotions proposed by Eckman [1999]) were included. To avoid losing track of any classes needed in later stages of the MoA Ontology's development, a list of the classes that were not included was kept (see Appendix 5-3).

5.5 Discussion

For the MoA Ontology to be ontologically correct, comprehensive and usable, the current study aimed to identify upper-level classes and lower-level classes that captured and clearly differentiated between MoAs in behaviour change interventions. In total, 202 classes were included in the MoA Ontology v1.2. Of these, 24 classes were added as domain specific upper-level classes and eight as parent classes for the upper-level classes, linking the MoA Ontology to BFO. As lower-level classes, 170 classes were included.

Compared to the MoA Ontology v1.1 with 412 classes in Study 3, the new version is less complex and more usable by having fewer classes and avoiding excessive detail in the ontology, while retaining classes relating to important MoAs suggested by behavioural theories or used by behaviour change interventions. In addition, the MoA Ontology v1.2 captured the nature of MoAs (i.e., that a behaviour change intervention's MoA works through the classes in the MoA Ontology) more accurately. In line with the principles for developing 'gold standard' ontologies (OBO Foundry, 2019b), some reused classes from the Emotion and Mental Functioning Ontologies were negotiated with a developer of these ontologies. The respective class labels and definitions were updated to align more closely with thinking in behavioural sciences or be more comprehensible. Collaborating with this developer also ensured that classes from the other ontologies were reused correctly in the MoA Ontology v1.2.

5.5.1 Limitations of the MoA Ontology v1.2

While the MoA Ontology v1.2 was developed using feedback from more researchers than the previous version, all the researchers were associated with the Human Behaviour-Change Project (Michie et al., 2017). In addition, the current methods for selecting the ontology's classes relied on researcher judgement, rather than being informed by MoAs reported in the literature. Therefore, the current classes might not capture some MoAs that are frequently hypothesised in behaviour change interventions. While the MoA Ontology developers followed principles for writing clear labels and definitions, the studies, so far, also did not investigate whether the ontology's labels and definitions can be used to capture hypothesised MoAs in the literature.

5.5.2 Future research

The next step to develop the ontology will involve a data-driven method for selecting and refining the classes, namely annotating (coding) MoAs in behaviour change reports. This will be followed by international experts in the behaviour change field not involved in the project reviewing the ontology. Any classes or definitions that do not align with broader perspectives in the behaviour change field will be revised, and any key classes that are missing from the ontology added. Accordingly, the ontology will more extensively cover classes needed to capture MoAs.

5.5.3 Conclusion

This study developed an MoA Ontology that captured a wide range of MoAs, but was more ontologically correct and usable than the previous version of the ontology, containing 202 classes instead of 412. The MoA Ontology v1.2 can be applied to annotate MoAs in behaviour change intervention reports. Through iterative refinements of the ontology, the ontology will become fit-for-purpose, allowing researchers to synthesise evidence about MoAs in behaviour change interventions.

6 Chapter 6: Refining the Mechanism of Action Ontology through annotations of mechanisms of action in published reports of behaviour change interventions (Study 5)

6.1 Abstract

Rationale: Ontologies should have clear content (classes, their labels and definitions) that is relevant to their scope, e.g., mechanisms of action (MoAs) in behaviour change interventions. To ensure that ontologies are clear and align with their intended scope, they can be tested by applying them to annotate (i.e., code) relevant information in the literature. Based on difficulties encountered during annotations, class labels and definitions can be updated to be clearer and missing classes can be added.

Aim: To refine the classes, labels and definitions of the MoA Ontology by applying this ontology to annotate hypothesised MoAs in published reports of behaviour change interventions.

Methods: The MoA Ontology was applied to annotate hypothesised MoAs in 135 behaviour change intervention reports, 115 identified through a literature search and 20 reports from a systematic review. An annotation manual was developed to support the researchers identifying MoAs in reports and selecting relevant classes to annotate. At least two researchers annotated hypothesised MoAs in each intervention report. Researchers involved in the MoA Ontology's development annotated the 115 reports identified by searching. Researchers unfamiliar with the ontology annotated the 20 reports from the systematic review. The researchers compared their annotations and discussed disagreements to identify issues with the ontology, the annotation manual or the reporting of hypothesised MoAs. Where necessary, these issues were discussed with at least one behavioural science expert to decide whether changes were needed for the

ontology or annotation manual. The ontology was refined by adding new classes or updating its classes (e.g., refining definitions).

Results: Thirty-five new classes were added to the ontology (e.g., 'belief about social support'), eight classes' labels and/or definitions were updated, and three broad and domain non-specific classes were no longer shown as part of the MoA Ontology. The resulting ontology had 234 classes.

Conclusions and implications: By refining the MoA Ontology to capture MoAs reported in the literature, the ontology has become more comprehensive and usable. This study demonstrated that the MoA Ontology can be applied to identify hypothesised MoAs in reports of behaviour change interventions. As the current MoA Ontology's development was limited to the input from researchers working in the same institution and their collaborators, the next steps require feedback from international behavioural scientists not collaborating with the ontology developers.

6.2   Introduction

In the previous studies reported in this thesis, various principles for developing 'gold standard' ontologies (OBO [Open Biological and Biomedical Ontology] Foundry, 2019i; Smith et al., 2007) were applied to develop the Mechanism of Action (MoA) Ontology. One principle proposed that ontologies need to have specified scopes, and content that adheres to their scope (OBO Foundry, 2019f). This principle was reflected in Studies 2, 3 and 4 (see Chapters 3-5), which specified the MoA Ontology's scope by defining MoAs and identifying relevant content, i.e., the ontology's classes, labels and definitions. In addition, the principles for writing clear labels and definitions (OBO Foundry, 2019d, 2019g) was applied to label and define the MoA Ontology's classes in Studies 3 and 4.

To further address these principles of good practice in ontology development, the next step was to investigate whether the MoA Ontology's content sufficiently covered the scope of MoAs in the behaviour change literature (Wright et al., 2020). The ontology, therefore, needed to be applied to this literature to examine whether the labels and definitions of MoA Ontology classes can be used to code hypothesised MoAs (Wright et al., 2020). Through such an application, ontology developers can get feedback on the changes needed to make class labels and definitions clearer and, where necessary, add new classes.

To be useful for synthesising knowledge about MoAs in published intervention reports, the MoA Ontology also needed to be fit-for-purpose for annotating MoAs in these reports. Annotating refers to coding specific sections of a document to identify and record the occurrence of an ontological class (Michie et al., 2017), in this case an MoA.

For example, an intervention report might mention an MoA the authors call 'perceived self-efficacy' and define as '*The confidence in one's ability to execute a difficult or resource-demanding behaviour*' (Schwarzer, Antoniuk, & Gholami, 2015). This MoA could be annotated (identified, marked and recorded) using the class 'self-efficacy' in the MoA Ontology, which was defined as 'a belief about one's capabilities to enact a behaviour' (Study 4). Such annotations can be recorded on various software, including PDFAnno (Shindo, Munesada, & Matsumoto, 2018) and EPPI reviewer 4 software (Thomas, Brunton, & Graziosi, 2010). In other ontologies making up the Behaviour Change Intervention Ontology (Michie et al., 2017), classes were successfully made clearer and more comprehensive by annotating relevant content in the literature and iteratively revising these classes' labels and definitions or adding new classes (Norris et al., 2020; 2021b; Wright et al., 2020).

6.2.1 Aims and research questions

For the MoA Ontology's content to be relevant to its scope and clear, the current study aimed to investigate whether the ontology included classes, class labels and definitions useful for annotating hypothesised MoAs in behaviour change intervention reports. Figure 6-1 outlines the studies used to develop the MoA Ontology in this thesis, with the current study highlighted. To address its aim, this study considered the following research questions:

1. Which classes need to be added to the MoA Ontology in order to best capture hypothesised MoAs reported in published behaviour change interventions?

2. Which classes of the MoA Ontology need their labels and definitions to be refined in order for to best capture hypothesised MoAs reported in published behaviour change interventions?

3. Given the classes added and the changes in class definitions, what changes to the

    organisation of classes within the MoA Ontology were required to ensure the

    ontology was hierarchically well-structured?
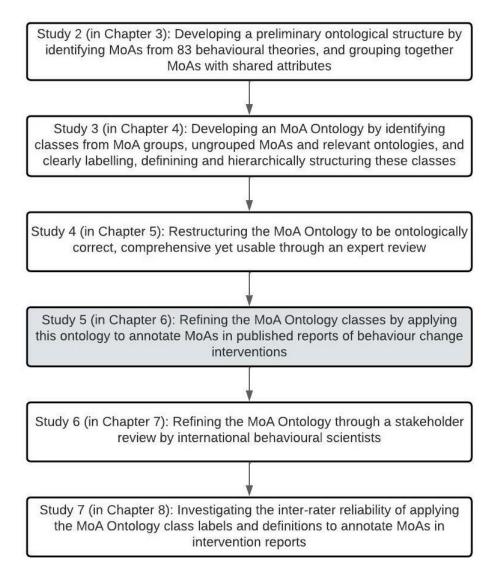
Figure 6-1. Studies used to develop the MoA Ontology reported in this thesis, with the
current study highlighted

6.3 Methods

The MoA Ontology was applied to annotate hypothesised MoAs in reports of behaviour change interventions in two rounds. The first round was by researchers involved in developing the ontology (PS, the author of this thesis, CM & EH). The second involved researchers who were unfamiliar with the ontology (AG & VA), to investigate whether the ontology could be applied to annotate hypothesised MoAs in a systematic review.

6.3.1 Annotations Round 1

6.3.1.1 Materials

6.3.1.1.1 MoA Ontology applied in annotations

The MoA Ontology v1.2 had 202 classes (see Study 4). The upper-most three classes 'independent continuant', 'specifically dependent continuant' and 'process' were broad and not domain specific. Therefore, these classes were not considered useful for annotations and were not shown as part of the MoA Ontology in the current study. The remaining 199 classes of the MoA Ontology v1.2 served as starting point for annotators.

6.3.1.1.2 Manual for annotating hypothesised MoAs in intervention reports

To support researchers when applying the ontology to intervention reports, one researcher (PS) and one behavioural science expert (AW) drafted a manual for identifying and annotating hypothesised MoAs. The researchers who would be using the annotation manual (CM & EH) reviewed this manual for clarity and suggested changes where necessary. The manual included information about:

1. What to annotate (i.e., hypothesised MoAs that were quantitatively measured during or after the intervention)

2. Where to find relevant information (i.e., review the introduction, the methods' measurement section and the results)

3. How to record the information on the web-based software EPPI-Reviewer v4 (Thomas et al., 2010)

4. How to record low and higher confidence for each annotation, as some intervention reports did not clearly report MoAs

5. How to apply specific classes in the MoA Ontology

Many intervention evaluation reports propose MoAs of the evaluated intervention, without the study including measures that help assess whether the proposed MoAs were changed by the intervention and so qualified as MoAs (Prestwich et al., 2014). Therefore, the manual instructed researchers to only annotate hypothesised **and** measured MoAs. To be annotated as an MoA, a construct needed to be described as a potential influence on a behaviour and be measured at least once during or after intervention delivery. Measurements taken at these timepoints for the intervention and comparison groups allow consideration as to whether the potential MoAs had changed due to the intervention. Measures of individual differences or population characteristics were excluded. For instance, if a construct labelled 'motivation to quit smoking' was only measured at baseline, this construct was considered an individual difference between participants and not annotated as MoA. Similarly, if an intervention report described a construct as a personality trait that could not be changed, then this construct was not annotated as an MoA. The final manual, updated during the annotations, is presented in Appendix 6-1.

6.3.1.1.3   Behaviour change intervention reports for Round 1 annotations

In line with the development of other ontologies that make up the Behaviour Change Intervention Ontology (Wright et al., 2020), 115 behaviour change intervention reports were used in the first round to refine the MoA Ontology through annotations. To identify these 115 reports, two databases were used: COCHRANE Central and Web of Science. COCHRANE Central was selected to be consistent with methods for developing other parts of the Behaviour Change Intervention Ontology, which have included annotating reports from this database (Wright et al., 2020). To increase the likelihood of including intervention evaluation reports beyond those targeting health-related behaviours, Web of Science was also used.

A researcher (PS) searched both databases for reports with titles and abstracts that had key terms relating to 'behaviours', 'theories', 'MoAs' and 'interventions' (see key terms in Appendix 6-2). To identify intervention evaluation reports with at least one comparison group, the option to include 'Trials' on COCHRANE Central was selected, and relevant terms were searched for in Web of Science (see Appendix 6-2). To exclude protocols and systematic reviews, the searches also excluded the terms 'protocol' and 'systematic review' from titles on Web of Science. Only English-language intervention reports were included. As there have been increasing calls to report MoAs in the last 20 years (e.g., Medical Research Council, 2000), publication dates were limited from January 2000 - October 2020 to identify studies more likely to report hypothesised MoAs.

From this search, 10581 records (2879 from COCHRANE Central and 7702 records from Web of Science) were identified. Once duplicates were removed, 9844 reports

remained. To select 115 intervention reports, PS screened the titles and abstracts of reports in sets of 200, randomly selected from the 9844 reports. For reports to be included for further screening, the title and abstract needed to:

1. Suggest the report was about an intervention evaluation

2. Mention one or more behavioural theories or MoAs of a behaviour change intervention

3. Mention a quantitative behavioural outcome (not necessarily as primary outcome)

For reports that met the criteria in the title and abstract screening, PS evaluated the full text of reports against specific criteria. The criteria were to include reports with:

1. At least one hypothesised MoA measured during or after the intervention's delivery

2. A behavioural outcome that was measured for participants for whom an MoA was also measured

To perform annotations, reports needed to be uploaded into EPPI-Reviewer software (Thomas et al., 2010). EPPI-Reviewer only allows the annotation of reports in certain formats (e.g., PDF files). Therefore, reports were excluded from the current study if they could not be found in a format suitable for annotations using EPPI-Reviewer.

The titles and abstracts of 1600 reports (8 randomly selected sets of 200 reports) were screened. From these, 289 reports were included for full-text screening. PS discussed 23 studies where there was uncertainty about eligibility with a behavioural science expert (AW) to decide on their inclusion. Following full-text screening, 130 reports were

judged to fit the inclusion criteria. From these, 115 were randomly selected for the annotations. The process to select these reports is summarised in Figure 6-2. Details of the 115 selected reports are presented in the following Open Science Framework (OSF) link, in line with the Human Behaviour-Change Project's (HBCP) procedure to make information about annotated reports accessible: https://osf.io/gufcz/. Common target behaviours in the reports were physical activity (N= 35 reports), dietary behaviour (N= 9) and smoking/other tobacco use (N= 9). Examples of less common target behaviours were road safety behaviours (N= 4), entrepreneurial action (N =1) and plastic consumption (N = 1).
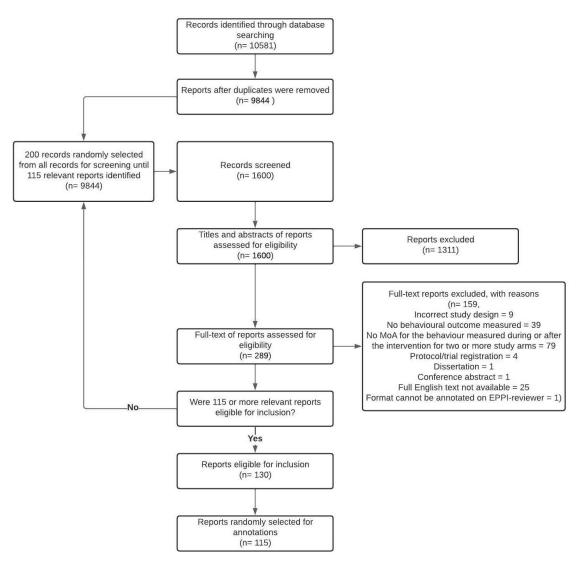
Figure 6-2. Flowchart for identifying 115 behaviour change intervention reports for annotating the MoA Ontology

6.3.1.2 *Procedure and analysis of Round 1 annotations*

Each intervention report was annotated independently by two researchers (PS & either CM or EH) on EPPI-Reviewer v4 (Thomas et al., 2010). The reports were annotated first in a set of three, then of five, and then the remaining reports were annotated in sets of 9-10.

After annotating each set of reports, the two researchers compared their annotations and discussed their differences. During these discussions, they noted down in issues needing discussion about the MoA Ontology (e.g., unclear class definition), the annotation manual or how an MoA was reported in a particular report. To resolve these issues, a researcher (PS) and behavioural science expert (AW) discussed potential changes to the ontology or annotation manual. These changes were then discussed with two additional behavioural science experts (SM & RW) and an ontology expert (JH). Based on these discussions, the ontology was updated by adding new classes, changing the classes' labels, definitions and/or hierarchical relationships. To help ontology users better understand certain classes and their definitions, the research team added comments, examples, synonyms and non-hierarchical relationships to classes in the ontology. These are optional entries for a class in an ontology. As ontological definitions should be concise, adding comments to classes helps elaborate their definitions, for example, explaining certain terms used in the definition. Examples show ontology users the types of things classes apply to in real-world contexts. Synonyms provide a record of different terms used for a specific class in the literature.

6.3.2 Annotations Round 2

6.3.2.1 Materials

The ontology and annotation manual resulting from Round 1 were used in Round 2. To refine the ontology to be usable in the real-world application of systematic reviews, intervention reports annotated in this round came from a systematic review on effective communication strategies targeting changes in behaviour relevant to infectious diseases. The search terms are in the protocol for this systematic review (Grimani et al., 2021). The inclusion criteria for the review were studies that:

1. Were published or unpublished randomised controlled trials, quasi experimental studies or time series analysis

2. Described interventions using communication strategies through mass media, social media, print media or messaging by health professionals

3. Tested at least one of the messages about protecting others

4. Had one comparison group

5. Had at least one behavioural outcome that was relevant for transmitting respiratory infection (e.g., hand washing or social distancing)

The search identified 4779 unduplicated study reports, of which 35 were judged to meet the relevant criteria during the title, abstract and key term screening. In the full-text screening, 20 of the 35 reports were judged to meet the relevant criteria (see reports in https://osf.io/gufcz/).

6.3.2.2 Procedure and analysis of Round 2 annotations

Each of the 20 reports were annotated by the two new researchers (AG & VA), who had PhD level qualifications related to behavioural science, and one researcher involved in

developing the MoA Ontology (PS). By involving two new researchers using the MoA

Ontology to conduct a systematic review, the second round aimed to develop the

ontology to be usable across research projects. The reports were annotated in sets of 2-4

on Microsoft Word using the MoA Ontology and the annotation manual, as the new

researchers were unfamiliar with using this ontology and the software EPPI-Reviewer

v4 (Thomas et al., 2010).

To help the two new researchers familiarise themselves with the MoA Ontology and the

annotation process, for the first 10 papers, all three researchers compared and discussed

their annotations after each annotation set. For the last 10 papers, the two new

researchers first compared and discussed their annotations. Once they agreed on their

annotations, the other researcher (PS) compared her own annotations to theirs and

discussed the differences with them.

Throughout the annotation process, any issues and uncertainties about the MoA

Ontology, the annotation manual or annotated papers were recorded in an annotation

issues log. As the ontology was considered more stable for these annotations, PS

discussed the issues with only one behaviour science expert (AW). Following their

discussions, the ontology and/or annotation manual was updated.

6.4 Results

There were 165 annotation issues recorded in the first round and 19 annotation issues recorded in the second round. A summary and examples of the type of issues are presented in Table 6-1. All issues, report titles and extracts, and proposed solutions for Rounds 1 and 2 are listed in the following OSF link in line with the HBCP's procedure: https://osf.io/n2qvh/. As the ontology was not revised immediately after each report was annotated, some of the same issues were recorded for different reports. The solutions agreed by the experts for re-occurring issues sometimes varied across reports, as newer reports sometimes revealed more evidence which suggested that a different change in the ontology or annotation manual was necessary.

Table 6-1. Annotation issues overview and examples

No	Issue type	Example of this issue encountered while annotating intervention reports
1	The researchers were unsure or disagreed on whether a construct qualified as an intervention's hypothesised MoA and so should be annotated.	The researchers were unsure whether the relationship between a construct labelled as 'resistance training movement skill competency' and behaviour was clearly enough specified in an intervention report (Lubans et al., 2016), for the construct to qualify as a hypothesised MoA of the intervention.
2	When a hypothesised MoA in an intervention report was different from a class in the MoA Ontology (e.g., broader or more granular), the researchers were unsure which class to use to annotate the MoA.	The researchers were unsure whether to use the class 'mental plan' to annotate a more specific hypothesised MoA, which was labelled as 'coping planning' and described as 'mental plan to cope with barriers" (Gholami, Knoll, & Schwarzer, 2015).
3	The researchers had difficulties differentiating between the definitions of some classes, making them unsure or disagree which class to use to annotate certain MoAs.	In an intervention report, the rules parents set for screen-time were hypothesised as an MoA (Smith et al., 2017). As the researchers perceived that two classes, 'social environmental system' and 'social opportunity', could be used to annotate this MoA, they were unsure which class to use.
4	The researchers interpreted the definitions of classes in the MoA Ontology differently, making them use these classes differently as well.	An intervention report included 'perceived pain' as a hypothesised MoA (Bryan et al., 2013). One researcher annotated this MoA using the class 'pain', while another was unsure whether the definition of the 'pain' class would cover perceiving the pain and so annotated the MoA as a 'belief'.
5	The researchers identified that certain classes in the MoA Ontology could be more logically organised within the hierarchy.	When annotating the hypothesised MoA 'antisocial behaviour' (measured as a belief) in an intervention report (Phillips et al., 2014), the researchers noted that 'perceived norm' (a subclass of 'belief') could be more logically organised as a subclass of 'belief about one's environment' (also a subclass of 'belief').
6	The researchers interpreted the descriptions of MoAs in the intervention report differently, leading them to use different classes to annotate these MoAs.	In an intervention report, a hypothesised MoA was labelled as 'identified regulation' and measured using items, such as "*I am doing it for my own good*" (Alfonsson, Johansson, Uddling, & Hursti, 2017). One researcher interpreted this MoA as fitting the class 'belief', while another annotated it using the class 'motivation'.

No	Issue type	Example of this issue encountered while annotating intervention reports
7	Some intervention reports included limited information about hypothesised MoAs (e.g., not including MoAs' definitions), making the researchers unsure which class to use to annotate these MoAs.	In one intervention report, the only information provided for a hypothesised MoA was its label, 'social support' (Lindqvist, Mikaelsson, Westerberg, Gard, & Kostenius, 2014). As the term 'social support' can be used for social processes or beliefs, the researchers were unsure whether to annotate the MoA using the class 'social influence process' or a subclass of 'belief'.
8	Hypothesised MoAs relating to the influence of the environment were often measured through self-report questionnaires and not defined, making researchers unsure on whether to annotate them using the classes 'environmental system' and 'opportunity' or the subclasses of 'belief' (e.g., 'belief about one's environment').	An intervention report included a hypothesised MoA labelled 'environment' and measured using responses to items, such as "*There are side-walks on most of the streets in my local area*" (Liebreich, Plotnikoff, Courneya, & Boulé, 2009). The researchers were unsure whether to use the classes 'environmental system' or 'belief about one's environment' to annotate this MoA.
9	The labels, definitions or measurement descriptions of hypothesised MoAs were unclear or mismatching in some intervention reports, making researchers uncertain or disagree on which classes to use to annotate the MoAs.	In an intervention report, a hypothesised MoA was labelled 'emotional awareness' but measured by asking participants to predict what feelings they would experience in response to hypothetical scenarios (Begeer et al., 2015). While the label might suggest the class 'awareness' as a fit for the MoA, the measurement suggested that a subclass of 'belief' would be a better fit.
10	The methods and results sections were unclear on the level of granularity at which the MoAs were measured.	The Methods section of an intervention report included a hypothesised MoA labelled 'self-regulation', which was a composite of two more granular MoAs: 'reinforcement' and 'goal setting' (Calfas et al., 2000). However, the Results section only included the outcome for 'self-regulation', making researchers unsure on whether to annotate the more granular MoAs described in the Methods section.
11	Some hypothesised MoAs in intervention reports were composites of different MoAs without shared parent classes, meaning that they needed to be annotated as a compound MoA.	In an intervention report, a hypothesised MoA was labelled as 'spirituality⁄religiousness' and its measurement items included questions on whether participants believed in a God and practiced religion (Kelly, Stout, Magill, Tonigan, & Pagano, 2011). As this MoA was relevant to classes which did not share a parent class, such as 'belief' and 'individual human behaviour', the researchers recorded the MoA as a compound MoA.

6.4.1 Classes added to the MoA Ontology

As a result of the issues raised during annotations in Round 1, 31 classes were added to the MoA Ontology. Four more classes were added to address the issues raised in Round 2. These new classes captured hypothesised MoAs that could not be annotated using existing classes or helped more logically organise other classes in the ontology. With the 35 new classes added to the MoA Ontology, it now had a total of 234 classes. Table 6-2 presents examples of the issues that led to adding classes to the ontology, as well as the labels, definitions, and parent classes of added classes.

Table 6-2. The classes added to the MoA Ontology, their labels, definitions and parent classes, and examples of the issues that led to adding these classes

No.	Example of issue that led to adding the class	Label of added class	Definition of added class	Parent class
1	In an intervention report (Begeer et al., 2015), the researchers were unsure which class to use to annotate a hypothesised MoA labelled as 'emotional awareness' but measured by asking children about their expected emotions in response to 12 social scenarios. While the researchers thought that the label suggested the 'awareness' class, the measurement related to a belief. To clearly capture this MoA, the class 'belief about anticipated emotion' was developed.	Belief about anticipated emotion	A belief about the potential emotional processes experienced as result of an event.	Belief
2	The researchers were unsure which class to use to annotate a hypothesised MoA labelled as 'perceived message quality' and measured as belief on whether a message was "*relevant, interesting, persuasive, helpful and accurate"* (Wileman et al., 2014). The researchers found the class 'belief about message relevance' too granular and the class 'belief' too broad to capture this MoA. Therefore, a new mid-level class labelled 'belief about message' was developed.	Belief about message	A belief regarding aspects of a verbal, graphic, written or recorded communication.	Belief
3	In one intervention report, 'message derogation' was not defined but measured by assessing whether participants thought a message was "(*1) overblown, (2) exaggerated, (3) tried to manipulate their feelings, and (4) tried to strain the truth*" (Düring & Jessop, 2015). One researcher annotated this MoA using the class 'belief about message', while another used the class 'belief'. As neither class fully captured the hypothesised MoA, the classes 'belief about message trustworthiness' was developed.	Belief about message trustworthiness	A belief about whether a verbal, graphic, written or recorded communication provides reliable information.	Belief about message
4	In response to the issue raised on annotating 'message derogation' (see previous row), the experts suggested to capture beliefs about the trustworthiness of messages more comprehensively, including trustworthiness of the message's source. Therefore, the class 'belief about credibility of a message's source' was also developed.	Belief about the credibility of a	A belief about whether a verbal, graphic, written or recorded communication is provided by	Belief about message

No.	Example of issue that led to adding the class	Label of added class	Definition of added class	Parent class
		message's source	people or institutions who are trustworthy.	
5	An intervention report included three hypothesised MoAs, which related to 'psychological need satisfaction' in physical education (Pardo, Bengoechea, Clemente, & Lanaspa, 2016). However, these MoAs were measured as 'perceived competence', 'perceived autonomy' and 'perceived relatedness to others'. The researchers were unsure whether these MoAs should be annotated as 'psychological need' or 'belief'. To capture these MoAs more precisely, the class 'belief about need satisfaction' was developed.	Belief about need satisfaction	A belief regarding whether one's psychological needs have been met.	Belief
6	When annotating a hypothesised MoA labelled as 'antisocial behaviour', with a measure described as perceptions of antisocial behaviour (Phillips et al., 2014), the researchers questioned why the class 'perceived norm' was not a subclass of 'belief about one's environment.' To organise these classes more logically, the class 'belief about one's social environment' was added as the parent class of 'perceived norm' and the subclass of 'belief about one's environment'.	Belief about one's social environment	A belief about the aspects of one's immediate social settings in which people live, including culture and the people and institutions with whom they interact.	Belief about one's environment
7	The researchers found the class 'belief about one's environment' too general to annotate a hypothesised MoA labelled as 'perceived social support', and measured with items, such as "*My parents encourage me to brush my teeth regularly*" (Scheerman, Hamilton, Sharif, Lindmark, & Pakpour, 2020). To capture this MoA clearly, the class 'belief about social support' was developed.	Belief about social support	A belief about whether others will provide assistance or comfort to help the person cope with one or more stressors.	Belief about one's social environment
8	The researchers were unsure which subclass of 'belief' to use to annotate a hypothesised MoA labelled as 'attitude', which was assessed with items, such as "*In my view, encouraging cardiovascular patients to become physically active is very good - very bad*" (Sassen, Kok, Schepers, & Vanhees, 2014). As a class to capture beliefs about whether a behaviour is	Evaluative belief about behaviour	An evaluative belief about whether a behaviour is positive or negative.	Evaluative belief

No.	Example of issue that led to adding the class	Label of added class	Definition of added class	Parent class
	positive or negative was missing from the ontology, the class 'evaluative belief about behaviour' was developed.			
9	A parent class for the new class 'evaluative belief about behaviour' and the class 'evaluative belief about the consequences of a behaviour' (previously labelled 'evaluative belief' in Study 4) was missing from the ontology. To serve as a parent for these classes, 'evaluative belief' (reusing the label from its subclass), was developed.	Evaluative belief	A belief about whether a particular aspect of the world is positive or negative.	Belief
10	The researchers were unsure which class to use when annotating a hypothesised MoA labelled as 'stigmatizing attitude' and measured with items such as "*If I know someone who has HIV, I will stay far away from him/her*" (Li, Zhang, Mao, Zhao, & Stanton, 2011). The researchers thought that more specific classes about evaluative perceptions of others might be missing from the ontology, and so the class 'evaluative belief about others' was developed.	Evaluative belief about others	An evaluative belief about the attributes of others.	Evaluative belief
11	Based on the hypothesised MoA labelled 'stigmatizing attitude' (see previous row), the experts thought another class was needed to capture evaluative beliefs relating to stereotypes (e.g., prejudiced beliefs). Therefore, the class 'evaluative belief about a stereotype' was developed.	Evaluative belief about a stereotype	An evaluative belief about a set of attributes considered to generally inhere in the members of a social group.	Evaluative belief
12	An intervention report included a hypothesised MoA labelled as 'perceived behavioural control' measured with items such as "*There are factors outside my control that would prevent me from requesting an FSH test for this patient*" (Ramsay, Thomas, Croal, Grimshaw, & Eccles, 2010). The researchers disagreed on whether this MoA could be annotated using the class 'self-efficacy' or whether a more general class was needed to capture participants' perceived opportunity within an environment and capability to perform a behaviour. To capture this more general MoA in the ontology, the class 'belief about control over behaviour' was added.	Belief about control over behaviour	A belief about one's capabilities and opportunities within an environmental system to perform a behaviour or achieve the outcomes resulting from a behaviour.	Belief

No.	Example of issue that led to adding the class	Label of added class	Definition of added class	Parent class
13	The researchers were unsure which class to use when annotating a hypothesised MoA labelled as 'perceived behavioural control', which was defined as "*the individual's belief that he or she has the resources and opportunities required to perform a particular behavior and can overcome the obstacles that stand in the way of doing it*" (Kopelowicz et al., 2015). The researchers found that this MoA overlapped with the class 'self-efficacy' but captured an additional dimension, beliefs about the opportunity and resources within an environment for a behaviour. Adding the class 'belief about control over behaviour' (see previous row) helped capture the composite of 'self-efficacy' and beliefs about one's resources and opportunities in an environment. However, to capture the dimension that is about control over the environment, the experts also decided to add a more specific class that would capture beliefs about one's resources and opportunities: 'belief about control over the environment'.	Belief about control over the environment	A belief about one's resources and opportunities within an environment to perform a behaviour.	Belief about control over behaviour
14	A class relating to self-efficacy for behaviour was included in the MoA Ontology in Study 4. When discussing the annotation of classes relating to self-efficacy and belief about control over behaviour (see previous two rows), the experts underlined the need for another class that captured self-efficacy for behaviour AND its associated outcomes. Therefore, in addition to the class 'self-efficacy belief for a behaviour' (previously labelled 'self-efficacy' in Study 4), a new class that captured belief about ability to do a behaviour and achieve its outcomes was added to the ontology. As the definition of this new class better aligned with the definition of 'self-efficacy' in Social Cognitive Theory (Bandura, 1986, 1997), the experts decided that the new class should be labelled 'self-efficacy belief'.	Self-efficacy belief	A belief about one's capabilities to organise and execute a behaviour and achieve the outcomes associated with this behaviour.	Belief about control over behaviour
15	In an intervention report, a hypothesised MoA labelled 'habit' was not defined but measured using responses to items such as "*Encouraging patients to be physically active is something I do without thinking, and …something I do automatically*" (Sassen et al., 2014). As the measure was closely associated with a person's explicit belief about their habit, the researchers found this MoA difficult to annotate. The example MoA prompted discussions with experts to develop classes that better captured different aspects of a habit. One of these	Learned stimulus-behaviour co-occurrence	A mental disposition to behave in a particular way in response to an event in a person's environment, which is acquired through habit learning.	Learned stimulus-response co-occurrence

No.	Example of issue that led to adding the class	Label of added class	Definition of added class	Parent class
	classes was 'learned stimulus-behaviour co-occurrence', relating to tendencies to enact learned habitual behavioural responses.			
16	The issue relating to the annotation of 'habit' in an intervention report (see previous row) prompted discussions with experts on adding more specific classes to capture different aspects of 'habit'. One of the added classes was 'learned stimulus-thought co-occurrence' to capture mental habits.	Learned stimulus-thought co-occurrence	A mental disposition to think in a particular way in response to an event in a person's environment.	Learned stimulus-response co-occurrence
17	The issue relating to the annotation of 'habit' in an intervention report (see previous two rows) prompted discussions with experts on adding more specific classes to capture different aspects of a habit. One of the added classes was 'habitual behaviour' to capture formed habitual behaviours that might act as MoAs for other behaviours.	Habitual behaviour	A behaviour that is strongly influenced by a learnt stimulus-behaviour association.	Individual human behaviour
18	The issue relating to the annotation of 'habit' in an intervention report (see previous three rows) prompted discussions with experts on adding more specific classes to capture different aspects of a habit. One of the added classes was 'habit learning' to capture the process of acquiring or strengthening a habit.	Habit learning	Associative learning that involves strengthening an association between a stimulus and an impulse through repetition of co-occurrence of the stimulus and the behaviour.	Associative learning
19	In an intervention report, 'coping planning' was described as plans "*to identify barriers and strategies to cope with them*" and measured with the item "*If I miss the opportunity to floss as I planned, I will do it later on the same day or next morning*" (Gholami et al., 2015). The researchers were unsure whether to annotate this class with the more general 'mental plan' class, as the report distinguished between a mental plan (labelled 'action planning') and mental plan to cope with barriers. To capture 'coping planning' more precisely, the class 'mental plan for coping with barriers' was developed.	Mental plan for coping with barriers	A mental plan regarding a strategy to deal with conditions that could prevent the performance of a behaviour.	Mental plan

No.	Example of issue that led to adding the class	Label of added class	Definition of added class	Parent class
20	An intervention report included a hypothesised MoA labelled as 'tension/discomfort' (Rupp et al., 2019). The researchers were unsure whether the more general class 'emotion process' sufficiently captured this MoA. Therefore, a more specific class labelled 'feeling nervous' was added to the ontology.	Feeling nervous*	A subjective feeling of being not at ease, of being anxious or nervous or agitated.	Emotion process
21	An intervention report included a hypothesised MoAs labelled as 'guilt' (Rupp et al., 2019). As the researchers found 'emotion process' too general to capture this MoA, a more specific class, labelled 'guilt', was added to the ontology.	Guilt*	A self-evaluative emotion that occurs when a person brings about a negative outcome by acts of commission or omission.	Emotion process
22	The researchers were unsure whether a hypothesised MoA labelled 'enjoyment of PA' could be annotated using the class 'pleasure' (Pardo et al., 2016). To capture the MoA more specifically, a subclass, 'enjoyment of behaviour', was added.	Enjoyment of behaviour	Pleasure that is experienced as a result of engaging in a behaviour.	Pleasure
23	In an intervention report, a hypothesised MoA was labelled as 'craving' and measured using items such as "*Have you indulged in the item you reported craving previously?*" (Skorka-Brown, Andrade, Whalley, & May, 2015). The researchers were unsure which class to annotate for 'craving'. Therefore, a class that captured 'craving' was developed.	Craving	A subjective experience of powerful want or need for something or urge to engage in a behaviour.	Subjective emotional feeling
24	The researchers disagreed on which class to use to annotate an MoA labelled 'defensive avoidance' and measured with the item "*When I read the message about skin cancer my first reaction was that I did not want to think about skin cancer*" (Jessop, Simmonds, & Sparks, 2009). To capture this MoA more precisely, the class 'avoidance mental process' was added.	Avoidance mental process	A mental process that reduces the frequency by which an aversive cognitive representation is evoked.	Mental process
25	In an intervention report, an MoA was labelled 'just a thought' and measured using items, such as "*Please rate to what extent you responded to obsessions that you have experienced since the last prompt in the following ways: I told myself that it is just a thought*" (Rupp et al.,	Targeted mental distancing	Mental distancing that involves identifying particular immediate thoughts and detaching from these thoughts.	Mental distancing

No.	Example of issue that led to adding the class	Label of added class	Definition of added class	Parent class
	2019). As researchers were unsure which class to use to annotate this MoA, a specific class to capture this MoA was added to the ontology: 'targeted mental distancing'.			
26	To link the added class 'targeted mental distancing' (see previous row) to the broader class 'mental process', the class 'mental distancing' was developed, capturing more general processes of detaching oneself from one's thoughts.	Mental distancing	A cognitive process that involves detaching oneself from one's immediate thoughts.	Mental process
27	An intervention report drawing on the Self-Determination Theory (SDT) (Deci & Ryan, 2012), hypothesised 'autonomous motivation' as an MoA, assessing it as a composite of 'intrinsic motivation', 'integrated motivation/regulation' and 'identified motivation/regulation' (Silva et al., 2011). The researchers were unsure whether 'autonomous motivation' should be annotated using the class 'motivation' or its subclass in the ontology, 'intrinsic motivation'. Therefore, a mid-level class labelled 'autonomous motivation' was added as a subclass of 'motivation' and the parent class of 'intrinsic motivation.'	Autonomous motivation	Motivation that is internally generated and based on a behaviour being interesting or valuable to an individual.	Motivation
28	In an intervention report, 'integrated motivation/regulation' was a hypothesised MoA and measured using items such as "*I do exercise outside school... because it suits my lifestyle*" (Huéscar Hernández, Andrés Fabra, & Moreno-Murcia, 2020). The researchers were unsure whether this MoA could be captured with the broader class 'autonomous motivation'. Therefore, the class 'fundamental need-based motivation' was added. The chosen label was intended to allow ontology users, unfamiliar with SDT to understand this class more easily. However, the labels used in SDT, 'integrated motivation' and 'integrated regulation,' were included as the class's synonyms.	Fundamental need-based motivation**	Autonomous motivation for behaviours that are perceived as satisfying core psychological needs.	Autonomous motivation
29	In the intervention report (Huéscar Hernández et al., 2020), 'identified motivation/regulation' was hypothesised as an MoA and measured using items such as "*I do exercise outside school... because it's important for me to do it regularly.*" The researchers were again unsure whether to annotate this MoA using the broad class 'autonomous motivation'. Therefore, a	Behavioural importance-	Autonomous motivation due to the perceived value or	Autonomous motivation

No.	Example of issue that led to adding the class	Label of added class	Definition of added class	Parent class
	more specific class 'behavioural importance-based motivation' was added to the ontology. The label was chosen to enable ontology users unfamiliar with SDT to understand the class, with the labels used in SDT, 'identified motivation' and 'identified regulation,' recorded as the class's synonyms.	based motivation**	importance of the behaviour to oneself.	
30	The researchers found the class 'motivation' too broad to capture a hypothesised MoA labelled as 'introjected motivation' and described as reflecting motivation to engage in a behaviour to "*avoid feelings of guilt or shame*" (Lubans et al., 2016). To capture motivation relating to external factors (including need for approval and internalised feelings of shame), the experts added the class 'controlled motivation' to the ontology.	Controlled motivation	Motivation that is based on external rewards, punishments or pressure regarding a behaviour.	Motivation
31	In an intervention report, one hypothesised MoA was 'introjected motivation/regulation', measured using items such as "*I do exercise outside school... because I feel I've failed when I haven't done it*" (Huéscar Hernández et al., 2020). The researchers thought the class 'controlled motivation' was too broad to capture this MoA, as the intervention report differentiated 'extrinsic motivation' (a subclass of 'controlled motivation') from 'introjected motivation'. To capture the MoA 'introjected motivation' more granularly, the class 'approval-based motivation' was added. The label was chosen to allow ontology users unfamiliar with SDT to understand the class, while the labels used in SDT were added as the class's synonyms.	Approval-based motivation**	Controlled motivation to gain or maintain a positive evaluation of self or feel others approval of oneself.	Controlled motivation
32	An intervention report included a hypothesised MoA labelled 'feeling of joint responsibility to protect from coronavirus' and measured using questions such as "*To what extent did this message make you feel responsible for other people's well-being*" (Ceylan & Hayran, 2021). The researchers found the class 'belief' too broad to annotate this MoA. To better capture this MoA, the class 'belief about responsibility to act' was added.	Belief about responsibility to act	A belief about whether someone is obliged to take a certain course of action.	Belief

No.	Example of issue that led to adding the class	Label of added class	Definition of added class	Parent class
33	In an intervention report, a hypothesised MoA was labelled 'perceived public threat of coronavirus' (Yardley, Miller, Schlotz, & Little, 2011). Its measurement items related to perceived susceptibility to a threat for the self and for others. The MoA Ontology class 'belief about susceptibility to a threat' was about personal susceptibility to threats, but not others' susceptibility. Therefore, the class 'belief about others' susceptibility' was added to the ontology to capture the MoA 'perceived public threat of coronavirus'.	Belief about others' susceptibility	A belief about how vulnerable others are to a threat.	Belief about susceptibility to a threat
34	When the class 'belief about others' susceptibility' was added (see previous row), a parent class for this new class and 'belief about personal susceptibility' (previously labelled 'belief about susceptibility to a threat') was required. This new parent class was labelled 'belief about susceptibility to a threat'.	Belief about susceptibility to a threat	A belief about vulnerability to a threat.	Belief
35	An intervention report included a hypothesised MoA that was a composite of the classes 'belief about susceptibility to a threat' and 'belief about severity of an outcome' (Favero & Pedersen, 2020). Therefore, the researchers were unsure about which class to use for this MoA. To capture this MoA, the class 'belief about threat' was developed. A non-hierarchical relationship was also specified with the classes 'belief about belief about susceptibility to a threat' and 'belief about severity of an outcome', i.e., these beliefs are part of 'belief about threat'.	Belief about threat	A belief about a potential harm.	Belief

Notes. *Class reused from other ontologies
**Synonyms for these classes were added, which are presented in Appendix 6-4.

6.4.2   Classes and hierarchical relationships changed in the MoA Ontology

At the end of Round 1, the labels and/or definitions of seven classes were updated and the parent classes of nine classes were updated, mostly due to the new classes being added to the MoA Ontology (see Table 6-2). In Round 2, the label of only one class was updated. Table 6-3 shows examples of issues that led to changes in the MoA Ontology's classes, as well as the relevant classes' final labels, definitions, and parent classes. The complete updated MoA Ontology is presented in Appendix 6-3. The synonyms, examples and comments added for all classes are presented in Appendix 6-4, and the annotation issues that led to adding these entries are captured in the annotation issues log (https://osf.io/n2qvh/).

Table 6-3. The labels, definitions and parent classes of classes changed in the MoA Ontology, and examples of the annotation issues that led to changing these classes

No	Example of issue that led to changing the class	Class label	Class definition	Parent class
1	An intervention report included a hypothesised MoA labelled 'outcome expectations' and measured using items such as "*I will feel better physically if I get regular physical activity*" (Liebreich et al., 2009). The researchers thought that this MoA was related to the class 'belief about the desirability of consequences' and its parent class 'evaluative belief about behavioural outcomes'. However, the researchers were unsure whether the parent class and subclass were sufficiently distinguished, i.e., which class to use for the annotation. Therefore, the label and definition of 'belief about the desirability of behaviour' were updated to capture the personal desirability of a behaviour more clearly, matching the granularity of the intervention's MoA.	Belief about the personal desirability of consequences of behaviour	A belief about the worth of the outcomes of a behaviour to oneself.	Evaluative belief about behavioural outcomes
2	Following discussions to delineate classes relating to self-efficacy more clearly, the class 'self-efficacy belief' was added to the MoA Ontology (see Table 6-2). As the new class's label overlapped with an existing class 'self-efficacy', the label of this older class was updated. The class was changed to 'self-efficacy belief for a behaviour' to better reflect its definition. In addition, the experts decided to broaden the class's definition by adding the term 'organise' and thereby capturing ability to organise mental processes to enact a behaviour. Finally, the class was made a subclass of the newly added broader class 'belief about control over behaviour'.	Self-efficacy belief for a behaviour	A belief about one's capabilities to organise and execute a behaviour.	Belief about control over behaviour
3	Following discussions to delineate classes relating to self-efficacy more clearly (see previous row), to match the changes in its parent class, the label of 'situational self-efficacy' was changed to 'situational self-efficacy belief for a behaviour'. Its definition was also changed to reflect the updated label of its parent class: 'self-efficacy belief for a behaviour'.	Situational self-efficacy belief for a behaviour	Self-efficacy belief for a behaviour under certain conditions.	Self-efficacy belief for a behaviour
4	In Study 4, one class had been labelled as 'evaluative belief' but defined as being about evaluative beliefs relating to the consequences of behaviour. While reviewing the classes in the MoA Ontology, researchers found that classes related to evaluative beliefs (e.g., 'evaluative belief' and 'evaluation of self') were not organised together. So, to hierarchically organise all classes related to evaluative beliefs, the experts decided to introduce a new class, reusing the broad label 'evaluative belief' (see	Evaluative belief about behavioural outcomes*	A belief about whether the consequences of the behaviour are positive or negative.	Evaluative belief

No	Example of issue that led to changing the class	Class label	Class definition	Parent class
	Table 6-2). The class from Study 4 previously labelled 'evaluative belief' was relabelled to better reflect its definition: 'evaluative belief about behavioural outcomes'. A synonym was recorded as 'evaluative belief about the consequences of behaviour' to capture the variations in the terms used for the class.			
5	After the class 'evaluative belief' was added to the ontology to organise classes relating to evaluative beliefs (see Table 6-2), the class 'evaluative of self' was recorded as a subclass of this broader class.	Evaluation of self	An evaluative belief about one's attributes.	Evaluative belief
6	The class 'belief about message' was added to the MoA Ontology to capture a broad range of beliefs about messages as MoAs (see Table 6-2). As the class 'belief about message relevance' was more granular than this broader new class, it needed to be organised as the subclass of 'belief about message'.	Belief about message relevance	A belief regarding whether the content of a verbal, written or recorded communication is relevant to oneself.	Belief about message
7	The researchers were unsure which class to use when annotating the hypothesised MoA 'habit', which was measured as a belief about one's habits (Sassen et al., 2014). This issue prompted discussions about delineating classes related to habits more clearly (see Table 6-2). When discussing the class 'learned stimulus-response association' from Study 4, the experts suggested that the term 'association' in the label would imply a causal relationship between a response and a stimulus. To allow a broader interpretation of the class, its label was updated to be: 'Learned stimulus-response co-occurrence'. In addition, to clarify that the class could involve learning mental and/or behavioural responses, a comment was added to specify that 'respond... to an event' in the definition can include thinking and impulses to respond.	Learned stimulus-response co-occurrence*	A mental disposition to respond in a particular way to an event in a person's environment, which is acquired through an associative learning process.	Mental disposition

No	Example of issue that led to changing the class	Class label	Class definition	Parent class
8	As shown in Table 6-2, the class 'autonomous motivation' was added to the MoA Ontology in order to capture hypothesised MoAs, such as 'autonomous motivation, in intervention reports (e.g., Silva et al., 2011). To logically organise the more granular class 'intrinsic motivation', this class was reorganised as the subclass of the new class 'autonomous motivation'. The definition of 'intrinsic motivation' was also updated to reflect its new parent class.	Intrinsic motivation	Autonomous motivation due to a behaviour's inherent enjoyment or satisfaction for oneself.	Autonomous motivation
9	The class 'controlled motivation' was added to the ontology (see Table 6-2) to capture mentions of 'introjected motivation' in an intervention report (Lubans et al., 2016). As this new class related to motivation due to all forms of external pressures and rewards to perform a behaviour, the class 'extrinsic motivation' qualified as its subclass. Accordingly, the class 'extrinsic motivation' was reorganised in the hierarchy of the ontology, and its definition was updated to appropriately reflect its new parent class. In one intervention report, the researchers raised that they were confused about the interchangeable use of the labels 'extrinsic motivation' and 'external motivation' (Huéscar Hernández et al., 2020). To avoid any uncertainty moving forward, 'external motivation' was recorded as a synonym for the class 'extrinsic motivation'.	Extrinsic motivation*	Controlled motivation due to externally administered rewards, approval or punishments.	Controlled motivation
10	As described in Table 6-2, 'belief about one's social environment' was added to organise the class 'perceived norm' more logically under the broader class 'belief about one's environment'. Accordingly, the parent class of 'perceived norm' was recorded as 'belief about one's social environment'.	Perceived norm	A belief about what is typical for people who belong to a particular social group.	Belief about one's social environment
11	While reviewing the classes in the MoA Ontology, the researchers questioned the reason the class 'belief about likelihood of consequences of behaviour' was not organised as a subclass of 'belief about likelihood of potential outcomes'. As the experts agreed that these two classes needed to be hierarchically organised, the parent class of 'belief about likelihood of behaviour' was updated to be 'belief about likelihood of potential outcomes'.	Belief about likelihood of consequences of behaviour	A belief about the likelihood a particular behaviour will result in particular outcomes.	Belief about likelihood of potential outcomes

No	Example of issue that led to changing the class	Class label	Class definition	Parent class
12	As shown in Table 6-2, a new class was added to the ontology to capture perceived susceptibility of a threat to the self and others: 'belief about susceptibility to a threat'. This new class reused the label of a class from Study 4, which was about the perceived personal susceptibility of a threat. The label of this older class was updated to better reflect its definition: 'belief about personal susceptibility'. In addition, to logically organise this class in relation to the broader new class, 'belief about personal susceptibility' became the subclass of 'belief about susceptibility to a threat'.	Belief about personal susceptibility	A belief about how vulnerable one is to a threat.	Belief about susceptibility to a threat

Notes. * Classes for which synonyms, examples and comments were added, which are presented in Appendix 6-4

Many annotation issues stemmed from intervention reports providing insufficient or inconsistent information about hypothesised MoAs (e.g., not defining MoAs or specifying labels that mismatched the MoAs' measurements). Updates to the MoA Ontology's annotation manual often supported researchers to better agree on annotations for MoAs that were underspecified in intervention reports. For instance, one intervention report had a hypothesised MoA labelled as 'environment' (Liebreich et al., 2009). To measure this MoA, participants were asked to what extent they agree with there being sidewalks for most streets in their area. As the researchers were unsure whether to annotate this MoA using the classes 'environmental system' or 'belief about one's environment' without a definition being provided, the manual was updated. The manual was updated to recommend annotating the class 'environmental system' for MoAs measured by asking participants about objective information about their environment (e.g., how many side-walks are there in an area). As the measurement was not objective in the example intervention report, the MoA 'environment' would be annotated with the class 'belief about one's environment'.

6.5   Discussion

This study aimed to develop an ontology of MoAs with clear content that helped comprehensively capture its scope. Therefore, the study investigated whether the MoA Ontology's classes, labels and definitions could be used to annotate hypothesised MoAs in intervention reports. As a result of applying the ontology to annotate MoAs, 35 new classes were added to the ontology, and three broad classes were removed, bringing the number of classes in the ontology to 234. To better reflect the nature of classes and be clearer for annotators, the labels and/or definitions of eight classes and the parent classes of nine classes were updated.

Consistent with the development of other parts of the Behaviour Change Intervention Ontology (Michie et al., 2017; Norris et al., 2020; 2021b), the current study helped refine the ontology to be more usable for annotating relevant content, hypothesised MoAs. By adding classes based on MoAs reported in intervention reports, the current study built on Studies 2, 3 and 4 to develop an ontology that captured a wider range of MoAs. Thereby, these four studies led to a more thorough cover of the ontology's intended scope, in line with ontological principles (OBO Foundry, 2019f). To address the principles for writing clear labels and definitions for ontologies (OBO Foundry, 2019d, 2019g), the current study also refined the class labels and definitions to be understandable for researchers annotating hypothesised MoAs in intervention reports.

6.5.1   Strengths and limitations

In terms of refining the classes in the MoA Ontology, the current study was limited to the hypothesised MoAs that were reported in the selected literature corpus. This study could not add classes or investigate the usability of classes if relevant MoAs were not hypothesised in the randomly selected intervention reports. Therefore, the method to identify intervention reports intended to include reports that described a wide range of MoAs. For annotations in Round 1, only reports published since 2000 were used, since they were likely to include clearer intervention descriptions in general, including of descriptions of hypothesised MoAs. However, certain behavioural theories (e.g., Self-Determination Theory) have been applied more often in recent years (Van den Broeck, Ferris, Chang, & Rosen, 2016), meaning that their MoAs will be better represented in the ontology than those appearing more frequently in pre-2000 reports. Since many of the selected reports focused on commonly targeted behaviours (e.g., physical activity),

the generalisability of the identified MoAs to more rarely studied behaviours would need to be investigated.

With its 234 classes, the MoA Ontology resulting from the current study had a large number of classes that help capture various MoAs in intervention reports. However, the number of its classes can also make the ontology hard to use, for example when identifying a specific class to annotate an MoA in an intervention report. The current study did not allow us to judge which classes to remove from the ontology, as the 135 annotated intervention reports included a limited number of MoAs. More intervention reports would need to be annotated to judge which of the ontology's classes do not capture MoAs reported in the wider behaviour change literature.

In this study, all the researchers annotating the intervention reports were MoA Ontology developers or collaborators of these developers based in the UK. Those unfamiliar with the ontology were given their instructions by an MoA Ontology developer (PS) during annotations. These researchers might share views on behaviour change and have some knowledge about the language used in ontologies (e.g., 'mental disposition'). Potential users from other countries or more disparate backgrounds might have different perspectives on the ontology (e.g., its organisation) and/or have more difficulties applying the ontology in its current form (e.g., understanding the technical terms used in definitions). Future steps for refining the MoA Ontology need to involve stakeholders further removed from the initial developers of this ontology.

6.5.2 Implications

The current study has developed the MoA Ontology, making it more fit-for-purpose as a resource for identifying and synthesising evidence about MoAs in behaviour change intervention reports. As classes were added to the ontology to capture hypothesised MoAs based on the literature, the ontology's current version is more likely include classes relevant for coding hypothesised MoAs in behaviour change intervention reports. Through the updates to the class labels and definitions, the ontology may also have become clearer and could be used when labelling and defining MoAs proposed in intervention reports or theories.

As the current study showed, many intervention reports underspecify hypothesised MoAs, making consistent annotations using the MoA Ontology difficult. Therefore, the current findings emphasise the need for a detailed annotation manual to help researchers consistently apply this ontology. For instance, clear guidance can help researchers agree on annotating the same class for an MoA, when an intervention report only mentions the MoA's label (e.g., 'environment') and not its definition or measurement.

6.5.3 Future research

By refining the MoA Ontology based on feedback from people with different perspectives on MoAs in behaviour change interventions, the ontology can become more widely useable and useful. For instance, involving people from a wider range of countries is likely to tap into expertise on a broader range of behavioural theories and MoAs, than the MoA Ontology developers are familiar with or had identified from intervention reports or theories. Therefore, potential users with different expertise could propose new classes that are important for capturing MoAs. To ensure class labels and

definitions can be understood by a wide range of potential users, feedback from individuals less familiar with the language used in ontologies is essential. Therefore, the next step for developing the MoA Ontology is to seek input from a broader range of international behavioural scientists and potential ontology users.

6.5.4 Conclusion

In this study, the MoA Ontology was refined to become more fit-for-use to capture hypothesised MoAs in intervention reports. The ontology became more extensive through the addition of new classes, and clearer through the refinement of its class labels and definitions. A manual for annotating MoAs was developed to support researchers and others who might use this ontology. The ontology now needs to be refined through the feedback from a wider range of potential users from different countries who are not collaborating with the Human Behaviour-Change Project.

7 Chapter 7: Refining the Mechanism of Action Ontology through a stakeholder review of the ontology by behavioural scientists (Study 6)

7.1 Abstract

Rationale: The Mechanism of Action (MoA) Ontology's development so far involved researchers associated with the Human Behaviour-Change Project. To ensure that the ontology reflects scientific consensus more broadly and extensively covers MoAs of behaviour change interventions, feedback from a wider range of potential users was needed.

Aim: To refine the MoA Ontology's class labels and definitions to be clearer and to capture new classes that were needed, based on feedback from international behavioural scientists

Methods: Nine international behavioural scientists with research experience regarding MoAs in behaviour change interventions completed an online survey to provide feedback on the MoA Ontology. This survey included closed- and open-ended questions on whether the class labels and definitions were clear, and whether any classes were missing from the ontology. The MoA Ontology developers reviewed participants' feedback to decide on the changes that needed to be made to the ontology. When feedback suggested that classes needed to be clearer, the developers refined their labels, definitions or relationships and/or added comments, synonyms and informal definitions to classes. Classes could also be removed or added, based on participants' feedback about whether they were necessary in the ontology.

Results: Participants suggested that 61 class labels and 195 class definitions needed changing. In addition, 606 comments were made suggesting issues with the ontology.

Drawing on these comments, 34 class labels, 127 class definitions and 25 classes' parent classes were updated. To clarify classes, comments were also added to 59, synonyms were added to 11, examples were added to three and non-hierarchical relationships with other classes were specified for three classes. Moreover, 23 classes were removed from the ontology and 43 new classes were added, bringing the number of the ontology's classes to 254 organised on seven hierarchical levels.

Conclusions: The MoA Ontology has become more extensive, and its class labels and definitions clearer as a result of international behavioural scientists' feedback. The ontology now also reflects broader scientific consensus about MoAs. As a next step, the revised ontology will be evaluated by investigating whether it can be reliably applied to annotate hypothesised MoAs in behaviour change intervention reports.

7.2   Introduction

The Mechanism of Action (MoA) Ontology's development follows the principles for developing 'gold standard' ontologies (Open Biological and Biomedical Ontology [OBO] Foundry, 2019i; Smith et al., 2007). One of these principles is 'Commitment to collaboration', aiming to ensure an ontology meets the scientific community's needs and reflects the broader scientific consensus about the relevant field (OBO Foundry, 2019b). To ensure the ontology captures relevant MoAs, steps taken thus far were to identify potential classes from behavioural theories (Studies 2 & 3) and hypothesised MoAs reported in the literature (Study 5). The researchers developing the MoA Ontology were all affiliated with the Human Behaviour-Change Project (HBCP; Michie et al., 2017). There is a need to explore whether the ontology reflects a wider range of scientists' views about which classes are needed to describe MoAs of behaviour change interventions. Moreover, it's important to ensure that the ontology's class labels and definitions are not only ontologically sound, but also usable and clear to other behavioural scientists (OBO Foundry, 2019b).

To refine the MoA Ontology, the next step needed to investigate whether its classes, labels and definitions met the needs of potential users and reflected broader scientific consensus about the nature of MoAs (OBO Foundry, 2019b). Stakeholder reviews can help investigate whether its potential users think that the ontology includes the classes necessary for describing relevant entities (e.g., MoAs) in behaviour change interventions (Wright et al., 2020). Such reviews can help refine the class labels and definitions to be clearer and more relevant to potential users. For instance, in a stakeholder review of the Source Ontology (focusing on who delivers an intervention) within the Behaviour Change Intervention Ontology, a participant suggested that the

definition of the class 'psychologist' was too narrow (Norris et al., 2021b). In this case, the 'psychologist' definition was expanded to include professional roles relevant to a wider range of areas in psychology, such as counselling, forensic, health and neuropsychology.

7.2.1 Aim and research questions

To build consensus on the MoA Ontology's content and ensure its useability by a range of users, the current study aimed to investigate whether international behavioural scientists, with research experience relevant to MoAs, found the ontology's class labels and definitions clear and the ontology itself sufficiently comprehensive. The studies to develop the MoA Ontology in this thesis are shown in Figure 7-1, with the current study highlighted. The research questions to address this study's aim were as follows:

1. Which classes of the MoA Ontology need to be refined in order to make their labels and definitions clear, based on the feedback from international behavioural scientists with research experience relevant to MoAs?

2. Which classes need to be added to the MoA Ontology in order for this ontology to more comprehensively capture MoAs in behaviour change interventions, based on feedback from international behavioural scientists with research experience relevant to MoAs?

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Study 2 (in Chapter 3): Developing a preliminary ontological structure by
identifying MoAs from 83 behavioural theories, and grouping together
MoAs with shared attributes
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Study 3 (in Chapter 4): Developing an MoA Ontology by identifying
classes from MoA groups, ungrouped MoAs and relevant ontologies, and
clearly labelling, defining and hierarchically structuring these classes
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Study 4 (in Chapter 5): Restructuring the MoA Ontology to be ontologically
correct, comprehensive yet usable through an expert review
```

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Study 5 (in Chapter 6): Refining the MoA Ontology classes by applying
this ontology to annotate MoAs in published reports of behaviour change
interventions
```

```
Study 6 (in Chapter 7): Refining the MoA Ontology through a stakeholder
review by international behavioural scientists
```

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Study 7 (in Chapter 8): Investigating the inter-rater reliability of applying
the MoA Ontology class labels and definitions to annotate MoAs in
intervention reports
```

Figure 7-1. Studies used to develop the MoA Ontology in this thesis, with the current
study highlighted

7.3 Methods

The current study was approved by the University College London Ethics Committee (CEHP/2020/579).

7.3.1 Design

This study involved an online questionnaire with closed and open-ended questions on whether the classes of the MoA Ontology had clear labels and definitions, and whether any classes were missing from the ontology.

7.3.2 Participants

In the stakeholder reviews of other ontologies making up the Behaviour Change Intervention Ontology, between three and 29 reviewers were considered sufficient (Michie et al., 2021; Norris et al., 2021b). Different ontologies require different types and numbers of reviewers. For instance, the Setting Ontology included classes about aspects of where an intervention could take place, such as a hospital or a school, which were easy to grasp. For this ontology, wide global feedback was particularly important to capture classes that would be relevant for interventions delivered in different countries, e.g., capturing the characteristics of healthcare settings for various countries. Therefore, as many participants as possible were recruited to review this ontology, and these participants volunteered their time. Fewer reviewers were used for the upper-level Behaviour Change Intervention Ontology (Michie et al., 2021), as this ontology required in-depth feedback from people with highly specialised expertise, i.e., in depth knowledge about ontologies.

The current stakeholder review intended to include participants with in-depth knowledge about MoAs, as MoAs can be conceptually difficult to understand and differentiate from one another. The MoA Ontology also had more classes than other ontologies (e.g., Norris et al., 2020, 2021b) and so required a more detailed and longer review (estimated to take 12 hours). To obtain feedback from participants with relevant expertise and from different countries, while compensating them for their time, 8-10 experts were considered feasible for this study. Considering potential dropouts from the study, the aim was to recruit 10 participants.

7.3.2.1 *Recruitment*

Recruitment aimed to identify international participants with in-depth knowledge of MoAs and theories of behaviour change and no close collaborations with the HBCP members. To operationalise the criteria for selecting participants, the current study drew on the conditions necessary to be a peer reviewer in Wellcome Open Research (https://wellcomeopenresearch.org/for-authors/tips-for-finding-referees). These criteria were:

1. **Qualified**: The participant needed to have a doctoral level degree in a related field, including psychology, neuroscience, economics, sociology or anthropology

2. **Expert**: The participants needed to have published **at least three articles** as lead, second or corresponding author relating to (a) developing, refining or evaluating behavioural theories, (b) behaviour change intervention reports using behavioural theories, or (c) systematic reviews, meta-analysis or scoping reviews of such interventions, and at least one of these articles should be published in the last five years

3. **Impartial:** The participants could not be close collaborators of the authors, i.e., they could not:

   - Have co-authored with the MoA Ontology's lead developers (AW, JH, SM, PS & RW) in the three years preceding this study (2018 and onwards)

   - Be working at the lead developers' institutions

4. **Global**: The participants needed to be from different institutions than the developers of the MoA Ontology. If sufficient people with relevant expertise were interested in participating in the study, participants should be included considering geographical diversity

There were three recruitment strategies in order to reach those with relevant expertise on MoAs and from diverse populations. These strategies included posting an invitation on social media, identifying potential participants from the authors of book chapters and literature reviews on MoAs and behaviour theories.

7.3.2.1.1 *Recruitment strategy 1: Social media call*

To recruit a diverse range of international experts and those who might be under-represented in the pools of people generated by other recruitment strategies, one strategy involved a general social media call. A short message was posted on the University College London Centre for Behaviour Change's Twitter account. People interested in developing the MoA Ontology were asked to contact the HBCP's email. Those responding were sent an invitation letter to the study (see Section 7.3.2.1) outlining the eligibility criteria.

7.3.2.1.2   Recruitment strategy 2: Identifying potential participants from the authors
of book chapters on MoAs and behavioural theories

To identify potential participants with broad expertise on MoAs, we identified the authors of book chapters on MoAs and/or behavioural theories. Books were searched for using the broad terms 'behaviour OR behavior' and 'intervention' and 'theory or model' on the search engine GoogleBooks. The resulting books were ordered according to publication dates, as recently published books were more likely to be written by researchers who currently worked in the behaviour change field. PS screened the titles and content pages of books in sets of 50 according to exclusion criteria. To identify authors with different expertise and backgrounds, book sets were screened until there were chapters of at least 20 books for further screening. The exclusion criteria for books were:

1. The list of editors including a member of the HBCP

2. Textbooks aimed at undergraduates

3. Guidance on topics not relating to behaviour change (e.g., writing grant applications)

4. No authors specified for individual chapters

5. Not available online or in accessible libraries

After the relevant books were included for further screening, their chapter titles and abstracts or introductions were assessed against inclusion criteria: the titles, abstracts or introductions needed to refer to at least one human behaviour and a theory or potential MoA that influenced a behaviour. Chapters meeting these criteria were included in full-text screening, where PS judged whether the chapter mentioned at least one human behaviour and one potential MoA that influenced the behaviour.

Figure 7-2 summarises the chapters identified. Altogether, 560 chapters of 30 books were screened. After the full-text screening, 274 chapters were considered relevant to MoAs of behaviour change interventions. Drawing on these chapters' authors, 452 unique individuals were identified. For 368 individuals, the contact details, institutions, and countries of the institutions they worked for could be identified from official websites.
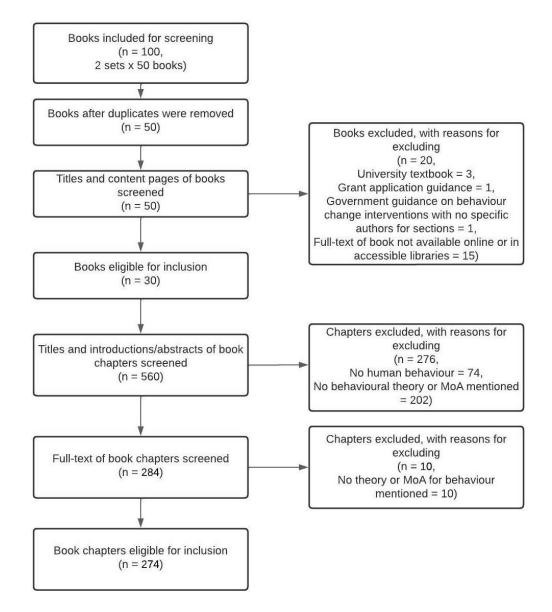
Figure 7-2. Flowchart for identifying book chapters relevant to MoAs in behaviour change interventions

7.3.2.1.3   Recruitment strategy 3: Identifying potential participants from literature reviews

The third strategy, searching for literature reviews relevant to MoAs and identifying their authors, aimed to identify participants with relevant expertise at different career stages. To identify such reviews, PS searched for articles mentioning key terms ('behavio*', 'theory or model or framework' and 'intervention') anywhere in their texts in two journals, Health Psychology Review and Annual Reviews of Psychology. These journals were chosen as they include broad reviews of behavioural theories and/or interventions. Next, 100 articles were randomly selected from the search results for each journal, and PS screened these articles' titles and abstracts against inclusion criteria. These criteria were for the title or abstract to mention:

1. A scoping review, systematic review, meta-analysis, theory/model building or theory integration, conceptual critique, conceptual review, narrative review or literature review

2. One or more interventions being delivered to a human population

3. One or more human behaviours

4. One or more theories, theoretical frameworks or models, or MoAs relevant to behaviour

After the title and abstract screening, articles that met the eligibility criteria were included in the full-text screening. The criteria for the full-text screening were the same as the criteria used for the title and abstract screening.

Figure 7-3 summarises the article screening process to identify reviews relevant to MoAs in behaviour change interventions. After the full-text screening, 52 articles met

the eligibility criteria. From these articles, 222 unique authors were identified. For 205 authors, the contact details, institutions, and countries of the institutions they work for could be identified from official websites.

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┌─────────────────────────┐        ┌─────────────────────────┐
│ Records identified      │        │ Records identified      │
│ through Health          │        │ through Annual Review   │
│ Psychology Review       │        │ of Psychology           │
│ (n = 155)               │        │ (n = 438)               │
└─────────────────────────┘        └─────────────────────────┘
            │                                  │
            ▼                                  ▼
┌─────────────────────────┐        ┌─────────────────────────┐
│ Records randomly        │        │ Records randomly        │
│ selected for screening  │        │ selected for screening  │
│ (n = 100)               │        │ (n = 100)               │
└─────────────────────────┘        └─────────────────────────┘
```

Titles and abstracts of articles assessed for eligibility (n = 200)

Records excluded, with reasons (n = 148, Incorrect study design = 13, No mention of intervention = 95, No mention of behaviour = 31, No mention of theory or MoA for behaviour = 8, Not a study but list of abstracts = 1)

Full-text of articles screened (n = 52)

No records excluded

Articles eligible for inclusion (n = 52)

Figure 7-3. Flowchart for identifying review articles relevant to MoAs in behaviour change interventions

The list of authors identified from the book chapter and literature screening processes was checked for duplicates. De-duplication left 558 potential participants who were checked for whether they had co-authored (since 2018) with the lead MoA Ontology developers (AW, JH, SM, PS & RW) or currently worked in the same institution as them. Accordingly, 33 contacts were excluded, leaving 525 potential participants.

7.3.2.1.4   Invitation letters sent to potential participants

In response to the social media call, six people expressed interest in participating in the study, and three replied to the invitation letter outlining the eligibility criteria (see Section 7.3.2.1). Potential participants identified from the book and literature screening were invited in batches of 50 people, to avoid inviting too many participants. Many potential participants were affiliated with institutions in specific countries, such as the United States (see Appendix 7-1). Therefore, to recruit potential participants from diverse countries, who might have different views on MoAs, they were purposively sampled. To select 50 potential participants to contact each time, those from less frequently occurring countries (i.e., with fewer than 10 potential participants) were given a higher chance for being selected (see numbers of potential participants approached per country in Appendix 7-2). For instance, in the first set of 50 people approached, those from the United States were limited to 35% of those approached, rather than the ~50% that they represented in the contact list. To avoid representing a single institution too strongly, potential participants were also not contacted if someone from their institution had already agreed to participate in the study. In addition, only one person from a specific institution was contacted per batch. Potential participants who declined the invitation were asked if anyone else from their team would be interested in participating, and these people were invited.

In total, 159 potential participants (3 batches x 50 potential participants and nine potential participants recommended by those who declined the invitation) were approached until sufficient people responded to the invitations and met the eligibility criteria. Of these 159, 12 responded positively to the invitation, 17 declined the

invitation due to limited availability or not meeting the eligibility criteria, 114 did not respond and 16 email addresses were out of date.

7.3.2.2 *Screening potential participants*

The 15 potential participants who expressed interest following the invitation letters were sent questions to verify that they met the eligibility criteria (see Appendix 7-3). For instance, participants were asked to list three studies they had been involved in conducting that fit the eligibility criteria. Two researchers (PS & AW) checked whether the 15 participants met the eligibility criteria and judged that 10 met these criteria. The remaining five did not meet the publication criterion or had collaborated with a leading MoA Ontology developer since 2018. Participants were compensated for their time with £650 per person (£50 per hour x 13 hours, including 1 hour of training).

7.3.3 Materials

7.3.3.1 *Training material for the stakeholder review*

As the current study recruited participants with expertise in MoAs but not ontologies, six training sessions were prepared to explain key concepts relating to ontologies, the MoA Ontology's development and the task itself. These sessions (1) provided an overview of the training sessions, (2) introduced MoAs, (3) introduced ontologies, (4) described how the MoA Ontology's content was identified, (5) described how the MoA Ontology was structured and (6) explained what would be asked of participants in the task. PS prepared the relevant training session slides in PowerPoint. Next, two MoA Ontology developers (AW & SM) and three researchers unfamiliar with the ontology reviewed these slides for clarity and the slides were refined. Two MoA Ontology

developers (PS & AW) recorded the six training sessions, in which they presented the slides online. The sessions lasted between 4:40-9:09 minutes and were sent to participants using a YouTube link:

https://www.youtube.com/playlist?list=PLnSpykYHzbdL2dOcRwUtsX-Li3mbuKKye.

7.3.3.2 *Presentation of the MoA Ontology in the online survey*

The refined version of the MoA Ontology from Study 5 was presented to participants. However, of its 234 classes, five classes reused from Basic Formal Ontology (BFO; 'disposition', 'quality', 'role', 'representation' and 'process profile') were not shown as part of the MoA Ontology, as these classes were domain non-specific and would not be MoAs in their own right. For instance, while 'bodily disposition' could be considered a broad MoA, its parent class from BFO 'disposition' would be too unspecific to be an MoA (see Study 4). However, as the terms 'disposition' and 'representation' were used to define other classes in the ontology (e.g., 'bodily disposition') and not commonly known terms, they were explained in the training sessions.

Given that the ontology had 229 remaining classes, there were too many to view all at once on a screen. Therefore, the class labels and definitions were presented in 23 blocks. The block sizes reflected the number of classes that was feasible to view on a laptop screen at one time. Presenting classes in blocks revealed their hierarchical relationships to other classes clearly. Each block had 6-14 hierarchically organised classes, presented with their labels and definitions (see example in Figure 7-4 and all blocks in Appendix 7-4).

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
Anatomical structure								A material anatomical entity that is a single connected structure with inherent 3D shape generated by coordinated expression of the organism's own genome.
Environmental system								A system which has the disposition to surround and interact with one or more material entities.
	Social environment system							An environmental system that consists of people, social and cultural institutions and processes involving these that influence the life of people and social groups.
		Family environment system						A social environmental system that consists of persons related as members of a domestic group, or a number of domestic groups linked through descent from a common ancestor, marriage, or adoption.
		Friendship network						A social environmental system that consists of persons who share a bond of mutual affection and are in contact or communication among which transmission of knowledge, behaviour, values or of an infectious agent is possible.
Personal role								A role that inheres in a human being by virtue of their social and institutional circumstances.
	Personal social role							A personal role that is realised in human social processes.
		Occupational role						A social role that involves the person's occupation.
	Personal financial resource							A personal role in which the individual has access to a material or an immaterial entity which may confer economic benefits.
Location								A spatial quality inhering in a bearer by virtue of the bearer's spatial location relative to other objects in the vicinity.

Figure 7-4. Example of a block of the MoA Ontology classes presented to participants

To be able to view the ontology as a whole, the participants were also sent the complete ontology as a spreadsheet and a visualisation of the ontology as a PDF file (see extract in Figure 7-5 and complete version in the following link https://mfr.osf.io/render?url=https://osf.io/y7v5c/?direct%26mode=render%26action=download%26mode=render)
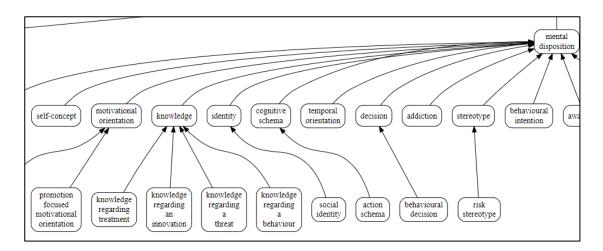
Figure 7-5. Extract of MoA Ontology visualisation sent to participants

7.3.4 Procedure

Consenting participants were invited to watch the training sessions and email PS with any questions they had about the ontology. As participants could watch the training sessions at their convenience, they could send questions at any time during the four weeks of data collection. The responses to these questions were sent to all participants (see questions and responses in Appendix 7-5).

After the training sessions, participants were asked to provide feedback on the MoA Ontology in a survey, hosted on the online software Qualtrics (https://www.qualtrics.com). As participants were asked about classes that should be added to the MoA Ontology at the end of the task, the initial instructions recommended noting down potentially missing classes throughout the task. Next, participants were presented the blocks of classes and asked to read each class's label and definition. Below each block, participants were presented with the class labels and definitions as a list and asked: 'Please indicate below whether you think the label or definition of any of the presented classes needs to be refined.' Participants could tick boxes to indicate that a class's label and/or definition required changing and write down their comments on this class (e.g., point out issues or suggest changes).

After reviewing all blocks, participants were asked about whether they thought there were any classes missing from the ontology, as follows: 'After reviewing all classes in the MoA Ontology, do you think any classes need to be in the ontology, but are currently not? If so, please suggest the labels and definitions of these classes.' Finally, participants were prompted to write down any other comments on the ontology with the following instruction: 'If you have any other comments on the MoA Ontology that

310

have not been covered so far, please write them down below. We appreciate any feedback that you can give us.'

7.3.5 Analysis

The data were downloaded from Qualtrics, and descriptive analyses were conducted to provide an overview of the class labels and definitions marked as needing change. Participants' comments on each class and the open-ended questions were organised using spreadsheets. Comments on the open-ended questions that were specific to one class were organised under that class. PS divided the comments into smaller segments if they needed to be addressed separately by the MoA Ontology developers. For instance, a participant might have commented that a class's definition was unclear but also that a subclass could be added to this class. This comment would be divided into two, to help separately consider the definition's clarity and the suggested subclass.

Each comment about the ontology was reviewed by PS and at least another MoA Ontology developer (AW, JH, SM & RW). PS read all comments, noting how the comment could be addressed (e.g., by changing a class's definition) and who needed to review this comment. Comments relating to conceptual issues with classes required all five developers to agree on changes to the MoA Ontology and were discussed in team meetings. The comments on classes reused from the Emotion and Mental Functioning Ontologies were discussed with the ontology expert (JH), who was also the developer of these two ontologies (Hastings, Ceusters, Jensen, Mulligan, & Smith, 2012; Hastings, Ceusters, Smith, & Mulligan, 2011). All remaining comments that addressed minor issues with the labels, definitions or structure of classes were discussed by two MoA

Ontology developers (PS & AW). Decisions on how to address each comment were recorded.

As a result of expert feedback, several types of changes could be made to the MoA Ontology. When participants' feedback suggested that class labels and definitions were unclear or underspecified the classes' scope, these labels and definitions could be refined to improve clarity and/or coverage. When participant comments suggested that the relationship between two classes was unclear or wrong, the relationship to other classes could be changed (e.g., the parent class could be updated) or relationships between classes could be added. When feedback indicated that a class was unclear, but the ontology developers did not think their label or definition needed updating, synonyms, comments, examples and informal definitions could be added to the class. Synonyms, comments, examples and informal definitions are optional entries for a class in an ontology. Synonyms help indicate different terms that can be used for a class. Comments provide additional information about a classes' definition, explaining parts not elaborated on in the more concise definition. Examples provide instances of a class in real-life, helping ontology users contextualise a class. Informal definitions provide user-friendly descriptions of classes, without needing to follow the principles for writing ontological definitions. Where expert comments implied that classes were unclear or could not be distinguished from other classes, these classes could be removed from the ontology. In addition, when changes in the MoA Ontology meant that certain classes were no longer necessary, they could be removed. Finally, to capture classes that the participant comments suggested were missing from the MoA Ontology, new classes could be added to the ontology.

7.4   Results

7.4.1   Participant characteristics and engagement

Nine participants completed the study, as one participant dropped out before starting the task. The institutions that the remaining participants worked at were based in Australia (n = 1), Canada (n = 1), France (n = 1), Ireland (n = 1), United Kingdom (n = 3) and United States (n = 2). The median time taken to complete the task was 3 days and 4.5 hours (range 1.5 hours - 10 days and 27 minutes).

Participants commented on an average of 55 classes (range 25 – 93 classes). Eight participants suggested new potential classes, and all participants made additional comments about the ontology or the task. PS separated comments into a total 606 comment segments relating to a single topic concerning a class, the ontology's structure or the task. These segments and ontology developers' responses to them are presented in the following link on Open Science Framework (OSF) in line with the HBCP's procedure for stakeholder reviews: https://osf.io/82g9c/.

7.4.2   Changes to the classes in MoA Ontology

7.4.2.1   *Class labels and definitions requiring changing*

Of the 229 classes presented to participants, 61 class labels and 195 class definitions were suggested as requiring changes by at least one participant. The class labels that were suggested to require changing most often were: 'personal financial resource' (n = 4 participants), 'subjective need' (n = 4 participants), 'health care accessibility' (n = 3 participants), 'positive evaluation of self' (n = 3 participants) and 'negative evaluation of self' (n = 3 participants). The class definitions that participants indicated as requiring changing most frequently were: 'self-efficacy belief for a behaviour' (n = 7

participants), 'bodily disposition' (n = 6 participants), 'cognitive representation' (n = 6 participants) and 'friendship network' (n = 6 participants). For each class, the number of participants who indicated that the class label or definition required changing, along with the number of comments on the class, are presented in the following OSF link: https://osf.io/9fmyu/.

7.4.2.2   Classes changed in response to participant comments

In response to the comments on specific classes and the open-ended questions, 34 labels and 127 definitions were changed, with both labels and definitions being updated for 24 classes. The parent classes of 25 classes were updated and other types of relationships were specified for three classes. Comments were added to 59 classes, synonyms were added to 11 classes, examples were added to five classes. Informal definitions were developed for 31 classes. Finally, 18 classes were removed from the ontology. A record of the changes made to each class is presented in Table 7-1. The updated hierarchically organised MoA Ontology, with its labels, definitions, synonyms and informal definitions, is presented in Appendix 7-6. The comments, examples and non-hierarchical relationships for the ontology classes are presented in Appendix 7-7. For brevity, the current chapter only discusses examples of the comments made on the ontology that led to changing the ontology.

7.4.2.2.1   Class labels and definitions changed to improve clarity

Participants often suggested that class labels and definitions could be worded more simply, without using jargon. For instance, Participant 4 wrote that the definition of 'reflective thinking' included "*a lot of jargon/terminology… making it difficult to understand."* To simplify the definition, the wording was changed from 'Thinking that

314

involves generation of inferences based on syllogistic reasoning or decision making based on the evaluation of anticipated consequences or the construction of propositional representations' to 'Thinking that involves the generation of inferences by reasoning based on one or more statements, evaluating anticipated consequences or considering the relationships between concepts.'

Participants also suggested that some class definitions specified their parent class incorrectly. For instance, the class 'affective process' (reused from the Emotion Ontology) was defined as 'Any process that has positive or negative valence.' In relation to this class, Participant 1 wrote "*Any MENTAL process that...?*" As the participant suggested, the definition of 'affective process' should have specified its parent class, 'mental process'. Accordingly, the 'affective process' definition was updated to read as 'A mental process that has positive or negative valence.'

7.4.2.2.2   *Labels and definitions changed to align with or clarify the class's scope*

For some classes, participants recommended that the definitions should be broader. For instance, Participant 2 suggested that the 'physical skill' definition ('A physical capability acquired through training and practice.') should allow skills to be acquired through training 'and/or' practice. As the ontology expert (JH) explained that the term 'or' was logically equivalent to 'and/or' in ontologies, the 'physical skill' definition was updated to refer to physical capability acquired through training 'or' practice.

Participant comments sometimes implied that class labels or definitions needed to specify their classes' scopes more clearly. For instance, for 'family environmental system' (definition: 'A social environmental system that consists of persons related as

members of a domestic group, or a number of domestic groups linked through descent from a common ancestor, marriage, or adoption'), two participants were uncertain if the definition encompassed "*non-traditional families*" and "*foster families*". Therefore, the class definition was updated to finish with 'linked through descent from a common ancestor, marriage, adoption or *other legal arrangements.*' For the class 'alienation' (defined as 'A mental disposition to perceive or experience oneself as isolated from and not meaningfully involved in social groups.'), Participant 4 questioned whether the class was limited to social alienation as the definition suggested or was broader as the label suggested. To match the definition's specificity, the class's label was updated to be 'social alienation'.

Participants also commented on the scope of classes that had been reused from the Mental Functioning and Emotion Ontologies, suggesting that their class labels or definitions might require changing. For instance, Participant 7 suggested that the 'mental process' definition ('A bodily process that is of a type such that it can of itself be conscious.') was underspecified. More specifically, they pointed out that "*other classes under bodily process can also be conscious - goal pursuit, self-regulation, plan enactment etc - so it is not something unique to this class.*" They also mentioned that some 'mental process' subclasses did not always involve consciousness (e.g., 'awareness'). As conscious and unconscious mental processes were difficult to distinguish, the MoA Ontology developers decided to broaden the scope of 'mental process' to include processes that can lead to consciousness or behaviour. The class definition was updated to read as 'A bodily process that occurs in the brain, and that can of itself be conscious, or can give rise to a process that can of itself be conscious or can give rise to behaviour.' An informal definition was also developed to help ontology

users better understand this class: 'A process that takes place in the brain and can involve consciousness.'

Participants' comments sometimes suggested that two or more classes' scopes should be distinguished more clearly. For instance, regarding the classes 'mental plan' and 'behaviour intention', Participant 5 noted *"'Behavioural intention' and 'mental plan' do not seem to warrant separate classes in the same hierarchical level. Perhaps behavioural intentions are simple versions of mental plans?"* The class 'behavioural intention' (defined as: 'A mental disposition that is a commitment to enact or not enact a behaviour.') was intended to be different from the class 'mental plan' (defined as: 'A mental disposition to form a representation of a behaviour, the conditions under which it will be enacted and an intention to enact the behaviour under those conditions.') with the dimension of committing to a behaviour. To emphasise the active process of committing to a behaviour in the class 'behaviour intention', its definition was updated to read, 'A mental disposition to commit to enact or not enact a behaviour.'

7.4.2.2.3   Adding comments, examples, synonyms and informal definitions to classes to improve clarity

Participants' comments sometimes implied that aspects of certain classes should be clarified, which the ontology developers thought could be addressed by providing additional information for these classes. For instance, Participant 6 queried whether the 'anatomical structure' class qualified as an MoA by writing "*Curious if this should be included within the ontology as the example given for what an MOA is not... defined as 'Cannot be changed or are difficult to change through an intervention to change behaviour'.*" In the MoA Ontology's formal structure, the class would be 'MoA through

317

anatomical structure', implying that anatomical structure would need to change (see Study 4). For instance, a bypass surgery could alter a person's intestinal structure and thereby modify eating behaviour. To make this class easier to understand, examples were added to this class in the MoA Ontology (e.g., 'the structure of the stomach and intestines'). In addition, a comment outlining the bypass surgery example was added to the class to demonstrate when this class would qualify as an MoA.

Some participants suggested that there might be overlaps between MoAs, behaviour and behaviour change techniques (BCTs; 'systematic procedure included as an active component of an intervention designed to change behaviour' [Michie, Johnston, & Carey, 2016]). In response to the open-ended question, Participant 7 wrote "*Some MoAs are behaviours, and some are BCTs (e.g., self-reinforcing self-regulation, behavioral self-regulation)*." First, as the participant suggested, the MoA Ontology developers agreed that behaviours can be MoAs. However, these behavioural MoAs can be distinguished from behavioural outcomes, which are targeted in an intervention. To clarify this distinction, a comment was added to the class 'individual human behaviour'. Secondly, distinguishing BCTs and MoAs seemed to be a common confusion for participants, as similar comments were raised for specific classes (e.g., 'associative learning'). Whilst BCTs are components of an intervention (e.g., provide information or support), MoAs are bodily or mental processes that lead to changes in behaviour. For classes where this issue was raised, comments were added to distinguish the classes from behaviour change techniques. In addition, the Behaviour Change Technique Ontology developers were contacted to advise them to label behaviour change techniques more clearly as techniques.

Some comments suggested that participants were uncertain about a class's link to other overlapping MoAs. For instance, Participant 5 expressed uncertainty about 'belief about voluntariness of behaviour', by asking '*how is this linked to autonomy*?' As a person believing that their behavioural performance is voluntary closely relates to their belief in their autonomy level, beliefs about behavioural voluntariness and autonomy could be used interchangeably. The overlapping nature of these concepts meant that a relationship to another class did not need to be specified. Instead, to capture the class more clearly, a synonym was added to the 'belief about voluntariness of behaviour' class: 'belief about autonomy in performing behaviours'.

Participants sometimes expressed finding specific terms or phrases in definitions confusing. Where the MoA Ontology developers thought substituting such terms or phrases would interfere with the definition's clarity, they added comments that explained these terms or phrases. For instance, regarding the class 'affective process' (defined as 'Any process that has positive or negative valence'), Participant 8 expressed concerns about whether the term 'valence' would be understood "*outside of psychology*." As the term clearly captured that 'affective process' would be experienced as positive or negative, it was kept in the definition. However, a comment was added to explain what 'valence' meant: 'Valence refers to the "the subjective value of an event, object, person, or other entity in the life space of the individual" (https://dictionary.apa.org/valence). Valence ranges from negative to positive.'

Participants also expressed being uncertain about several classes' definitions being worded as future-oriented conditions (e.g., 'knowledge' and 'decision'), suggesting these definitions should be changed. For instance, 'knowledge' was defined as 'a mental

disposition to understand the nature of the world, or a specific aspect of the world, that corresponds to the actual state of the world and is acquired through experience or learning.' Participant 2 expressed that the 'knowledge' class would be clearer if it was defined as a current state, by writing: "*General point relating to the disposition items: Would it be clearer if these were phrased as 'of'' rather than 'to'? To make it clearer that the items are referring to a current state rather than a propensity towards something.*" However, a 'mental disposition' (e.g., 'knowledge') involves a propensity towards something: mental dispositions are future-oriented conditions that can be realised through processes under specific circumstances. For instance, after a person has learned something, they need to retrieve that information in order to 'know' this information at a given moment. Therefore, 'knowledge' will involve a process (e.g., recalling information) to be realised. To explain 'knowledge' conceptualised as a mental disposition, a comment was added to this class. In addition, an informal definition for 'knowledge' was developed for users unfamiliar with ontology-specific terms: 'An understanding of something that results from experience or learning.'

Several participant comments drew attention to some class definitions referring to 'humans', while others referred to 'organisms' or 'some extended organism'. For instance, Participant 2 suggested that the ontology would be clearer "*if throughout phrases, such as 'some extended organism' were replaced with phrases such as 'a person.'*" Many classes that used terms, such as 'organism' or 'some extended organism' (referring to an organism and its biome, e.g., intestinal bacteria), were originally from other ontologies. These ontologies' scope was beyond humans and needed to be relevant to various organisms. As the MoA Ontology developers did not work with the developers of many ontologies, these class labels and definitions could

not be changed. However, for all relevant classes from other ontologies, informal definitions were developed to avoid using the terms 'organism' or 'extended organism'.

7.4.2.2.4   Changes to classes' relationships and relevant updates to their definitions
Several participant comments underlined inconsistencies in the definitions of classes and their subclasses, implying that their relationships might be incorrect. For instance, Participant 7 pointed out that 'interpersonal process' (reused from the Mental Functioning Ontology) was defined as a 'process', when its parent class was 'bodily process'. When the MoA Ontology developers referred to the Mental Functioning Ontology (Hastings et al., 2012), they found that 'interpersonal process' had been re-organised as a subclass of 'behaviour' in that ontology. After discussing this class, the developers agreed that all interpersonal processes would involve some behaviour from at least one agent. However, the 'behaviour' class in the Mental Functioning Ontology was broader than the class 'individual human behaviour' in the MoA Ontology, which had been reused from the Behaviour Ontology. As a class relevant to behaviour between two people was identified in the Behaviour Ontology (labelled as 'interpersonal behaviour'), this class was reused in the MoA Ontology to replace 'interpersonal process'. Relevant updates were also made to the labels and definitions of subclasses now organised under 'interpersonal behaviour' in the MoA Ontology. For instance, the subclass 'communication' was relabelled as 'communication behaviour'.

In some cases, the participants' comments prompted the MoA Ontology developers to discuss the classes' hierarchical structure and reorganise these classes. For instance, participants expressed confusion about why 'self-efficacy belief for a behaviour' was not organised as subclass of 'self-efficacy belief' (defined as 'A belief about one's

capabilities to organise and execute a behaviour and achieve the outcomes associated with this behaviour.'). First, the label of 'self-efficacy belief' was changed to 'self-efficacy belief for behaviour and its associated outcomes' to better reflect the class's definition. Then, the relationship between these two classes was specified, namely that 'self-efficacy belief for a behaviour' is a part of 'self-efficacy belief for a behaviour and its associated outcomes'.

By working on the two self-efficacy related classes, the ontology developers also re-evaluated their relationships to their shared parent class 'belief about control over behaviour'. The class 'belief about control over behaviour' captured self-efficacy for behaviour but also opportunities within an environment. However, 'self-efficacy belief for behaviour' and 'self-efficacy belief for behaviour and its associated outcomes' did not capture opportunities within an environment and so, did not strictly qualify as subclasses of 'belief about control over behaviour'. These two classes were reorganised as the subclasses of the broader 'belief' class. In addition, a relationship was added to specify that 'self-efficacy for a behaviour' is part of 'belief about control over behaviour'.

7.4.2.2.5   *Classes removed from the ontology*

Participant comments sometimes implied that a class could be covered by another class in the ontology or was unnecessary for describing MoAs. For instance, Participant 7 suggested that the class 'belief about control over the environment' was already captured by its parent class 'belief about control over behaviour'. Therefore, 'belief about control over the environment' was removed from the MoA Ontology.

In other cases, some classes were no longer needed in the MoA Ontology due to changes made to the ontology's other classes. For instance, Participant 7 expressed that the 'subjective emotional feeling's subclasses were *"not emotions (in the basic emotion sense…). They are rather motivational, physiological, emotional, and cognitive experiences."* The MoA Ontology developers agreed that the subclasses of 'subjective emotional feeling' (e.g., 'craving' and 'feeling an urge') did not only involve experiencing emotions but more broadly experiencing mental and physiological processes. When trying to expand the class 'subjective emotional feeling', the developers struggled to generate a definition that did not overlap with the class 'bodily feeling'. Therefore, the label and definition of 'subjective emotional feeling' were refined to be broad enough to cover 'bodily feeling'. The class's new label was 'subjective affective feeling', and its definition was 'An affective process that involves the experience of internal or external sensory stimuli.' The class 'bodily feeling' was removed from the MoA Ontology, as it was no longer needed, and its subclasses were organised under the class 'subjective affective feeling'.

Table 7-1. Record of changes made to classes in the MoA Ontology (from Study 5) in response to participant comments in the stakeholder review

Class label	Changed label	Changed definition	Parent class updated	Non-hierarchical relationship added	Informal definition added	Comment added	Example added	Synonym added	Removed from ontology
Anatomical structure			✓		✓	✓	✓		
Environmental system			✓		✓	✓			
Social environment system	✓	✓							
Family environment system	✓	✓							
Friendship network		✓							
Personal role					✓	✓			
Personal social role	✓					✓			
Occupational role	✓	✓	✓			✓			
Personal financial resource									✓
Location		✓			✓	✓			
Opportunity	✓	✓	✓			✓			
Financial opportunity	✓	✓	✓		✓	✓			
Healthcare service accessibility	✓	✓			✓	✓			
Physical opportunity	✓	✓			✓	✓			
Social opportunity	✓	✓			✓				
Temporal opportunity	✓	✓	✓		✓				
Cognitive representation					✓	✓			
Appraisal					✓	✓			
Appraisal of causal agency									

Class label	Changed label	Changed definition	Parent class updated	Non-hierarchical relationship added	Informal definition added	Comment added	Example added	Synonym added	Removed from ontology
Appraisal as caused by self		✓							
Appraisal as caused by factors external to the person									✓
Appraisal of dangerousness		✓				✓			
Appraisal of expectedness									
Appraisal of obligation to act									
Desired standard						✓			
Mental image		✓							
Bodily disposition					✓	✓			
Personal capability		✓			✓	✓			
Mental capability		✓							
Mental skill		✓				✓			
Self-regulation capability									
Behavioural self-regulation capability									
Cognitive self-regulation capability									
Emotional self-regulation capability		✓							
Physical capability	✓	✓	✓						
Physical skill		✓							
Social capability	✓	✓	✓						

Class label	Changed label	Changed definition	Parent class updated	Non-hierarchical relationship added	Informal definition added	Comment added	Example added	Synonym added	Removed from ontology
Social skill		✓							
Mental disposition						✓			
Addiction		✓							
Alienation	✓								
Awareness		✓				✓			
Behavioural intention*		✓							
Cognitive schema		✓			✓				
Action schema		✓							
Mental plan	✓	✓	✓						
Mental plan for coping with barriers									
Social embeddedness									
Decision					✓	✓			
Behavioural decision									
Goal		✓	✓						
Identity	✓	✓	✓						
Social identity		✓				✓			
Knowledge					✓	✓			
Knowledge regarding a behaviour									
Knowledge regarding an innovation									
Knowledge regarding a threat									
Knowledge regarding treatment									

Class label	Changed label	Changed definition	Parent class updated	Non-hierarchical relationship added	Informal definition added	Comment added	Example added	Synonym added	Removed from ontology
Self-concept									✓
Learned stimulus-response co-occurrence*		✓							
Learned stimulus-behaviour co-occurrence		✓			✓	✓		✓	
Learned stimulus-thought co-occurrence		✓						✓	
Mental image disposition	✓	✓			✓				
Willingness to comply		✓							
Motivational orientation	✓								
Prevention focused motivational orientation		✓							
Promotion focused motivational orientation		✓							
Personal value		✓							
Psychological need									
Autonomy need	✓								
Need for self-esteem									
Need for sense of security	✓								
Need for social relatedness	✓								
Need to feel competent		✓						✓	
Stereotype		✓	✓						
Risk stereotype									✓
Subjective need		✓	✓		✓				
Temporal orientation									✓

Class label	Changed label	Changed definition	Parent class updated	Non-hierarchical relationship added	Informal definition added	Comment added	Example added	Synonym added	Removed from ontology
Emotional action tendency		✓	✓		✓	✓	✓		
Belief		✓			✓				
Belief about anticipated emotion*		✓	✓			✓			
Belief about barriers		✓							
Belief about conformity to behavioural norms									
Belief about consequences of behaviour			✓			✓			
Belief about social consequences of behaviour		✓				✓			
Belief about consequences of goal attainment			✓			✓			
Belief about control over one's future									
Belief about responsibility to act		✓							
Belief about gain						✓		✓	
Belief about likelihood of potential outcomes	✓	✓	✓			✓			
Belief about likelihood of consequences of behaviour		✓							
Belief about likelihood of health consequences of behaviour		✓							

Class label	Changed label	Changed definition	Parent class updated	Non-hierarchical relationship added	Informal definition added	Comment added	Example added	Synonym added	Removed from ontology
Belief about loss	✓					✓		✓	
Belief about message									
Belief about the credibility of a message's source		✓							
Belief about message relevance									
Belief about message trustworthiness		✓							
Belief about need satisfaction		✓							
Belief about one's environment									
Belief about one's social environment									
Belief about social support		✓							
Perceived norm		✓				✓			
Perceived descriptive norm									
Perceived injunctive norm		✓							
Normative belief									
Belief about threat									
Belief about severity of an outcome									
Belief about susceptibility to a threat									
Belief about personal susceptibility		✓							

Class label	Changed label	Changed definition	Parent class updated	Non-hierarchical relationship added	Informal definition added	Comment added	Example added	Synonym added	Removed from ontology
Belief about others' susceptibility									
Belief about the timing of the consequences of behaviour		✓	✓						
Belief about voluntariness of behaviour								✓	
Evaluative belief									
Evaluation of self						✓		✓	
Positive evaluation of self									✓
Negative evaluation of self									✓
Evaluative belief about behaviour									
Evaluative belief about behavioural outcomes		✓							
Belief about the personal desirability of consequences of behaviour	✓	✓				✓			
Evaluative belief about others									
Evaluative belief about a stereotype									✓
Belief about control over behaviour				✓					
Belief about control over the environment									✓

Class label	Changed label	Changed definition	Parent class updated	Non-hierarchical relationship added	Informal definition added	Comment added	Example added	Synonym added	Removed from ontology
Self-efficacy belief	✓		✓	✓		✓			
Self-efficacy belief for a behaviour			✓	✓		✓			
Situational self-efficacy belief for a behaviour		✓							
Bodily quality									✓
Mental quality									✓
Bodily process					✓				
Bodily behavioural cue									
Mental behavioural cue									
Individual human behaviour		✓				✓			
Habitual behaviour		✓				✓			
Normative behaviour						✓			
Goal pursuit process						✓			
Internal reward for a response		✓							
Experiential rightness of goal pursuit									✓
Interpersonal process	✓	✓	✓						
Communication	✓	✓							
Linguistic communication	✓	✓					✓		
Non-linguistic communication	✓	✓					✓		
Interpersonal reciprocal communication									✓

Class label	Changed label	Changed definition	Parent class updated	Non-hierarchical relationship added	Informal definition added	Comment added	Example added	Synonym added	Removed from ontology
Behaviour-influencing social interaction process									✓
Social influence process	✓	✓							
Plan enactment		✓							
Physiological response to emotion process	✓	✓			✓				
Self-regulation of behaviour		✓							
Behavioural self-regulation of behaviour		✓			✓	✓			
Introjected self-regulation		✓							
Self-reinforcing self-regulation		✓			✓				
Value-congruent self-regulation		✓							
Mental process		✓			✓	✓			
Appraisal process		✓			✓				
Arousal		✓							
Attending		✓							
Avoidance mental process									
Heuristic process									
Affective process		✓				✓			
Bodily feeling									✓
Pain		✓	✓		✓				
Subjective emotional feeling	✓	✓			✓	✓	✓		

332

Class label	Changed label	Changed definition	Parent class updated	Non-hierarchical relationship added	Informal definition added	Comment added	Example added	Synonym added	Removed from ontology
Cognitive dissonance		✓							
Craving		✓							
Feeling an urge		✓				✓			
Emotion process		✓				✓			
Anger									
Anxiety		✓				✓			
Disgust		✓							
Fear		✓				✓			
Feeling nervous		✓	✓			✓			
Guilt		✓							
Happiness									
Pleasure		✓							
Sexual pleasure		✓							
Enjoyment of behaviour	✓							✓	
Sadness		✓							
Shame									
Surprise		✓							
Cognitive process									
Comprehension									
Decision simplification		✓							
Mental distancing		✓						✓	
Targeted mental distancing		✓						✓	
Thinking									
Reflective thinking		✓							
Memory									

Class label	Changed label	Changed definition	Parent class updated	Non-hierarchical relationship added	Informal definition added	Comment added	Example added	Synonym added	Removed from ontology
Associative memory		✓							
Episodic memory		✓							
Semantic memory		✓							
Procedural memory		✓							
Iconic memory		✓							
Learning		✓				✓			
Associative learning						✓			
Classical conditioning*		✓							
Discrimination learning									
Extinction in classical conditioning						✓			
Extinction in operant learning		✓				✓			
Generalisation (learning)	✓	✓				✓			
Habit learning		✓							
Operant conditioning		✓							
Non-associative learning									
Habituation									
Sensitization									
Observational learning									
Imitative learning		✓							
Dissonance reduction process									
Goal setting process		✓							
Mental categorising									
Mental imagery		✓							

Class label	Changed label	Changed definition	Parent class updated	Non-hierarchical relationship added	Informal definition added	Comment added	Example added	Synonym added	Removed from ontology
Mentally comparing against a standard		✓				✓			
Perception		✓			✓	✓			
Planning		✓							
Motivation									
Automatic motivation		✓							
Autonomous motivation									
Intrinsic motivation		✓				✓			
Fundamental need-based motivation		✓							
Behavioural importance-based motivation									✓
Controlled motivation	✓							✓	
Extrinsic motivation									✓
Approval-based motivation		✓							
Judging		✓							
Decision-making		✓				✓			
Judging consequences of behaviour									✓
Social comparison process									
Self-monitoring		✓				✓			
Wanting		✓							
Subliminal process		✓	✓						
Consciousness						✓			

Notes. *Class not marked as requiring change by participants but changed due to participant comments on other parts of the ontology.

7.4.3   Classes added to the MoA Ontology

In total, 43 classes were added to the MoA Ontology as a result of participants suggesting that classes were missing from the ontology, or the scope of certain MoAs were insufficiently captured by the current classes. The new classes' labels and definitions are presented in Table 7-2. With 43 classes added and the 23 removed (see Sections 7.3.3.2 & 7.4.2.2), the refined MoA Ontology had 254 classes on seven hierarchical levels and is presented in Appendix 7-6.

7.4.3.1   Classes identified as missing and added to the ontology

Participant comments sometimes explicitly suggested classes that should be added to the MoA Ontology. For instance, Participant 9 wrote "*Within mental processes/emotion processes should there also be 'exhaustion', 'depersonalisation' and 'personal accomplishment' (definitions from Maslach) because these are the facets of burnout and burnout has been linked to inabilities to enact certain behaviours.*" To capture the 'exhaustion' dimension mentioned in this comment, the class 'feeling exhausted' and its parent class 'feeling tired' were reused from the Emotion Ontology (Hasting et al., 2011). In addition, the class 'disengagement due to workload' was developed to capture 'depersonalisation' as described by Maslach and Leiter (2016). The class's label was not recorded as 'depersonalisation', as this term can be used for other mental health conditions' symptoms (e.g., Hunter, Phillips, Chalder, Sierra & David, 2003). No class was developed for 'personal accomplishment', as the MoA Ontology developers judged that this burnout dimension was a compound MoA, including emotional processes and beliefs (Leiter & Maslach, 1988).

For some classes, participants suggested that the appropriate parent class might be missing from the ontology. For instance, a participant commented on the class 'anatomical structure' (defined as 'a material anatomical entity that is a single connected structure with inherent 3D shape generated by coordinated expression of the organism's own genome.'), suggesting that its definitions did not specify its parent classes correctly. This class had been reused from the Uber-Anatomy Ontology (Mungall, Torniai, Gkoutos, Lewis, & Haendel, 2012), where its parent class had been 'material anatomical entity'. However, to keep the MoA Ontology's structure simpler, this parent class had not been reused in earlier studies. Instead, 'anatomical structure' had been on the ontology's highest hierarchical level presented to participants in the survey. In the MoA Ontology's visualisation, its parent class was shown as 'independent continuant' (a BFO class). As the participants expressed their confusion about this, the class 'material anatomical entity' was reused as the parent class of 'anatomical structure'. In addition, to link this new class clearly to BFO, its parent class, 'material entity', was also reused from BFO.

7.4.3.2 *Classes added to the ontology to capture the scope of certain MoAs more clearly*

Some participants' comments suggested that existing classes in the MoA Ontology did not sufficiently or clearly capture certain aspects of a class. For instance, the class 'disgust' had been defined as 'a negative emotion which guards the body against dangerous foods and microbial infections.' Three participants noted that this definition should be expanded beyond dangerous foods and microbial infections, such as disgust resulting from normatively or morally repulsing stimuli. While the 'disgust' definition was updated, the MoA Ontology developers also decided to add subclasses to 'disgust'

to clearly capture the class's different dimensions. These subclasses, reused from the

Emotion Ontology (Hastings et al., 2011), were labelled 'animal-nature disgust', 'core

disgust', 'interpersonal disgust' and 'moral disgust'.

Table 7-2. The labels and definition of classes that were added to the MoA Ontology in response to participant comments in the stakeholder review

No.	Class label	Class definition	Parent class
1	Appraisal of desirability of consequences*	An appraisal that represents an evaluation of the desirability of the expected consequences of an event.	Appraisal
2	Appraisal of pleasantness*	An appraisal that represents an evaluation of the pleasantness of an object or event.	Appraisal
3	Appraisal of goal importance*	An appraisal that represents an evaluation of whether an event or object is important to the person's goals or needs.	Appraisal
4	Appraisal of avoidability of consequences*	An appraisal which represents a judgement about how avoidable the expected consequences of an event will be.	Appraisal
5	Appraisal as caused by an other*	An appraisal that represents an evaluation that an event was caused by another person.	Appraisal of causal agency
6	Appraisal as caused by external non-human factors	An appraisal that represents an evaluation that an event was caused by natural events and not by humans.	Appraisal of causal agency
7	Belief about sufficient time	A belief about having enough time or a suitable period of time to enact a behaviour.	Belief
8	Belief about anticipated regret	A belief about the potential regret experienced as a result of an event.	Belief about anticipated emotion
9	Belief about consequences of an occurrence	A belief about the outcomes resulting from an occurrence.	Belief
10	Belief about health consequences of behaviour	A belief about the consequences of behaviour in terms of one's health and wellbeing.	Belief about consequences of behaviour
11	Belief about the emotional consequences of a behaviour	A belief about the consequences of behaviour in terms of resulting emotions.	Belief about consequences of behaviour
12	Belief about likelihood of emotional consequences of behaviour	A belief about the probability of a behaviour resulting or not resulting in a change to emotions.	Belief about likelihood of consequences of behaviour
13	Belief about likelihood of social consequences of behaviour	A belief about the probability of a behaviour resulting or not resulting in a change to social outcomes.	Belief about likelihood of consequences of behaviour

No.	Class label	Class definition	Parent class
14	Belief about one's physical environment	A belief about parts of one's environment that do not involve people or organisations.	Belief about one's environment
15	Belief about healthcare accessibility	A belief about one's environment in terms of how easy it is for a person to approach and use a healthcare service.	Belief about one's environment
16	Animal-nature disgust*	Disgust elicited by poor hygiene, inappropriate sex, gore or violations of bodily boundaries, and death or the odour of decay.	Disgust
17	Core disgust*	Disgust elicited by "contaminated" food substances: rotten food, culturally variable "bad" food, certain animals associated with rotten food (maggots, rats), and every body product except tears.	Disgust
18	Interpersonal disgust*	Disgust elicited by contact with others, especially contact with strangers or other individuals or groups we are averse to.	Disgust
19	Moral disgust*	Disgust elicited by some kinds of especially egregious moral violations.	Disgust
20	Environmental disposition*	A disposition which is realised by an environmental system or system parts thereof.	Disposition
21	Regret	A negative emotion that occurs when a person wishes they chose or acted differently in the past, due to the consequences of that choice or action being unfavourable.	Emotion process
22	Ecosystem*	An environmental system which includes both living and non-living components.	Environmental system
23	Feeling exhausted*	Feeling tired to an extremely strong degree.	Feeling tired
24	Professional identity	Identity that is associated with one's occupational role.	Identity
25	Material entity*	An independent continuant that is spatially extended whose identity is independent of that of other entities and can be maintained through time.	Independent continuant
26	Material anatomical entity*	Anatomical entity that has mass.	Material entity
27	System*	A material entity consisting of multiple components that are causally integrated.	Material entity
28	Temporal orientation to the future	A mental disposition to focus more on future than present outcomes.	Mental disposition
29	Temporal orientation to the present	A mental disposition to focus more on present than future outcomes.	Mental disposition
30	Disengagement due to workload	A mental disposition to be detached from other people due to exhaustion experienced in one's working environment.	Mental disposition
31	Mental plan	A mental disposition that is realized in mental processes mentally manipulating representations of steps in an imagined process which has some goal.	Mental disposition
32	Impulse	A mental process that is sudden and compels an organism to think or behave in some way.	Mental process

No.	Class label	Class definition	Parent class
33	Self-binding	A bodily process that involves creating adverse consequences for oneself if one does not stick to an intended course of action.	Mental process
34	Non-judgemental acknowledgement	A mental process that involves taking notice of one's affective, mental or bodily experience without judging it as good or bad.	Mental process
35	Behavioural capability	A personal capability that includes behaviours in its realisation.	Personal capability
36	Self-regulatory skill	A self-regulation capability that is acquired through training or practice.	Self-regulation capability
37	Attentional self-regulation capability	A self-regulation capability to modulate one's attention toward internal or external stimuli.	Self-regulation capability
38	Professional network	A social environmental system that consists of persons who have shared interests relating to their occupational roles and are in contact or communication.	Social environmental system
39	Feeling tired*	A subjective affective feeling of tiredness, needing sleep.	Subjective affective feeling
40	Hunger*	A subjective affective feeling that involves discomfort and is associated with a need to consume food.	Subjective affective feeling
41	Feeling sadness	A subjective affective feeling of sadness.	Subjective affective feeling
42	Positive surprise*	Surprise with a positive valence	Surprise
43	Negative surprise*	Surprise with a negative valence.	Surprise

Note. *The classes reused from other ontologies

While all participant comments were responded to by the MoA Ontology developers (see https://osf.io/82g9c/), some comments were not addressed by changing or adding classes to the MoA Ontology. For instance, Participant 5 wrote "*It seems a bit incomplete to have a single sub-class of a higher-order class. E.g., physical skill is the only subclass of physical capability.*" As ontologies can have a class with only one subclass (which has a differentiating attribute from its parent class), only a response explaining this principle was recorded for the comment. Other comments pointed out the proliferation of 'belief' subclasses, suggesting that some subclasses should be removed. However, without further systematic guidance, the MoA Ontology developers were unsure which subclasses to remove. A few participants also made suggestions on

disseminating and presenting the MoA Ontology moving forward. For instance, Participant 6 mentioned that the ontology should be disseminated with learning tools, e.g., on how to use the ontology to code papers. Such suggestions were recorded for consideration in the future.

7.5   Discussion

To refine the MoA Ontology's content and usability, the current study used a stakeholder review to investigate whether its classes were clearly labelled and defined, and any classes were missing. Based on feedback from nine international behavioural scientists, 34 class labels and 127 class definitions were updated in the MoA Ontology. The parent classes of 25 classes were also changed. In addition, clarifying comments, synonyms, examples, informal definitions and non-hierarchical relationships were specified for classes. As 23 classes were not considered necessary in the MoA Ontology, these were removed. With 43 new classes added to the MoA Ontology to more comprehensively capture MoAs, the ontology now had 254 classes.

This study helped further address the 'Commitment to collaboration' principle for 'gold standard' ontologies (OBO Foundry, 2019b), according to which ontologies' content should reflect scientific consensus and meet their users' needs. The study included experienced behavioural scientists who could provide feedback on where the ontology misaligned with wider perspectives on MoAs. This feedback helped refine class labels and definitions to be more understandable and reflect wider consensus about MoAs in the ontology. For instance, synonyms were added to classes to record different terms that behavioural scientists might be familiar with for a particular MoA, making it easier to find this MoA in the ontology. Like other ontologies developed as part of the

Behaviour Change Intervention Ontology (Michie et al., 2017; Wright et al., 2020), the stakeholder review study helped broaden the coverage of the MoA Ontology in line with the broader scientific community's needs (e.g., Norris et al., 2021b).

7.5.1 Strengths and limitations

This study served as a formal step to systematically investigate domain experts' feedback on the MoA Ontology and revise the ontology accordingly. As the study's experts were given training regarding ontologies, they were able to provide relevant and detailed feedback on the MoA Ontology. However, these experts' feedback might not have reflected the needs of potential users with less knowledge about MoAs or less time to engage with the ontology. Despite efforts to include participants working at geographically diverse institutions, most participants also worked in countries with English as an official language. Therefore, their feedback might not have sufficiently captured challenges that potential users with less fluent English may face. Further research is needed to investigate how useable the ontology is with a wider range of potential users, e.g., those unfamiliar with ontologies. Some changes made to the ontology (e.g., adding informal definitions) might support such users. Later iterations of the ontology are likely to be further improved by integrating feedback from a wider group of potential users.

Participants were given an opportunity to express any issues with the ontology's structure for specific classes in the open-ended questions. Therefore, some of the feedback received on the MoA Ontology's classes led to changes in the ontology's structure. However, the present study did not explicitly ask participants to comment on the classes' hierarchical relationships. The size of the ontology, with its 229 classes,

posed a challenge to visually presenting the hierarchically structured classes with their definitions, and prompting feedback on their relationships. Future stakeholder reviews for ontologies or other classification systems could use different methods, involving refined visualisation programs, to systematically prompt feedback on hierarchical relationships between classes.

The current study required participants to read the class labels and definitions and provide feedback on them, but not apply the ontology to annotate MoAs in the published behaviour change intervention reports. The issues that participants experience when applying the ontology might be different or be more pronounced than the issues identified in the current study. For instance, participants might find it more difficult to distinguish certain classes (e.g., 'belief' and 'judging') based on MoA descriptions in intervention reports and suggest that more guidance needs be provided to distinguish such classes.

7.5.2 Future studies

Having refined the ontology to better reflect broader scientific consensus about MoAs and to have clearer class labels and definitions, the next question is whether ontology users interpret and apply the classes in the same way as each other. For instance, if researchers achieve 'good' inter-rater reliability when annotating MoAs using the ontology, this suggests that they interpret the ontology's class labels and definitions similarly. It would be particularly important for researchers who are unfamiliar with the MoA Ontology to apply this ontology to the literature, in order to investigate whether the ontology is useable.

7.5.3   Conclusion

The current study aimed to refine the MoA Ontology to better reflect scientific consensus about MoAs in behaviour change interventions. It investigated feedback from nine international behavioural scientists about which class labels and definitions were unclear and which classes were missing from the ontology. By integrating this feedback into the MoA Ontology, the current study produced a version of the ontology that is more usable and aligned more closely with wider perspectives on MoAs than its previous version. To investigate the revised ontology's broader usability, the next step is for researcher to use this ontology to annotate MoAs in behaviour change intervention reports.

8 Chapter 8: Investigating the inter-rater reliability of applying the Mechanism of Action Ontology to annotate mechanisms of action in behaviour change intervention reports (Study 7)

8.1 Abstract

Rationale: Ontologies need to have classes with clear labels and definitions that allow ontology users to agree on which class to select to capture relevant information (e.g., mechanisms of action; MoAs) reported in the literature.

Aim: To refine the MoA Ontology's class labels and definitions by testing whether they can be reliably applied to annotate (i.e., code) hypothesised MoAs in the behaviour change intervention reports

Methods: Researchers applied the MoA Ontology to annotated hypothesised MoAs in 100 behaviour change reports in two rounds. In the first round, two researchers familiar with the ontology applied it to annotate 50 reports. Then, researchers unfamiliar with the ontology used it to annotate the remaining 50 reports. For each round, the inter-rater reliability of annotations using the MoA Ontology across the respective 50 reports was calculated using Krippendorff's alpha. When the inter-rater reliability values in an annotation round were below the set threshold for 'acceptable' reliability ($\alpha = 0.67$), the annotation disagreements for classes with 'low' inter-rater reliability were analysed to refine the ontology and its annotation manual. The refinements to the ontology and its annotation manual were discussed and agreed upon by the MoA Ontology developers.

Results: The researchers familiar with the MoA Ontology were able to apply the ontology to annotate with 'acceptable' inter-rater reliability ($\alpha = 0.678$). However, the inter-rater reliability was lower for annotations by researchers unfamiliar with the ontology ($\alpha = 0.471$). Examination of annotation disagreements led to three class labels,

12 class definitions and two classes' informal definitions being updated. In addition, comments were added to seven classes and a synonym was added to one class. With seven classes being added to the MoA Ontology to address disagreements, it had 261 classes. Many disagreements stemmed from MoAs being underspecified in intervention reports. Therefore, the annotation manual was updated to help researchers make judgements based on limited reported information.

Conclusions and implications: Researchers familiar with the MoA Ontology were able to use it to annotate MoAs in intervention reports with 'acceptable' inter-rater reliability, while those less familiar with the ontology may need more training than was provided here. By updating the MoA Ontology to address annotation disagreements, this study produced a refined version of the ontology. This study's findings implied that clearer reporting of MoAs is needed to support the synthesis of evidence about MoAs.

8.2   Introduction

To develop the Mechanism of Action (MoA) Ontology, the principles for developing 'gold standard' ontologies developed by the Open Biological and Biomedical Ontology (OBO) Foundry (2019i) are being followed (Chapter 1). Two of these principles suggest that ontologies should have clear textual labels and definitions for their classes (OBO Foundry, 2019d, 2019g). To reflect these principles, the MoA Ontology's classes were labelled and defined by drawing on recommendations for writing 'good' ontological labels and definitions (Michie, West, & Hastings, 2019; Seppälä, Ruttenberg, & Smith, 2017) in Studies 3 and 4 (see Chapters 4 & 5). These class labels and definitions were then refined in Study 5 (see Chapter 6) by applying them to annotate (i.e., code) hypothesised MoAs in behaviour change intervention reports. In Study 6 (see Chapter 7), stakeholder feedback on this refined version of the ontology led to updating 34 classes' labels, 127 classes' definitions and 25 classes' parent classes. Moreover, 18 classes were removed from the ontology and 43 new classes were added. Therefore, there was a need to check if the class labels and definitions in the newly revised MoA Ontology were sufficiently clear to enable shared understanding.

Labels and definitions of MoA Ontology classes need to be clear enough for users to agree on the class that MoAs reported in the literature belong to. Therefore, the next step to develop the MoA Ontology needed to test whether its class labels and definitions could be reliably applied to annotate hypothesised MoAs in behaviour change intervention reports. As defined in Chapters 1 and 6, annotations refer to the coding of a relevant extract within a document as reflecting the presence of an ontology class (Michie et al., 2017). For instance, annotations using the MoA Ontology involve: (1) identifying the hypothesised MoA(s) of a behaviour change intervention in a given

report, (2) selecting the appropriate class in the ontology to which the MoA belongs and (3) recording the text (e.g., sentence or table row) in which the MoA was identified.

Testing the inter-rater reliability of researchers applying a classification framework can reflect:

1. The quality (e.g., clarity) and/or complexity of the classification system (Gwet, 2014; Krippendorff, 2011)

2. The variance, clarity and/or complexity of the data the framework is applied to, e.g., how clearly aspects of an intervention are reported (Gwet, 2014; Krippendorff, 2011)

3. The raters' proficiency, e.g., how familiar raters are with a framework, and/or preferences for certain categories (Gwet, 2014)

Low inter-rater reliability for annotations across the whole of the MoA Ontology (i.e., all its classes) can suggest that an ontology needs to be updated to be clearer and more usable (Marques et al., 2020; Norris et al., 2020; 2021b; Wright et al., 2020). If the inter-rater reliability for annotating a particular class is low, then the class's label and definition might need to be refined to be clearer (Wright et al., 2020). By revising the MoA Ontology based on inter-rater reliability results, it would become more fit-for-use in potential applications, such as annotating hypothesised MoAs in intervention reports for systematic reviews. Other parts of the Behaviour Change Intervention Ontology (Michie et al., 2017) have been successfully refined by testing whether their class labels and definitions can be reliably used to annotate relevant content in intervention reports (Norris et al., 2021b; Wright et al., 2020). For instance, following the feedback from annotators using the Source Ontology (specifying classes related 'who' delivers a

behaviour change intervention), several lower-level classes (e.g., 'general and keyboard clerk') were removed from the ontology to improve its usability (Norris et al., 2021b).

8.2.1   Aims and research questions

To refine the class labels and definitions of classes in the MoA Ontology, this study aimed to test whether researchers could reliably use these labels and definitions to annotate hypothesised MoAs in behaviour change intervention reports. This study is highlighted in Figure 8-1, which outlines studies that informed the MoA Ontology's development in this thesis. To investigate its aim, the current study addressed the following research questions:

1. With what level of inter-rater reliability can two researchers familiar with the MoA Ontology apply its class labels and definitions to annotate hypothesised MoAs in behaviour change intervention reports?

2. With what level of inter-rater reliability can two researchers unfamiliar with the MoA Ontology apply its class labels and definitions to annotate hypothesised MoAs in behaviour change intervention reports?

3. If the overall inter-rater reliability for the ontology was low, then which classes in the MoA Ontology seemed to be particularly difficult to apply with acceptable reliability, suggesting their labels and definitions need to be refined?

4. What are the final class labels and definitions of the MoA Ontology?
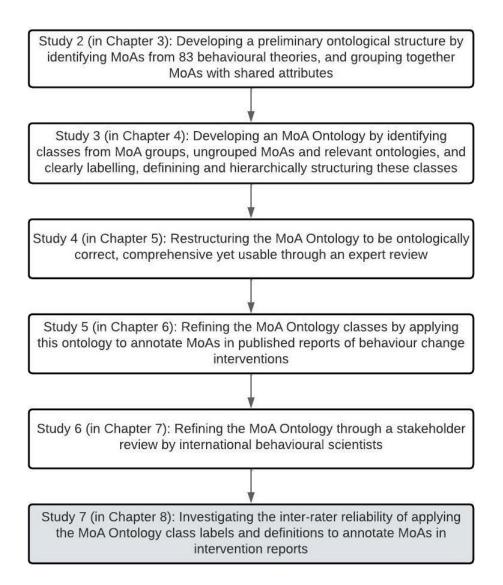
Figure 8-1. Studies used to develop the MoA Ontology in this thesis, with the current study highlighted

8.3   Methods

To test whether the MoA Ontology can be reliably applied to annotate hypothesised MoAs in behaviour change interventions, there were two annotation rounds. First, two researchers involved in developing the MoA Ontology (PS, the author of this thesis, & AW) applied this ontology. Secondly, to investigate whether new users could reliably apply the ontology, two researchers who were unfamiliar with the ontology (EH & VS) applied this ontology.

8.3.1 Materials

8.3.1.1 *MoA Ontology and annotation manual*

Following Study 6, the MoA Ontology had 254 classes on seven hierarchical levels, which were used as a starting point for annotations. The annotation manual from Study 5 (see Appendix 6-1) was updated in line with the changes to the ontology in Study 6. The annotation manual included information about:

1. What to annotate in intervention reports (i.e., hypothesised MoAs that were measured after the intervention started being applied)

2. Where to look for relevant information (e.g., prioritise most detailed information about MoAs provided in the methods and results sections or the supplementary files)

3. How to annotate specific classes in the MoA Ontology

4. How to use the web-based software EPPI-Reviewer v4 (Thomas, Brunton, & Graziosi, 2010) and record relevant information on this software

As specified in Study 5, many intervention reports describe MoAs of the evaluated intervention in their introductions, but do not report data concerning whether MoAs have actually changed and thereby brought about the interventions' influence on behaviour (Prestwich et al., 2014). Therefore, the annotation manual prompted researchers to only annotate MoAs that were measured during or after interventions had begun. Evaluations at these timepoints allow studies to test whether a given construct is an MoA. The reports also needed to suggest that the MoA had an influence on behaviour. The final annotation manual, updated following the annotations, can be found in the following Open Science Framework (OSF) link: https://osf.io/um7w6/. The

guidance on using EPPI-Reviewer v4, which was added for researchers unfamiliar with the MoA Ontology, is presented in Appendix 8-1.

8.3.1.2 Behaviour change intervention reports for annotations

Consistent with the method for developing other ontologies that make up the Behaviour Change Intervention Ontology (Wright et al., 2020), 100 behaviour change intervention reports were used to test whether the MoA Ontology can be reliably applied. Fifty reports were used for the annotations by the researchers familiar with the ontology, and the remaining 50 were used for annotations by researchers unfamiliar with the ontology. By including 50 reports in each annotation round, inter-rater reliability of annotations can be calculated with a 10-15% margin of error, providing an acceptable estimate of this reliability according to Gwet (2014).

To ensure that various classes from the MoA Ontology would be applied during annotations, the aim was to identify 100 behaviour change intervention reports that included a range of different potential MoAs. As Study 5 had identified such reports, the current study first used reports that had been screened at full-text level and identified as relevant in Study 5 but were not annotated. In Study 5, 130 reports were identified as relevant but only 115 were needed for annotations. The remaining 15 reports were therefore used in the current study for annotations.

For the remaining 85 intervention reports needed for annotations in this study, the 8244 reports retrieved by the search strategy but not screened in Study 5 were used as a starting point (see Study 5 in Chapter 6 for details of the search strategy that identified these reports). A researcher (PS) first screened the titles and abstracts of reports in sets

of 200, which were randomly selected from the 8244 reports. The same inclusion

criteria as in Study 5 were used. Briefly, the title and abstract needed to mention:

1. That the report was about an intervention evaluation

2. One or more behavioural theories or MoAs of a behaviour change intervention

3. A behavioural outcome that was quantitatively measured (not necessarily the

   intervention's primary outcome)

Full texts of reports that met the inclusion criteria at title and abstract level were further

screened. For the full-text screening, the criteria were for reports to include:

1. One or more hypothesised MoAs, measured during or after the intervention was

   applied

2. A behavioural outcome measured for participants for whom an MoA was also

   measured

Altogether, PS screened the titles and abstracts of 1000 reports (5 sets of 200 randomly

selected reports). Of these reports, 186 were taken forward for full-text screening.

During full-text screening, PS was unsure on whether 22 reports should be included and

so discussed these with a behavioural science expert (AW) to decide on their inclusion

eligibility. After the full-text screening, 88 reports were judged as meeting the inclusion

criteria. An overview of screening process for these 88 reports is shown Figure 8-2.
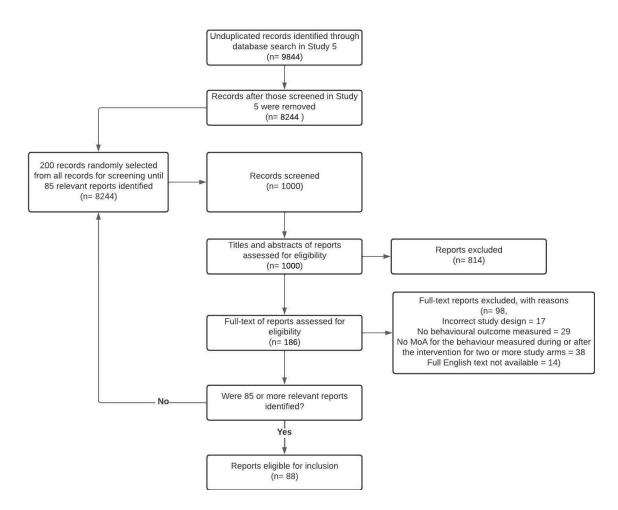
Figure 8-2. Flowchart for identifying 85 behaviour change interventions for annotating the MoA Ontology

With the 15 reports from Study 5 and the 88 identified in the current study, there were 103 intervention reports that could be included to annotate the MoA Ontology. For pilot annotations using the updated MoA Ontology from Study 6, three reports were randomly selected. Of the remaining 100 intervention reports, 50 were randomly assigned to the researchers familiar with the ontology for annotation, and the remaining 50 were assigned to the researchers unfamiliar with the ontology. The 103 reports' titles, first authors, target behaviours and their assigned annotators are presented in the following OSF link: https://osf.io/sjd2b/. The behaviours most frequently targeted in these reports were: Physical activity (N= 29 studies), social interaction behaviour (N= 10) and dietary behaviour (N=8). Behaviours that were less commonly targeted in these

reports included: Food waste behaviours (N= 1), volunteering (N= 1) and vaccination uptake (N= 1).

8.3.2   Procedure

8.3.2.1   Annotation Round 1: Annotations by researchers familiar with the MoA Ontology

Before starting the annotations to test inter-rater reliability, to investigate whether any changes needed to be made to the annotation manual, AW and PS practiced using the ontology to annotate three intervention reports on the EPPI- Reviewer v4 software (Thomas et al., 2010). They then compared their annotations and discussed differences in these annotations, noting down issues stemming from the ontology or the annotation manual. To address these issues, they revised the manual and judged whether any classes needed to be added to the ontology or revised.

The researchers independently annotated each of the 50 intervention reports, in sets of 5-10 reports on EPPI-Reviewer v4 (Thomas et al., 2010). They compared their annotations after each set, discussing the differences in their annotations. They noted down any annotation issues encountered and potential solutions to these. However, any issues that seemed to stem from the ontology were only addressed after the reports in all sets were annotated. This meant that the version of the MoA Ontology upon which inter-rater reliability of annotations was assessed was kept constant.

8.3.2.2 Annotation Round 2: Annotations by researchers unfamiliar with the MoA Ontology

Testing the inter-rater reliability of annotations by researchers unfamiliar with MoA Ontology served as a more challenging test of whether the ontology's class labels and definitions could be reliably applied to annotate hypothesised MoAs in the intervention reports. The two annotators (EH & VS) were provided with training. First, the annotators were instructed to read the MoA Ontology's class labels, definitions and additional content (e.g., class comments), and the annotation manual. To practice using the ontology and its annotation manual, the researchers then independently annotated five intervention reports, selected from the set of reports annotated by AW and PS. Each researchers' practice annotations were reviewed and discussed with PS. The researchers provided feedback on the annotation manual and the clarity of the ontology's class labels and definitions. The feedback was discussed by AW and PS, who updated the manual or ontology where necessary.

The researchers then independently annotated hypothesised MoAs in each of the randomly selected 50 reports on EPPI-Reviewer v4 (Thomas et al., 2010). To clarify misunderstandings during the annotations, researchers could ask PS general questions about the annotation manual or using EPPI-Reviewer. However, to avoid the two researchers' influencing each other's use of the ontology, EH and VS did not have any communication about their annotations. At the end of annotations, the two researchers and PS had a feedback session, in which the researchers outlined issues they had experienced using the ontology or with the annotation manual.

8.3.3   Analysis

8.3.3.1   *Inter-rater reliability calculations for annotations using the MoA Ontology*

To assess whether the MoA Ontology could be used to reliably identify the same classes to annotate hypothesised MoAs in behaviour intervention reports, the inter-rater reliability of annotations in Round 1 and 2 was calculated. The test for Round 2 intended to provide more generalisable knowledge about whether new users would be able to reliably apply the MoA Ontology.

Krippendorff's alpha (Hayes & Krippendorff, 2007) was selected to assess whether researchers reliably identified a class's presence in an intervention report. This coefficient can be used with nominal data (e.g., presence vs absence for a class) generated by two or more raters. An advantage of this coefficient is that it accounts for chance agreement, without underestimating high levels of agreement between raters to the extent of some other commonly used coefficients (Feinstein & Cicchetti, 1990; Gwet, 2014; Krippendorff, 2004). For instance, to account for chance agreement, Cohen's kappa can 'punish' agreement that is above its expected agreement levels, resulting in lower calculated inter-rater reliability values despite high agreement between raters (Krippendorff, 2011). Unlike other inter-rater reliability coefficients, Krippendorff's alpha is calculated based on expected disagreements rather than agreements, meaning that its values can range from 1 (perfect agreement) to -1 (values below '0' suggesting systematic disagreement) (Zapf, Castell, Morawietz, & Karch, 2016).

For each annotation round, the overall inter-rater reliability for applying the MoA Ontology was assessed for the annotations of all classes across all 50 reports. As MoAs

related to various classes in the MoA Ontology were unlikely to be reported (e.g., 'anatomical structure'), the inter-rater reliability was also calculated only for classes that were annotated at least once across the 50 reports. This second test served as a more stringent test of inter-rater reliability. If the overall inter-rater reliability was low for annotations in a round, then the reliability for each ontology class with data (i.e., applied at least once during annotations) was assessed over the round's 50 reports. This helped identify which classes were particularly difficult to apply reliably.

To calculate inter-rater reliability, each annotator's 'coding record' (i.e., a record of their annotations for the ontology's classes across 50 reports) was extracted as JavaScript Object Notation (JSON, i.e., a standardised text-based format for representing data) files from EPPI-Reviewer. For each class's annotation in a report, nominal data was automatically recorded in these files, i.e., '0' if the presence of a class was not detected and '1' if the presence of a class was detected by a researcher. Krippendorff's alpha was assessed using the python package (https://pypi.org/project/krippendorff/), which was integrated into a python script by the Human Behaviour-Change Project team (Finnerty & Moore, 2020). This script was able to read researchers' coding records and calculate the inter-rater reliability by comparing two researchers' records. To calculate the inter-rater reliability for the first round, PS's and AW's coding records were provided as input for the script, while for the second round, EH's and VS's coding records were used as input.

8.3.3.2 Judging changes that needed to be made to the MoA Ontology and its

annotation manual

A Krippendorff's alpha value above 0.67 was considered to represent 'acceptable'

reliability (Krippendorff, 2004). Values below this might suggest that raters applied the

ontology differently to the data (Gwet, 2014; Krippendorff, 2011). Therefore, if an

overall Krippendorff's alpha above 0.67 was achieved in an annotation round,

annotations using the ontology were considered to have acceptable inter-rater reliability.

Accordingly, no systematic changes to refine the ontology were considered necessary.

To resolve the issues annotators raised, minor changes could be made to the ontology's

class labels or definitions, classes could be added, or the annotation manual could be

updated.

If the overall Krippendorff's alpha for annotations with the MoA Ontology was below

0.67 after an annotation round, further analysis was necessary to identify changes that

needed to be made to the ontology or its annotation manual. For all individual classes

with a Krippendorff's alpha value below 0.67, PS noted down information about

annotation disagreements (i.e., a class being detected by only one researcher in a report)

across the 50 intervention reports. To identify relevant information, PS reviewed the

text annotated by each researcher for the disagreed classes and the reporting of the

relevant construct or MoA in the intervention report. For each disagreement, she

responded to whether the disagreement needed to be addressed by changing the

ontology or annotation manual. The proposed changes to the MoA Ontology and its

annotation manual were discussed with AW, and where necessary with the other

ontology developers (SM, RW & JH). Accordingly, the ontology's class labels and

definitions or additional content (e.g., class examples) and the annotation manual was

refined. Table 8-1 provides on overview on how different types of disagreements were

addressed.

Table 8-1. Types of annotation disagreements and the general approach to address these disagreements

No.	Disagreement type	General approach for addressing the disagreements
1	Disagreements on judging whether constructs qualified as MoAs	• The annotation manual could be refined to help identify MoAs in intervention reports • To capture MoAs that could not be annotated with current classes, new classes could be added to the ontology
2	Disagreements that stemmed from the underspecified reporting of MoAs in intervention reports (e.g., only the label being provided for an MoA)	• If the disagreement revealed specific issues with the ontology, class labels, definitions, examples or comments could be updated or added • If the disagreement revealed issues with the annotation manual, the manual could be updated • When the disagreement did not provide clear information about issues with the ontology or annotation manual, these disagreements were not addressed
3	Disagreements based on mismatching information about MoAs in an intervention report or researchers using different sections of a report	• If the annotation manual did not provide relevant guidance for annotating classes, the manual was updated
4	Disagreements relating to researchers interpreting classes or MoAs in the intervention report (including their granularity) differently	• The class labels and definitions could be updated to help differentiate between the classes • Examples, comments, synonyms or informal definitions could be updated or added to classes • The annotation manual could be refined to help differentiate between classes

8.4 Results

8.4.1 Annotations by the researchers familiar with the MoA Ontology

8.4.1.1 Pilot annotations by the researchers familiar with the ontology

During the pilot annotations using the MoA Ontology for three intervention reports, AW and PS recorded four annotation issues (see https://osf.io/drtgm/), which were addressed by updating the ontology's classes and its annotation manual. The developers found that two classes were missing from the ontology. In one report, an MoA was labelled as 'self-efficacy' but measured using items, such as "*I feel comfortable talking about depression with patients*" (Agapidaki et al., 2013). While the label suggested the class 'self-efficacy for a behaviour' as a fit, the measurement item did not reflect this class's definition ('a belief about one's capabilities to organise and execute a behaviour.'). The researchers thought that a class that captured the MoA based on its measurement was missing from the ontology. Therefore, the class 'feeling at ease' (defined as 'a subjective affective feeling of being at ease, comfortable, relaxed.') was reused from the Mental Functioning Ontology (Hastings, Ceusters, Jensen, Mulligan, & Smith, 2012). Another report had an MoA for which only the label 'being energetic' was provided (Corbin, Gearhardt, & Fromme, 2008). As the researchers were also unsure which class to use for this MoA, they reused the class 'feeling energetic' (defined as 'a subjective affective feeling of having lots of energy, being energetic.') from the Emotion Ontology (Hastings, Ceusters, Smith, & Mulligan, 2011). Once these classes were added to the MoA Ontology, it had 256 classes.

8.4.1.2   Inter-rater reliability of annotations by the researchers familiar with the ontology

For all 256 classes, Krippendorff's alpha for the researchers' annotations using the MoA Ontology across 50 intervention reports was 0.678, representing 'acceptable' reliability (Krippendorff, 2004). Therefore, the MoA Ontology could be applied reliably by researchers already familiar with the ontology. As only 97 of the ontology's 256 classes were applied at least once by one researcher in Round 1 annotations, the inter-rater reliability for annotations using these 97 classes across the 50 reports was also calculated. The Krippendorff's alpha was 0.666, which was also within the range of 'acceptable' inter-rater reliability for annotations with the MoA Ontology. For the 97 classes, the Krippendorff's alpha values ranged from -0.031 to 1.00. These classes' labels, their alpha values and the number of reports in which each class was detected by one (disagreement) or both (agreement) researchers are shown in Appendix 8-2.

8.4.1.3   Changes to the MoA Ontology following Round 1 annotations

As the inter-rater reliability was above the pre-set criteria for Round 1 annotations using the MoA Ontology, the ontology was not significantly updated. However, based on the annotation issues recorded by the researchers during reconciliations (see https://osf.io/drtgm/), two classes were added to the ontology. One of these annotation issues was based on a hypothesised MoA labelled as 'rumination' (measured using the 'Rumination and Reflection Questionnaire') and defined as "*a cognitive process that involves repetitive negative thoughts, including a particular focus on past negative experiences and failures*" (Kemeny et al., 2012). While one researcher annotated this MoA using the class 'cognitive process', the other researcher was unsure which class would fit the MoA and so did not annotate it. To capture this MoA in the ontology, a

new class labelled 'ruminating' (defined as 'Thinking that is about negative experiences and feelings, and repeated.') was added to the ontology. The second issue that led to adding a class was based on an MoA labelled as 'identified motivation' (Kinnafick, Thøgersen-Ntoumani, & Duda, 2016). An example measurement item was given as "*I take part in the exercise class because I value the benefits of exercising.*" As there was no specific class to capture 'identified motivation', one researcher used the class 'intrinsic motivation' to annotate this MoA, while the other used the broader class 'autonomous motivation'. To capture this MoA more granularly in the ontology, a class labelled 'behavioural importance-based motivation' was added. Its definition was specified as 'Autonomous motivation due to the perceived value or importance of the behaviour to oneself' and the terms 'identified motivation' and 'identified regulation' were recorded as synonyms. With these two new classes, the ontology had 258 classes.

The ontology's annotation manual was also updated to provide clearer and more detailed descriptions about: (1) which constructs in reports qualified as MoAs, (2) which parts of a report to annotate and (3) how to differentiate between classes in the MoA Ontology (see annotation issues that led to these changes in https://osf.io/drtgm/). For instance, additional guidance was added to help differentiate between the classes 'emotion process' and 'subjective affective process', namely that the latter class does not refer to complete emotions but subjective experiences of emotions or other bodily processes. Finally, several disagreements related to challenges in finding relevant information about MoAs in intervention reports (e.g., due to sideways tables and missing supplementary files). Therefore, the tables in the reports for Round 2 were rotated where necessary, and, if reports' supplementary files were missing from the manuscripts, these were added.

8.4.2 Annotations by the researchers unfamiliar with the ontology

8.4.2.1 Pilot annotations by the researchers unfamiliar with the ontology

During the pilot annotations applying the MoA Ontology to five intervention reports, the researchers raised four issues that led to clarifications in the annotation manual but no changes in the MoA Ontology (see https://osf.io/76dux/). For instance, one researcher mentioned their confusion about which class to use for an MoA labelled as 'knowledge' which was measured with responses to the following item: "*How many servings of fruits and vegetables do you think a person should eat EACH DAY for good health?*" (Reynolds et al., 2004). The researcher thought that the classes 'knowledge' and 'belief' (e.g., belief about how many servings need to be consumed) could both be relevant to the MoA depending on how this MoA was interpreted. The manual was updated to help differentiate these two classes, e.g., clarifying that MoAs related to the class 'knowledge' are often scored in terms of accuracy in an intervention report.

8.4.2.2 Inter-rater reliability of annotations by the researchers unfamiliar with the ontology

Across 50 intervention reports in Round 2, the overall Krippendorff's alpha for annotations by the researchers unfamiliar with the MoA Ontology was 0.471. As this value was below the set criteria for the annotations to be considered reliable (i.e., $\alpha = 0.67$), the researchers' annotations applying the MoA Ontology did not reach 'acceptable' reliability. The Krippendorff's alpha for the MoA Ontology classes with at least one annotation by one researcher (101 classes of the 258 classes in the ontology) was 0.457. This value was also below 'acceptable' reliability. Therefore, the inter-rater reliability assessments suggested that the ontology needed to be updated.

To identify the classes that were particularly difficult to apply reliably across 50 reports, the inter-rater reliability for the 101 classes with at least one annotation by one of the researchers was calculated. For these classes, Krippendorff's alpha values ranged from -0.076 to 1.00. The labels of these classes, their alpha values, and the number of reports in which each class was detected by one (disagreement) or both (agreement) researchers are presented in Appendix 8-3.

For 19 classes, the researchers' annotations had an alpha value above 0.67 (range = 0.679 – 1.00), suggesting that these classes could be identified with 'acceptable' reliability in the intervention reports. Examples of these classes included 'belief about health consequences of behaviour' (α = 1.00), 'physical behavioural opportunity' (α = 1.00), 'planning' (α = 1.00), 'knowledge regarding a behaviour' (α = 0.780) and 'mental plan for a behaviour' (α = 0.731).

The remaining 82 classes' annotations had Krippendorff's alpha values below 0.67 (range = -0.076 - 0.660). Examples of such classes were 'friendship network' (α = 0.660), 'belief about control over behaviour' (α = 0.484), 'motivation' (α = 0.396), 'bodily disposition' (α = 0), 'linguistic communication behaviour' (α = 0), 'appraisal' (α = -0.010) and 'belief about barriers' (α = -0.021). Some classes' low alpha value was due to relevant MoAs being reported infrequently in intervention reports. For instance, the class 'linguistic communication behaviour' was only annotated in one report by a researcher (Feinberg et al., 2013), leading to an alpha value of '0', i.e., below the 0.67 threshold for 'acceptable' inter-rater reliability.

8.4.2.3 Changes to the MoA Ontology following Round 2 annotations

As the overall inter-rater reliability of annotations using the MoA Ontology in Round 2 were below the 'acceptable' threshold, 195 annotation disagreements for the 82 classes below the same threshold were recorded. As the disagreements were recorded separately for each class, some of these disagreements were duplicates. For instance, a disagreement based on researchers using the classes 'social influence process' and 'belief about social support' for the same MoA was recorded twice, i.e., once for each class. These disagreements and responses to them, including solutions to refine the ontology or annotation manual, are all presented in the following OSF link: https://osf.io/79gav/.

The changes to the MoA Ontology based on annotation disagreements and examples of these disagreements are shown in Table 8-2. In total, three class labels, 12 class definitions and two classes' informal definitions were updated. In addition, comments were added to seven classes and a synonym was added to one class. As three classes were also added to the ontology to address disagreements, the resulting ontology had 261 classes.

Table 8-2. Changes in the MoA Ontology and examples of the annotation disagreements that informed these changes

No.	Example annotation disagreement that informed a change in the ontology	Response to the disagreement, and change to the MoA Ontology
1	In an intervention report about physical activity, an MoA was labelled as 'subjective norm' and an example measurement item given for this MoA was "*Most people in my social network want me to do regular PA*" (Plotnikoff, Lubans, Penfold, & Courneya, 2014). To annotate this MoA, one researcher used the class 'normative belief', while the other researcher used the broader class 'belief about one's social environment'.	For the MoA 'subjective norm' in the physical activity intervention report, the class 'normative belief' (definition: 'A belief about whether important others think one should perform a behaviour.') could capture this MoA more granularly than the class 'belief about one's social environment' (definition: 'A belief about the aspects of one's immediate social settings in which people live, including culture and the people and institutions with whom they interact.'). To ensure that the class 'normative belief' captures this MoA more clearly, the ontology developers decided to refine its definition.
		Changes to the MoA Ontology: • The definition of the class 'normative belief' was updated to refer to 'key others' instead of 'important others'. The phrase 'key others' was considered to more clearly include people in one's social network (e.g., colleagues) relevant to a behaviour. • A comment was added to the class that 'key others' can include 'people in one's social network'.
2	A smoking cessation intervention report included a construct labelled as 'nicotine dependence' and measured with the Fagerström Test of Nicotine Dependence (Hajek et al., 2018). One researcher used the class 'addiction' to annotate this construct as an MoA, while the other researcher did not annotate this construct as an MoA.	The label 'nicotine dependence' and the intervention report suggested that this construct influenced smoking (the outcome behaviour). As the construct was also measured after the intervention was applied, this construct should have been annotated as an MoA. Two MoA Ontology developers (JH & RW), who were also developers of the Addiction Ontology (Hastings, Cox, West, & Notley, 2020), explained that the class 'addiction' (i.e., a disposition related to experiencing motivation to use a substance) could capture the measurement 'Fagerström Test of Nicotine Dependence' (Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991). However, these developers also recommended capturing substance dependence more precisely (i.e., disposition related to the impaired functioning in the absence of a substance).
		Changes to the MoA Ontology: • The class 'substance dependence' from the Addiction Ontology (Hastings et al., 2020) was reused in the MoA Ontology. • Comments were added the classes 'addiction' and 'substance dependence' to help distinguish them.

No.	Example annotation disagreement that informed a change in the ontology	Response to the disagreement, and change to the MoA Ontology
3	An intervention report about dietary behaviour included an MoA labelled as 'self-regulation' (Ghasab Shirazi, Kazemi, Kelishadi, & Mostafavi, 2019). No information about the MoA's measurement was provided. One researcher annotated this MoA using the class 'self-regulation capability', while the other researcher used the class 'self-regulation of behaviour'.	The MoA Ontology only included a class for behavioural self-regulation process (i.e., 'self-regulation of behaviour') and not for a general self-regulation process. This meant that there was no precise class to capture 'self-regulation', which may have contributed to the disagreement. *Changes to the MoA Ontology:* • A new class was developed as the parent class of 'self-regulation of behaviour' and labelled as 'self-regulation process'. • The definition of 'self-regulation of behaviour' was updated to reflect the change in its parent class.
4	An MoA in an intervention report was labelled as 'self-efficacy' and assessed using the measurement item "*I am sure I can obtain the flu shot, even if I have to overcome inner barriers such as uncertainty about its effectiveness, worry about side effects, the stress of going there, etc*" (Ernsting, Schwarzer, Lippke, & Schneider, 2013). One researcher used the class 'situational self-efficacy belief for a behaviour' for this MoA. The other researcher used its parent class 'self-efficacy belief for a behaviour'.	There seemed to be reoccurring issues in deciding whether to annotate the class 'situational self-efficacy belief for a behaviour' (definition: 'Self-efficacy belief for a behaviour when a particular situation that may affect the behaviour is encountered.') or its parent class 'self-efficacy belief for a behaviour' (definition: 'A belief about one's capabilities to organise and execute a behaviour.'). The MoA in the current example could have been annotated using the class 'situational self-efficacy belief for a behaviour', as the example refers to self-efficacy when encountering specific internally experienced situations (e.g., worry). However, this class's definition (in particularly the phrase 'particular situation') might suggest external situations that influence a behaviour, rather than internal ones. *Changes to the MoA Ontology:* • The phrase 'particular situation that may affect the behaviour' in the definition of 'situational self-efficacy belief for a behaviour' was changed to 'a barrier or facilitator of the behaviour'. • A comment was added to this class that the 'barrier and facilitator' specified in the definition can be external or internal.
5	In a smoking cessation intervention report, an MoA was labelled as 'smoking stereotypy' and measured with responses to items, such as "*I feel a sense of control over my smoking*" and "*I smoke about the same amount whether I'm relaxing or working, happy or sad, alone or with others, etc.*" (Hajek et al., 2018). One researcher used the class 'belief about voluntariness of behaviour' for this MoA, while the other researcher used the class 'belief about control over behaviour'.	The measurement items for the MoA 'smoking stereotypy' seemed to overlap with both annotated classes 'belief about voluntariness of behaviour' (definition: 'A belief about the extent to which one is free to choose whether to perform the behaviour.') and 'belief about control over behaviour' (definition: 'A belief about one's capabilities and opportunities within an environmental system to perform a behaviour or achieve the outcomes resulting from a behaviour.'), which might have led to the disagreement. However, as one measurement item emphasised sense of control and the other item behaviour in specific environments, the class 'belief about control over behaviour' might be a better fit for the MoA.

No.	Example annotation disagreement that informed a change in the ontology	Response to the disagreement, and change to the MoA Ontology
		Changes to the MoA Ontology: • To emphasise that the class 'belief about voluntariness of behaviour' (defined as: 'A belief about the extent to which one is free to choose whether to perform the behaviour.') is about a sense of choosing a behaviour, the label was updated to read as 'belief about choice over a behaviour'. • The former label, 'belief about voluntariness of behaviour', was recorded as a synonym for the class.
6	An intervention report about health-related behaviours included an MoA labelled 'perceived barriers of taking an action' (Rakhshanderou, Maghsoudloo, Safari-Moradabadi, & Ghaffari, 2020). One researcher annotated this MoA using the class 'evaluative belief about behavioural outcomes', while the other used the class 'belief about barriers'.	While the annotation disagreement might have related to the limited information provided about the MoA (only the MoA's label was provided), the class label 'belief about barriers' did not clearly emphasise that the class was about behavioural barriers. *Change to the MoA Ontology:* • The label of 'belief about barriers' was updated to read as 'belief about barriers to a behaviour'.
7	In an intervention report, an MoA was labelled 'implementation intention', and an example measurement item given for this MoA was "*To what extent do you have concrete plans for when you will do regular PA*" (Plotnikoff et al., 2014). One researcher annotated this MoA using the class 'behaviour intention'. The other researcher used the class 'mental plan for a behaviour'.	The disagreement about annotating the classes 'behaviour intention' (definition: 'A mental disposition to commit to enact or not enact a behaviour.') and 'mental plan' and its subclasses reoccurred across several intervention reports. As the term 'plan' is often used for behavioural intentions and more instructional mental plans (e.g., relating to when, where and how to do a behaviour), there seemed to be challenges differentiating these classes. *Changes to the MoA Ontology:* • To clarify the interchangeable use of the term 'plan', a comment was added to the classes 'behaviour intention' and 'mental plan for a behaviour', explaining that 'plan' can sometimes be used to refer to intention or instructional plans. • Another comment was added to the 'mental plan for a behaviour' class to specify that this class involves plans about 'when (specific times), where, how or with whom a behaviour would be enacted'. The definition for 'mental plan for a behaviour' ('A mental plan that is realised in mental processes representing a behaviour, the conditions under which the behaviour will be enacted and an intention to enact the behaviour under those conditions.') also suggested that the class would necessarily include 'behavioural intention'. Therefore, the MoA Ontology developers suggested amending this definition to avoid referring to an intention and more clearly emphasise the steps involved in a plan.

No.	Example annotation disagreement that informed a change in the ontology	Response to the disagreement, and change to the MoA Ontology
		Change to the MoA Ontology: • The definition was updated to read as 'A mental plan that is realised in mental processes representing the steps to enact a behaviour and the conditions under which the behaviour will be enacted.'
8	An intervention report about work-related behaviours included an MoA labelled as 'job satisfaction', which was measured by participants indicating "*how satisfied they are with aspects of their job*" (Gullekson, Griffeth, Vancouver, Kovner, & Cohen, 2014). One researcher annotated this MoA using the class 'evaluative belief about behaviour'. The other researcher used the class 'appraisal'.	The annotation disagreement might have stemmed from the measurement not being clear on whether an emotion or belief was being assessed. There was also no class that could fully capture an MoA relating to 'satisfaction'. ***Change to the MoA Ontology:*** • To capture the MoA 'job satisfaction' more precisely, the class 'satisfaction' from the Emotion Ontology (Hastings et al., 2011) was reused. The MoA Ontology developers also suggested that the definition of 'appraisal' (A cognitive representation which represents an evaluation of the relevance of some triggering object or event to the organism.) needed to be simpler and clearer to be useable. ***Change to the MoA Ontology:*** • The definition of 'appraisal' was updated: 'A cognitive representation of the emotional relevance of an object or event to the organism.'
9	In an intervention report, an MoA was labelled 'outcome expectation' and it was measured using the item "*Over the next 6 months regular PA will make me feel better physically*" (Plotnikoff et al., 2014). One researcher annotated this MoA using the class 'belief about consequences of behaviour', while the other researcher used the class 'evaluative belief about behavioural outcomes'.	As the example MoA explicitly referred to belief about a positive outcome of behaviour, it could have been annotated using the class 'evaluative belief about behavioural outcomes'. However, there were reoccurring challenges in judging when to annotate the class 'evaluative belief about behavioural outcomes' (a subclass of 'evaluative belief') and 'belief about consequences of behaviour'. Reviewing these classes, the MoA Ontology developers suggested that the class 'evaluative belief about behavioural outcomes' needed to have two parent classes: 'evaluative belief' and 'belief about consequences of behaviour'. Moreover, the developers emphasised that the labels and definitions of these classes needed to be more consistent to help annotators decide which class to use. ***Changes to the MoA Ontology:*** • The ontology was updated to reflect two parent classes of 'evaluative belief about behavioural outcomes': 'evaluative belief' and 'belief about consequences of behaviour'. However, to support easily finding the class 'evaluative belief about behavioural outcomes' in the ontology,

No.	Example annotation disagreement that informed a change in the ontology	Response to the disagreement, and change to the MoA Ontology
		it was presented under the class 'belief about consequences of behaviour'. A comment was added to the class 'evaluative belief' to signpost where to find the class 'evaluative belief about behavioural outcomes'. • The label of 'evaluative belief about behavioural outcomes' was updated to have a formulation that was more consistent with 'belief about consequences of behaviour': 'evaluative belief about the consequences of behaviour'. • The definitions of 'evaluative belief about behavioural outcomes', 'belief about consequences of behaviour' and their five subclasses were also updated to be more consistent, and avoid using synonyms of the labels (i.e., the term 'outcome').
10	In one intervention report, an MoA was labelled as 'rejection sensitivity' and measured using items such as "*This child is sensitive to rejection*" and "*This child tends to take things too personally*" (Kanchewa, Yoviene, Schwartz, Herrera, & Rhodes, 2018). Here, one researcher used the class 'subjective affective feeling', while the other researcher used the class 'bodily process'.	The annotation disagreement seemed to relate to the MoA being broad and the MoA's description not being very clear. However, there also seemed to be confusions about when to apply the classes 'subjective affective feeling' (definition: 'An affective process that involves the experience of internal or external sensory stimuli.') and 'bodily process' (definition: 'A process in which at least one bodily component of an organism participates.'). ***Changes to the MoA Ontology:*** • To make the definition of 'bodily process' easier to understand, a comment was added to specify that the phrase 'bodily component of an organism' in the definition refers to 'a part of the body'. • The informal definition of 'bodily process' was simplified to read as 'Any process going on in the body.' • The informal definition of 'subjective affective feeling' was also updated to include more examples that support understanding this class: 'The conscious experience that a person has of feelings in their body (e.g., hunger), their mood (e.g., feeling cheerful) and their emotion (e.g., feeling nervous), in response to internal or external stimuli.'

Many annotation disagreements seemed to relate to challenges in differentiating between classes based on the descriptions of MoAs in intervention reports. Therefore, the annotation manual was often updated to help annotators decide which classes to use (see the manual's final version in https://osf.io/um7w6/). For instance, one report included an MoA labelled as 'social support', for which an example measurement item was provided as "*My partner helps me/my family helps me/my friends and acquaintances help me to stay physically active*" (Duan et al., 2018). Based on the MoA's measurement item, one researcher used the class 'social influence behaviour' for this MoA and the other used the class 'belief about social support'. There were reoccurring disagreements about when to select classes relating to the environment, as opposed to classes relating to beliefs about the environment. To help annotate relevant MoAs, the annotation manual was updated to specify:

- If an MoA's measurement items suggest factual statements about the environment (e.g., 'My partner supports…'), then two classes should be annotated, namely:
  - The class relating to the environmental system, disposition or process, e.g., 'social influence behaviour'
  - The class capturing the relevant belief about the environment, e.g., 'belief about social support'
- If the MoA's description or measurement items are clearly about a belief (e.g., the measurement items start with 'I believe…'), then the MoA should be annotated using the class relating the belief about the environment, e.g., 'belief about social support'.

8.4.2.4 *Higher inter-rater reliability in annotations in Round 1 compared to Round 2*

The overall inter-rater reliability of annotations by the researchers familiar with the MoA Ontology ($\alpha = 0.678$) was higher than that of the researchers unfamiliar with the ontology ($\alpha = 0.471$). Examples of classes that were annotated with 'acceptable' inter-rater reliability in the first round and not in the second included 'belief about need satisfaction', 'extrinsic motivation' and 'behavioural intention'.

There are several reasons for the inter-rater reliability being lower in Round 2. First, the researchers familiar with the MoA Ontology were more likely to agree on which constructs qualified as MoAs than those unfamiliar with the ontology. AW and PS were MoA Ontology developers and had previously worked on annotating hypothesised MoAs in intervention reports, meaning that they shared perspectives on which constructs qualified as MoAs. In contrast, EH and VS annotated MoAs in intervention reports using the MoA Ontology for the first time and did not have any communication before or during their annotation round. Therefore, they disagreed much more often on which constructs qualified as MoAs. Secondly, as the MoA Ontology is complex and detailed, researchers new to the ontology with it might require more time to familiarise themselves with the ontology. As MoA Ontology developers, AW and PS were more aware of the different classes in the ontology and shared perspectives on how these classes should be applied during annotations. In contrast, EH and VS had limited time to learn about the ontology's classes and practice using them, meaning they were unlikely to have the same grasp of these classes as AW and PS. Finally, the Round 1 annotations involved reconciliations after each set of annotated intervention reports, allowing the researchers to discuss their annotations. While these discussions intended to iteratively identify issues with the ontology and the annotation manual before Round

2, they might have also facilitated better agreement in the next annotation sets. In the Round 2, the researchers could not improve their agreement about the MoA Ontology classes through such discussions.

8.4.3 Final MoA Ontology

The labels and definitions of all 261 classes in the MoA Ontology are presented in Table 8-3, while the full ontology (with its URIs, class examples, synonyms and comments) can be found on Github (https://github.com/HumanBehaviourChangeProject/ontologies/blob/master/MechanismOfAction/inputs/BCIO_MoA.xlsxhttps://github.com/HumanBehaviourChangeProject/ontologies/blob/master/MechanismOfAction/bcio_moa.owl) and OSF (https://osf.io/pkq4e/).

Table 8-3. Class labels and definitions in the final version of the MoA Ontology

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions
Material entity							An independent continuant that is spatially extended whose identity is independent of that of other entities and can be maintained through time.
	Material anatomical entity						Anatomical entity that has mass.
		Anatomical structure					A material anatomical entity that is a single connected structure with inherent 3D shape generated by coordinated expression of the organism's own genome.
	System						A material entity consisting of multiple components that are causally integrated.
		Environmental system					A system which has the disposition to surround and interact with one or more material entities.
			Ecosystem				An environmental system which includes both living and non-living components.
			Social environmental system				An environmental system that consists of people, their pets, social and cultural institutions and processes that influence the life of people and social groups.
				Family environmental system			A social environmental system that consists of persons related as members of a domestic group, or a number of domestic groups linked through descent from a common ancestor, marriage, adoption or other legal arrangements.
				Friendship network			A social environmental system that consists of persons who share a bond of mutual affection and are in contact or communication.
				Professional network			A social environmental system that consists of persons who have shared interests relating to their occupational roles and are in contact or communication.
Bodily disposition							A disposition that inheres in some extended organism.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions
	Personal capability						A bodily disposition whose realization ordinarily brings benefits to an organism or group of organisms, where "ordinarily" means within a typical range or context.
		Mental capability					A personal capability that includes mental processes in its realisation.
			Mental skill				A mental capability acquired through training or practice.
			Self-regulation capability				A mental capability that involves processes that modulate the frequency, rate or extent of a response to external or internal stimuli and that are instigated by the person themselves.
				Attentional self-regulation capability			A self-regulation capability to modulate one's attention toward internal or external stimuli.
				Behavioural self-regulation capability			A self-regulation capability to modulate one's behaviour.
				Cognitive self-regulation capability			A self-regulation capability to modulate one's cognitive processes.
				Emotional self-regulation capability			A self-regulation capability to modulate one's emotional responses to a stimulus.
				Self-regulatory skill			A self-regulation capability that is acquired through training or practice.
		Behavioural capability					A personal capability that includes behaviours in its realisation.
			Physical behavioural capability				A behavioural capability that involves a musculoskeletal process in its realisation.
				Physical skill			A physical capability acquired through training or practice.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions
			Social behavioural capability				A personal capability includes interpersonal behaviour in its realisation.
				Social skill			A social capability acquired through training or practice.
	Mental disposition						A bodily disposition that is realized in a mental process.
		Addiction					A mental disposition towards repeated episodes of abnormally high levels of motivation to engage in a behaviour, acquired as a result of engaging in the behaviour, where the behaviour results in risk or occurrence of serious net harm.
		Awareness					A mental disposition that is realized by attending to events, objects or sensory patterns in experience.
		Behavioural intention					A mental disposition to commit to enact or not enact a behaviour.
		Belief					A mental disposition to represent a proposition to be true.
			Belief about barriers to a behaviour				A belief about a factor could restrict or impede a person from engaging in a behaviour.
			Belief about conformity to behavioural norms				A belief about the extent to which one's own behaviour is similar to that of referent others.
			Belief about consequences of an occurrence				A belief about the outcomes resulting from an occurrence.
				Belief about anticipated emotion			A belief about the potential emotions experienced as result of an event.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions
					Belief about anticipated regret		A belief about the potential regret experienced as a result of an event.
				Belief about consequences of behaviour			A belief about what results from or follows the performance of a behaviour.
					Belief about emotional consequences of behaviour		A belief about consequences of behaviour in terms of emotions.
					Belief about health consequences of behaviour		A belief about consequences of behaviour in terms of health and wellbeing.
					Belief about social consequences of behaviour		A belief about consequences of behaviour in terms of their impact on the social environmental system.
					Belief about the timing of the consequences of behaviour		A belief about consequences of behaviour in terms of how long after the performance of the behaviour they will occur.
					Evaluative belief about the consequences of behaviour		A belief about consequences of behaviour in terms of whether they are positive or negative.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions
						Belief about the personal desirability of consequences of a behaviour	An evaluative belief about the value of the consequences of behaviour to oneself.
				Belief about consequences of goal attainment			A belief about the outcomes resulting from achieving a goal.
				Belief about likelihood of consequences of an occurrence			A belief about the probability that a given event or state will occur or not occur in the future.
					Belief about likelihood of consequences of behaviour		A belief about the probability a particular behaviour will result or not result in particular outcomes.
						Belief about likelihood of emotional consequences of behaviour	A belief about the probability of a behaviour resulting or not resulting in a change to emotions.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions
						Belief about likelihood of health consequences of behaviour	A belief about the probability of a behaviour resulting or not resulting in a change to health or wellbeing.
						Belief about likelihood of social consequences of behaviour	A belief about the probability of a behaviour resulting or not resulting in a change to social outcomes.
			Belief about control over one's future				A belief about the extent to which one can direct what happens in one's future.
			Belief about gain				A belief about the existence of an increase from an initial reference point.
			Belief about reduction				A belief about the existence of a decrease from an initial reference point.
			Belief about message				A belief regarding aspects of a verbal, graphic, written or recorded communication.
				Belief about the credibility of a message's source			A belief about whether a verbal, graphic, written or recorded communication is provided by people or institutions who provide reliable information.
				Belief about message relevance			A belief regarding whether the content of a verbal, graphic, written or recorded communication are relevant to oneself.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions
				Belief about message trustworthiness			A belief about whether a verbal, graphic, written or recording communication provides information that can be relied on as honest or truthful.
			Belief about need satisfaction				A belief regarding whether one or more of the person's needs have been met.
			Belief about sufficient time for a behaviour				A belief about having enough time or a suitable period of time to enact a behaviour.
			Belief about one's environment				A belief about the nature of the immediate physical and social settings in which people live, including culture and the people and institutions with whom they interact.
				Belief about healthcare accessibility			A belief about one's environment in terms of how easy it is for a person to approach and use a healthcare service.
				Belief about one's social environment			A belief about the aspects of one's immediate social settings in which people live, including culture and the people and institutions with whom they interact.
					Belief about social support		A belief about whether others will provide or are available to provide assistance or comfort to help the person cope with one or more stressors or enhance their wellbeing.
					Perceived norm		A belief about what is typical for people who belong to a particular group.
						Perceived descriptive norm	A belief about the prevalence of performance of a given behaviour by people within a group.
						Perceived injunctive norm	A belief about whether a behaviour is appropriate and correct for people who belong to a particular group.
						Normative belief	A belief about whether key others think one should perform a behaviour.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions
				Belief about one's physical environment			A belief about parts of one's environment that do not involve people or organisations.
			Belief about responsibility to act				A belief about whether oneself or another person is obligated to take a certain course of action.
			Belief about severity of an outcome				A belief about how serious the harm associated with an outcome could be.
			Belief about susceptibility to a threat				A belief about vulnerability to a threat.
				Belief about personal susceptibility			A belief about one's personal vulnerability to a threat.
				Belief about others' susceptibility			A belief about how vulnerable others are to a threat.
			Belief about threat				A belief about a potential harm.
			Evaluative belief				A belief about whether a particular aspect of the world is positive or negative.
				Evaluation of self			An evaluative belief about one's attributes.
				Evaluative belief about behaviour			An evaluative belief about whether a behaviour is positive or negative.
				Evaluative belief about others			An evaluative belief about the attributes of others.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions
			Belief about choice over a behaviour				A belief about the extent to which one is free to choose whether to perform the behaviour.
			Belief about control over behaviour				A belief about one's capabilities and opportunities within an environmental system to perform a behaviour or achieve the outcomes resulting from a behaviour.
			Self-efficacy belief for a behaviour and its associated outcomes				A belief about one's capabilities to organise and execute a behaviour and achieve the outcomes associated with this behaviour.
			Self-efficacy belief for a behaviour				A belief about one's capabilities to organise and execute a behaviour.
				Situational self-efficacy belief for a behaviour			Self-efficacy belief for a behaviour when a barrier or facilitator of the behaviour is encountered.
		Cognitive schema					A mental disposition that when activated, guides an interconnected network of perception, thought, emotion or behaviour.
			Action schema				A cognitive schema that when activate, guides a sequence of behaviours.
			Stereotype				A cognitive schema that when activated, guides perception, thought, emotion or behaviour toward members of a social group as having certain shared attributes, by virtue of their group membership.
		Decision					A mental disposition to represent one proposition as preferred from at least two.
			Behavioural decision				A decision that one behaviour is preferred from at least two behavioural options.
		Disengagement due to workload					A mental disposition to be detached from other people due to exhaustion experienced in one's working environment.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions
		Knowledge					A mental disposition to understand the nature of the world, or a specific aspect of the world, that corresponds to the actual state of the world and is acquired through experience or learning.
			Knowledge regarding a behaviour				Knowledge regarding a particular set of actions.
			Knowledge regarding an innovation				Knowledge regarding a novel invention or way of doing something.
			Knowledge regarding a threat				Knowledge regarding a potential harm.
			Knowledge regarding treatment				Knowledge regarding a therapy or medication for a health problem.
		Learned stimulus-response co-occurrence					A mental disposition to think or behave in a particular way in response to an internal or external event in the person's environment, which is acquired through associative learning.
			Learned stimulus-behaviour co-occurrence				A mental disposition to behave in a particular way in response to an internal or external event in the person's environment, which is acquired through habit learning.
			Learned stimulus-thought co-occurrence				A mental disposition to think in a particular way in response to an internal or external event in the person's environment, which is acquired through associative learning.
		Mental imagery disposition					A mental disposition to evokes the representation of the sensory characteristics of objects or events when these are not immediately present to the senses.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions
		Motivational orientation towards types of outcomes					A mental disposition for motivation to be guided by a focus on the presence or absence of outcomes of a certain valence.
			Prevention focused motivational orientation				A mental disposition for motivation to be guided by a focus on the presence or absence of positive outcomes.
			Promotion focused motivational orientation				A mental disposition for motivation to be guided by a focus on the presence or absence of negative outcomes.
		Personal value					A mental disposition to regard certain things as fundamentally important in life, which informs standards for behaviour.
		Psychological need					A mental disposition of a person to act to obtain or maintain a particular state due to this state's importance to the person's wellbeing.
			Need for autonomy				A psychological need to have a sense of personal agency and initiative.
			Need for self-esteem				A psychological need to have a positive evaluation of oneself and one's qualities and characteristics.
			Need for a sense of safety				A psychological need to feel safe from threats.
			Need for a sense of belonging and attachment				A psychological need to have caring relationships with other people.
			Need to feel competent				A psychological need to experience oneself as capable and effective.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions
		Mental plan					A mental disposition that is realised in mental processes mentally manipulating representations of steps in an imagined process which has some goal.
			Mental plan for a behaviour				A mental plan that is realised in mental processes representing the steps to enact a behaviour and conditions under which the behaviour will be enacted.
				Mental plan for coping with barriers			A mental plan regarding a strategy to deal with conditions that could prevent the performance of a behaviour.
		Social embeddedness					A mental disposition to experience a feeling of being connected by social attachments.
		Social alienation					A mental disposition to perceive or experience oneself as isolated from and not meaningfully involved in social groups.
		Temporal orientation to the future					A mental disposition to focus more on future than present outcomes.
		Temporal orientation to the present					A mental disposition to focus more on present than future outcomes.
		Willingness to comply					A mental disposition to act in accordance with the likely approval of others.
	Emotional action tendency						A bodily disposition to behaviour that inheres in an organism by virtue of the physical changes brought about by an emotion process.
	Substance dependence						A bodily disposition which is realised as impaired functioning following reduction or termination of use of a psychoactive substance.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions
Cognitive representation							A representation which specifically depends on an anatomical structure in the cognitive system of an organism.
	Appraisal						A cognitive representation of the emotional relevance of an object or event to the organism.
		Appraisal of avoidability of consequences					An appraisal which represents a judgement about how avoidable the expected consequences of an event will be.
		Appraisal of causal agency					An appraisal that represents an evaluation of who or what caused an event.
			Appraisal as caused by self				An appraisal that represents an evaluation that an event was caused by oneself.
			Appraisal as caused by an other				An appraisal that represents an evaluation that an event was caused by another person.
			Appraisal as caused by external non-human factors				An appraisal that represents an evaluation that an event was caused by natural events and not by humans.
		Appraisal of dangerousness					An appraisal which represents an evaluation of how threatening an object or situation is.
		Appraisal of desirability of consequences					An appraisal that represents an evaluation of the desirability of the expected consequences of an event.
		Appraisal of expectedness					An appraisal that represents an evaluation of whether an event was expected to occur.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions
		Appraisal of goal importance					An appraisal that represents an evaluation of whether an event or object is important to the person's goals or needs.
		Appraisal of obligation to act					An appraisal that represents an evaluation of how much one is personally obliged to respond to an event or person in need.
		Appraisal of pleasantness					An appraisal that represents an evaluation of the pleasantness of an object or event.
	Desired standard						A cognitive representation of a reference level that an individual wishes to obtain.
	Goal						A cognitive representation of an end state towards which one is striving.
	Mental image						A cognitive representation of the sensory characteristics of objects or events that are not immediately present to the senses.
	Self-identity						A cognitive representation that a person has about themselves.
		Professional identity					A self-identity that is associated with one's occupational role.
		Social identity					A self-identity in which the representation involves a relation between the identity holder and another person or group.
Personal role							A role that inheres in a human being by virtue of their social and institutional circumstances.
	Occupational role						A role that is realised in a person by doing a specified type of work or working in a specified way.
	Social role						A personal role that is realised in human social processes.
Location							A spatial quality that inheres in a bearer by virtue of its position relative to other entities.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions
Environmental disposition							A disposition which is realised by an environmental system or system parts thereof.
	Behavioural opportunity						An environmental disposition of that enables or facilitates a behaviour.
		Physical behavioural opportunity					A behavioural opportunity that involves time and parts of the environmental system that do not involve people or organisations.
			Financial behavioural opportunity				A physical behavioural opportunity that involves the person having sufficient financial resources.
			Temporal behavioural opportunity				A physical behavioural opportunity that involves the person having sufficient time or a suitable period.
		Healthcare access					A behavioural opportunity regarding how easy it is for a person to approach and use a healthcare service.
		Social behavioural opportunity					A behavioural opportunity that involves the social environmental system.
Bodily process							A process in which at least one bodily component of an organism participates.
	Bodily behavioural cue						A stimulus that arises from bodily processes and serves to elicit or guide behaviour.
		Mental behavioural cue					A stimulus that arises from mental processes and serves to elicit or guide behaviour.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions
		Individual human behaviour					A bodily process of a human that involves co-ordinated contraction of striated muscles controlled by the brain.
			Habitual behaviour				A behaviour that results from a learnt stimulus-behaviour co-occurrence.
			Inter-personal behaviour				An individual human behaviour that involves an interaction between two or more people.
				Communicatio n behaviour			An inter-personal behaviour that involves the intentional transmission of information.
					Linguistic communication behaviour		A communication behaviour in which the information that is communicated is encoded in language.
					Non-linguistic communication behaviour		A communication behaviour in which information is transmitted without being encoded in the meaning units of any language.
				Social influence behaviour			An interpersonal behaviour where a person exerts an influence on the behaviour of another.
			Normative behaviour				An individual human behaviour that is commonly enacted by people that are part of a social environmental system.
	Goal pursuit process						A bodily process in which attempts are made to achieve a desired end state.
	Internal reward for a response						A bodily process by which the person experiences an internally-generated positive physical or psychological state subsequent to a response.
	Physiological process involved in an emotion						A bodily process that encompasses all the neurophysiological changes accompanying an emotion, which take place in the central nervous system (CNS), neuro-endocrine system (NES) and autonomous nervous system (ANS).

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions
	Plan enactment						A bodily process by which a person attempts to follow the steps in a plan.
	Self-regulation process						A bodily process that modulates the frequency, rate or extent of a response to external or internal stimuli and that is instigated by the person.
		Self-regulation of behaviour					A self-regulation process that modulates the frequency, rate or extent of one's performance of a behaviour.
			Behavioural self-regulation of behaviour				Self-regulation of behaviour through the performance of a different behaviour.
			Introjected self-regulation				Self-regulation of behaviour undertaken to manage a sense of guilt, anxiety or obligation.
			Self-reinforcing self-regulation				Self-regulation of behaviour through self-administering a reward for performing an intended behaviour.
			Value-congruent self-regulation				Self-regulation undertaken to achieve consistency between one's values and the behaviour performed.
	Mental process						A bodily process that occurs in the brain, and that can of itself be conscious, or can give rise to a process that can of itself be conscious or can give rise to behaviour.
		Affective process					A mental process that has positive or negative valence.
			Emotion process				An affective process that is a synchronized aggregate of constituent mental processes, including an appraisal process, which is valenced, has an object, and gives rise to an action tendency.
				Anger			A negative emotion, characterised by feelings of unpleasantness and high arousal, in the form of antagonistic feelings and action tendencies.
				Anxiety			A negative emotion that is aversive and provoked by the prospect of distal threat.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions
				Disgust			A negative emotion that is characterised by a need to get rid of, or distance oneself from, a stimulus that is appraised as repulsing.
					Animal-nature disgust		Disgust elicited by poor hygiene, inappropriate sex, gore or violations of bodily boundaries, and death or the odor of decay.
					Core disgust		Disgust elicited by "contaminated" food substances: rotten food, culturally variable "bad" food, certain animals associated with rotten food (maggots, rats), and every body product except tears.
					Interpersonal disgust		Disgust elicited by contact with others, especially contact with strangers or other individuals or groups we are averse to.
					Moral disgust		Disgust elicited by some kinds of especially egregious moral violations.
				Fear			A negative emotion that is aversive and characterised by feelings of threat and impending doom, and by an urge to get out of the situation.
				Guilt			A negative self-evaluative emotion that occurs when a person brings about a negative outcome by acts of commission or omission that violate internal or external moral standards.
				Happiness			A positive emotion which is experienced in reaction to a positive experience or event.
				Sadness			A negative emotion felt when an event is appraised as unpleasant and resulting in loss or failure.
				Satisfaction			An emotion that is experienced when one's wishes, expectations or needs are fulfilled.
				Shame			A negative emotion that is distressing and occurs when one appraises one's behaviour or circumstance as wrong, dishonourable, immodest or indecorous.
				Surprise			An emotion caused by encountering unexpected events.
					Positive surprise		Surprise with a positive valence.
					Negative surprise		Surprise with a negative valence.
				Pleasure			A positive emotion which is sought out and is associated with happiness and satisfaction.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions
					Pleasure associated with behaviour		Pleasure that is experienced as a result of engaging in a behaviour.
					Sexual pleasure		Pleasure that is experienced as a result of sexual activities.
				Regret			A negative emotion that occurs when a person wishes they chose or acted differently in the past, due to the consequences of that choice or action being unfavourable.
			Subjective affective feeling				An affective process that involves the experience of internal or external sensory stimuli.
				Cognitive dissonance			An unpleasant subjective affective feeling experienced due to perceived inconsistency between two concurrently held cognitive representations.
				Craving			A subjective affective feeling of desiring or needing something.
				Feeling at ease			A subjective affective feeling of being at ease, comfortable, relaxed.
				Feeling energetic			A subjective affective feeling of having lots of energy, being energetic.
				Feeling an urge			A subjective affective feeling that arises when an impulse to enact a behaviour is activated but not immediately acted upon.
				Feeling nervous			A subjective affective feeling of being not at ease or agitated.
				Feeling sadness			A subjective affective feeling of sadness.
				Feeling tired			A subjective affective feeling of tiredness, needing sleep.
					Feeling exhausted		Feeling tired to an extremely strong degree.
				Hunger			A subjective affective feeling that involves discomfort and is associated with a need to consume food.
				Subjective need			A subjective affective feeling that involves experiencing anticipated relief or continued comfort by obtaining or maintaining a particular state.

393

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions
				Pain			A subjective affective feeling in an organism S, involving two integrated levels: (a) activation of the nociceptive system and associated emotion generating brain components of S, and (b) a simultaneous aversive sensory and emotional experience on the part of S, where (b) is phenomenologically similar to the sort of aversive experience involved in pain with concordant tissue damage.
		Appraisal process					A mental process that gives rise to an appraisal.
		Arousal					A mental process that involves heightened responding to an internal or external stimulus.
		Attending					A mental process whereby relevant aspects of one's mental experience are focused on specific targets.
		Avoidance mental process					A mental process that reduces the frequency by which an aversive cognitive representation is evoked.
		Cognitive process					A mental process that creates, modifies or has as participant some cognitive representation.
			Comprehension				A cognitive process that creates a representation of the meaning and significance of a communication, object, event or situation.
			Decision simplification				A cognitive process used prior to decision-making that reduces the perceived scope or complexity of available options.
			Mental distancing				A cognitive process that involves intentionally detaching oneself from one's immediate thoughts.
				Targeted mental distancing			Mental distancing that involves identifying particular immediate thoughts and intentionally detaching from these thoughts.
			Thinking				A cognitive process that involves the manipulation of mental language and/or mental images.
				Reflective thinking			Thinking that involves the generation of inferences by reasoning based on one or more statements, evaluating anticipated consequences or considering the relationships between concepts.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions
				Ruminating			Thinking that is about negative experiences and feelings, and repeated.
		Dissonance reduction process					A mental process through which a perceived inconsistency between two concurrently held cognitive representations is reduced.
		Goal setting process					A mental process that establishes a cognitive representation of the desired end state.
		Heuristic process					A mental process that uses simple rules and associations learnt from experience to make judgements.
		Impulse					A mental process that is sudden and compels an organism to think or behave in some way.
		Judging					A mental process during which information is evaluated, the outcome of which is a belief or opinion.
			Decision-making				Judging during which one proposition is selected as preferred from at least two.
			Social comparison process				Judging oneself or one's social group in relation to the qualities or characteristics of another person or social group.
		Learning					A mental process in which a lasting mental or behavioural change occurs as the result of experience.
			Associative learning				Learning that involves changing strength of association between two or more mental processes.
				Classical conditioning			Associative learning process that occurs when the pairing of a conditioned and unconditioned stimulus leads to the conditioned stimulus producing a response that would otherwise have only been produced by the unconditioned stimulus.
				Extinction in classical conditioning			Associative learning process in which the strength of a conditioned response is reduced because its conditioned stimulus is presented without being accompanied by the unconditioned stimulus.
				Operant conditioning			Associative learning process in which the likelihood of a particular behavioural response is influenced by the past consequences associated with performing that behaviour.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions
				Extinction in operant learning			Associative learning process in which the rate of behavioural response in the presence of a discriminative stimulus is reduced because the response is no longer followed by a reinforcer.
				Discrimination learning			Associative learning process in which people learn to distinguish between appropriate responses to similar but different stimuli depending on whether a generalised response is rewarded or not.
				Generalisation in learning			Associative learning process in which prior learning that an antecedent stimulus signals certain consequences of behaviour spreads to a stimulus that differs in certain aspects from the original antecedent stimulus.
				Habit learning			Associative learning process that involves strengthening an association between a stimulus and an impulse through repetition of co-occurrence of the stimulus and the behaviour.
			Non-associative learning				A simple form of learning whereby the repeated presence of a stimulus leads to a change in the probability or strength of the response to that stimulus. There is no association of one type of stimulus with another, rather it is a generalized response to the environment.
				Habituation			A decrease in a behavioural response to a repeated stimulus.
				Sensitization			An increase in a behavioural response to a repeated stimulus.
			Observational learning				Learning that occurs through observing the behaviour of others.
				Imitative learning			Observational learning in which new behaviours are acquired through imitation.
		Memory					The activities involved in the mental information processing system that receives (registers), modifies, stores, and retrieves informational stimuli.
			Associative memory				A memory process that deals with the receipt, storage, retrieval and modification of information regarding a set of entities associated with a particular object or event.
			Episodic memory				A memory process that deals with the receipt, storage, retrieval and modification of information regarding a personally experienced event at a particular time or place.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions
			Semantic memory				A memory process that deals with the receipt, storage, retrieval and modification of information associated with meanings, understandings or conceptual facts about the world.
			Procedural memory				A memory process that deals with the receipt, storage, retrieval and modification of information regarding how to perform a complex activity without conscious awareness.
			Iconic memory				A memory process that deals with the receipt, storage, retrieval and modification of information regarding a brief visual stimulus,
		Mental categorising					A mental process in which objects, events, people, or experiences are grouped into classes, on the basis of features shared by members of the same class and features distinguishing the members of one class from those of another.
		Mental imagery					A mental process that evokes the representation of the sensory characteristics of objects or events when these are not immediately present to the senses.
		Mentally comparing against a standard					A mental process in which conditions are compared against a particular reference level.
		Motivation					A mental process that energises and directs behaviour.
			Automatic motivation				Motivation that arises from emotions and impulses that result from associative learning or innate dispositions.
			Autonomous motivation				Motivation that is internally generated and based on a behaviour being interesting or valuable to an individual.
				Behavioural importance-based motivation			Autonomous motivation due to the perceived value or importance of the behaviour to oneself.
				Intrinsic motivation			Autonomous motivation due to a behaviour's inherent enjoyment, satisfaction or benefits to oneself.
				Fundamental need-based motivation			Autonomous motivation due to a behaviour being perceived to satisfy core psychological need.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions
			Extrinsic motivation				Motivation that is based on external rewards, punishments or pressure regarding a behaviour.
				Approval-based motivation			Extrinsic motivation to gain or maintain social approval or a positive self-evaluation.
		Perception					A mental process which is a) produced by a causal process involving a part of the environment of the organism, and b) is experienced by the organism as being so caused, and c) in which the relevant part of the environment is thereby represented to the organism.
		Planning					A mental process that involves mentally manipulating representations of steps in an imagined process which has some goal.
		Self-binding					A mental process that involves creating adverse consequences for oneself if one does not stick to an intended course of action.
		Self-monitoring					A mental process in which one observes one's own behaviour or mental processes.
		Subliminal process					A mental process that involves neuronal activity in response to a sensory stimulus but which is not the subject of consciousness.
		Non-judgemental acknowledgement					A mental process that involves taking notice of one's affective, mental or bodily experience without judging it as good or bad.
		Wanting					A mental process that involves thinking about a state of affairs that is not yet the case together with a desire for that state of affairs to come about.
Consciousness							That part of the mental process that confers a subjective perspective, a phenomenology, an experience of the mental process of which it is a part; and intends the object or event that the mental process is about, should such exist; it confers intentionality on the mental process.

8.5   Discussion

To refine classes in the MoA Ontology, this study investigated whether the MoA Ontology's class labels and definition could be reliably applied to annotate hypothesised MoAs in behaviour change intervention reports. While researchers familiar with the MoA Ontology applied this ontology with 'acceptable' inter-rater reliability to annotate MoAs in 50 reports, the inter-rater reliability coefficient for annotations performed by researchers unfamiliar with the ontology was lower. Examination of the annotation disagreements of researchers unfamiliar with the ontology led to three class labels, 12 class definitions and two classes' informal definitions being updated. In addition, comments were added to seven classes and a synonym was added to one class. Seven new classes were also added to the ontology, bringing its number of classes to 261. As the annotation disagreements revealed many issues around classifying underspecified MoAs, updates were made to the annotation manual to help apply the MoA Ontology.

In line with ontology development work on other parts of the Behaviour Change Intervention Ontology (e.g., Norris et al., 2020; Wright et al., 2020), inter-rater reliability testing helped refine the MoA Ontology. The finding that researchers familiar with an ontology achieved higher inter-rater reliability than the researchers unfamiliar with the relevant ontology was consistent with other ontology development studies (Norris et al., 2020; 2021b). The size of the difference in inter-rater reliability coefficients between raters familiar and unfamiliar with the ontology appears to be influenced by the complexity of the ontology. The difference was more pronounced for the MoA Ontology and the Mode of Delivery Ontology (Marques et al., 2020) than for the simpler Intervention Source (Norris et al., 2021b) and Setting (Norris et al., 2020) Ontologies.

8.5.1 Strengths and limitations

This study's method for selecting intervention reports aimed to include reports with a wide variety of MoAs relevant to various classes in the ontology. However, as the MoA Ontology is broad, with over 250 classes, MoAs relevant to some classes were not captured in the included reports. For instance, some MoAs (e.g., specific emotion-related MoAs) did not come up in the reports. Therefore, the inter-rater reliability of applying certain class labels and definitions (e.g., 'surprise' or 'shame') could not be tested. Other MoAs occurred infrequently in reports, meaning that inter-rater reliability statistics provided limited insight on whether those classes needed changing. For instance, one disagreement on a class across the 50 reports revealed little information about the reason for this disagreement. While the disagreement could be due to a problem with applying the class (e.g., difficulties differentiating it from another class in the ontology), it could also be due to the reporting of the MoA in a specific report.

The quality of construct descriptions in intervention reports created challenges for reliably identifying whether constructs qualified as MoAs and what types of MoAs they were. The lower inter-rater reliability for researchers unfamiliar with the MoA Ontology was often related to their disagreements on whether a construct was sufficiently specified in the report to qualify as an intervention's MoA. Some authors did not provide clear statements of which of the constructs measured in a study were hypothesised MoAs. In addition, many disagreements were associated with MoAs not being clearly defined. More specifically, some disagreements occurred when only the label and a single example questionnaire item were provided for an MoA in an intervention report. Even when greater detail of an MoA's measurement was provided, this information shows how an MoA was operationalised but not its intended definition.

Intervention reports with more precise definitions for MoAs and their relationship to behaviour would have reduced inter-rater disagreements due to poorly specified MoAs. However, the current results reflected realistic challenges when applying the MoA Ontology to intervention reports.

8.5.2 Implications

This study showed that the MoA Ontology could be annotated with 'acceptable' inter-rater reliability when researchers were familiar with the ontology. As the examination of annotation disagreements revealed 19 classes needed to be changed and seven classes were missing, the ontology seemed generally usable. Through the refinements that were made to the ontology, this study also produced a version ontology that could be shared online for others to use.

The lower inter-rater reliability for researchers unfamiliar with the ontology suggested that more training to help annotators familiarise themselves with the MoA Ontology and reconciliation sessions might be necessary when applying the ontology. Training about using the ontology, similar to the training offered for the Behaviour Change Technique Taxonomy Version 1 (https://www.bct-taxonomy.com/; Michie et al., 2013), could support new users of the ontology. Moreover, having reconciliation sessions for every set of 10 intervention reports could support annotators in reliably applying the ontology. In addition, considering challenges in agreeing on whether constructs qualified as MoAs in intervention reports, the developed annotation manual should be a helpful resource for coding hypothesised MoAs in intervention reports.

The findings also implied that clearer reporting of MoAs is necessary to help researchers reliably apply precise categorisation systems to code information about MoAs. Based on the current findings, intervention reports need to (1) clearly specify their MoAs (e.g., the relationship of constructs to behaviour), (2) define MoAs and (3) provide examples of the measurement items (more than one example, where possible) used for these MoAs. Such reporting will enable more accurate synthesis of evidence about MoAs and their potential measurements.

8.5.3 Future research

The MoA Ontology can be refined through further application in research. For instance, the ontology's use in systematic reviews can help identify whether any class labels and definitions are unclear, any classes are missing or any classes are overlapping and should be merged. Hosting the MoA Ontology on online platforms, such as Github, OSF and the Ontology Lookup Service (European Bioinformatics Institute, 2019), will allow more potential users (e.g., students and policymakers) to engage with the ontology and provide feedback on it (e.g., through the Github portal). Such feedback should be part of the process of informing updates to the ontology to make it more usable (e.g., refining the class labels and definitions to be simpler).

8.5.4 Conclusion

The current study refined the MoA Ontology's class labels and definitions by testing whether they could be reliably applied to annotate MoAs in behaviour change intervention reports. The ontology and its annotation manual were refined based on the examination of annotation disagreements. The resulting version of the MoA Ontology will be shared online for application in research, and feedback on the ontology can be

provided through the GitHub portal. By having more users applying the MoA Ontology

and providing feedback on where it might need to be refined, the ontology can become

an increasing useful resource for synthesising evidence about MoAs in behaviour

change.

9 Chapter 9: General discussion

This thesis aimed to: (1) investigate challenges in applying mechanisms of action (MoAs) to link these to behaviour change techniques (BCTs) and (2) develop an MoA Ontology as part of the Behaviour Change Intervention Ontology (BCIO). This final chapter outlines the extent to which these aims were met and the implications of the research findings. In the first part of the chapter, a summary of the findings in relation to the thesis aims will be presented, followed by a description of how the findings relate to previous research. The second part will outline key strengths and limitations of the MoA Ontology and its development; empirical and practical implications of this thesis; the future maintenance of the MoA Ontology; possibilities for future research and an overall conclusion.

9.1 Summary of key findings

9.1.1 Aim 1: Investigating the challenges in understanding and applying MoAs to link these to BCTs

Drawing on discussions between behavioural science experts about BCT-MoA links with high disagreement or uncertainty (Connell Bohlen et al., 2019), Study 1 involved a thematic analysis to investigate expert disagreements and uncertainties about MoAs, BCTs and their links. The findings suggested that there were three broad issues that created challenges for understanding and linking MoAs to BCTs. One was that experts differed in their prior knowledge about BCT-MoA links and had different approaches to judging these links, leading them to disagree on certain links. Another issue was that several MoAs and BCTs were considered too broad or overlapping with other MoAs or BCTs, creating challenges to understanding these constructs and judging their links. Some MoAs and BCTs were also perceived as having unclear definitions, or labels that

did not closely match their definitions. The final issue was that BCT-MoA links'
strength and existence were perceived to vary depending on several factors, such as
aspects of the intervention and its context. Therefore, judging one-to-one BCT-MoA
links was a challenge.

9.1.2 Aim 2: Developing an ontology of MoAs in behaviour change interventions

To develop an ontology of MoAs in behaviour change interventions, Studies 2 to 7
(Chapters 3-8) broadly followed a stepwise method that addressed principles for
developing 'gold standard' ontologies (Open Biological and Biomedical Ontology
[OBO] Foundry, 2019i; Wright et al., 2020). One principle proposes that an ontology
needs to have a specified scope (i.e., a clear subject area) and content (i.e., classes that
are labelled and defined) that falls within its scope (OBO Foundry, 2019f). To address
this principle in Study 2, MoAs were defined as 'processes that are potentially causally
active in bringing about the impact of a behaviour change intervention on the outcome
behaviour.' To identify relevant content for the ontology, 1062 MoAs were identified
from the constructs of 83 theories selected from a scoping review of behavioural
theories (Davis, Campbell, Hildon, Hobbs, & Michie, 2015). These MoAs were grouped
based on their shared attributes to form an initial structure that helped select classes for
the MoA Ontology. In total, 763 MoAs formed 104 groups, and 153 MoAs with unique
attributes were ungrouped. The remaining 146 MoAs were considered too broad to
group (they were compound MoAs).

To ensure that ontologies have non-overlapping content and that their users can
understand the meaning of their classes, ontologies need to have unique classes with
clear labels and definitions that are logically structured (OBO Foundry, 2019d, 2019e,

2019g). To be interoperable with other ontologies and meet potential users' needs, ontologies should also be developed collaboratively (OBO Foundry, 2019b). Therefore, ontology developers should, as far as possible, reuse other ontologies' relevant content and reflect scientific consensus about a subject area in their ontology. To address these principles, the MoA Ontology's 412 classes were identified, labelled and defined by drawing on the MoA groups, ungrouped MoAs and classes in other relevant ontologies. By reusing upper-level classes from other ontologies, the 412 classes were organised into eight hierarchical levels, forming the MoA Ontology's first draft. A review of the draft by three behavioural science experts and one ontology expert revealed that this version was too complex (e.g., included too many detailed classes) to be usable and did not clearly enough capture the nature of MoAs (e.g., that an MoA would work through dispositions, such as a belief).

To reflect the MoA Ontology's scope more accurately (i.e., that MoAs can work through various entities, including processes and dispositions), the definition of an 'MoA' was updated in Study 4: 'attribute of the process by which a behaviour change intervention influences the behaviour.' The ontology's upper-level classes were also updated to reflect that MoAs work through classes in the MoA Ontology (e.g., 'MoA through belief') in Study 4. In addition, for the MoA Ontology to be comprehensive but also more usable, its classes were revised (i.e., classes were added, removed or reorganised, and some class labels and definitions were updated) through discussions amongst the research team. The refined version of the ontology had 202 classes organised into seven hierarchical levels.

Ontologies' content (classes and their labels and definitions) should be clear and comprehensive enough to capture their intended scope (e.g., MoAs) as reported in the literature (OBO Foundry, 2019d, 2019f, 2019g; Wright et al., 2020). Therefore, the MoA Ontology's updated version was applied to annotate (i.e., code) hypothesised MoAs in published intervention reports in Study 5, resulting in eight classes with refined labels and/or definitions, three classes being removed and 35 additional classes. Next, to better reflect scientific consensus about MoAs and ensure the ontology's classes can be easily and widely understood (OBO Foundry, 2019b, 2019d, 2019g), nine international behavioural scientists provided feedback on the ontology in Study 6. Based on this feedback, 34 class labels, 127 class definitions and the parent classes of 25 classes were revised. With 23 classes being removed and 43 classes being added, the resulting ontology had 254 classes on seven hierarchical levels.

Ontologies' class labels and definitions also need to be clear enough for their users to agree on which classes to apply to capture relevant information reported in the literature (OBO Foundry, 2019d, 2019g; Wright et al., 2020). Therefore, the MoA Ontology's classes were applied to annotated MoAs in behaviour change intervention reports, and those that could not be reliably applied were refined in Study 7. While two researchers familiar with the MoA Ontology could apply its classes with 'acceptable' reliability, two researchers unfamiliar with the ontology did not reach 'acceptable' reliability. By drawing on the disagreements on classes that could not be reliably annotated by the researchers unfamiliar with the ontology, three class labels and 12 class definitions were updated. In addition, seven classes were added. As a result, the final version of the MoA Ontology had 261 classes on seven hierarchical levels.

9.2 How findings relate to previous research

There have been calls for better reporting of MoAs in behaviour change interventions, as several studies showed that MoAs are often underspecified across reports (Abraham, Johnson, De Bruin, & Luszczynska, 2014; Carey et al., 2019; Garnett et al., 2018; Prestwich et al., 2014; Prestwich, Webb, & Conner, 2015). The findings in this research (Studies 5 & 7) confirmed that many interventions do not include definitions for their hypothesised MoAs, and there are some mismatches between MoAs' labels, definitions and measurements. As suggested by others (Abraham et al., 2014; Prestwich et al., 2014), many intervention reports were also not explicit about the links between BCTs, MoAs and behaviours, making it difficult to understand which constructs are hypothesised as an intervention's MoAs.

Behavioural theories propose influences on behaviours, which can guide selecting the target MoAs of an intervention designed to changed behaviour (Eccles, Grimshaw, Walker, Johnston, & Pitts, 2005; Noar & Zimmerman, 2005). However, authors of behavioural theories sometimes underspecify their constructs, including potential MoAs, and the relationships between these constructs (Hale et al., 2020; West et al., 2019). Study 2 found that many constructs from 83 behavioural theories (Davis et al., 2015) were not clearly defined within their original theory descriptions and their relationships to other constructs were often unclear. For instance, some descriptions did not clarify whether constructs were fixed or modifiable, or whether and how they influenced behaviour, creating challenges for identifying which constructs could be considered potential MoAs in an intervention. By clearly labelling and defining classes that capture MoAs in the MoA Ontology, the research reported in this thesis contributes

to developing a more formal and precise language for reporting, comparing and synthesising evidence about MoAs (Michie, West, & Hastings, 2019).

The research findings reported in this thesis aligned with other reviews of theories, concluding that many theories are overlapping (Davis et al., 2015; Sheeran, Klein, & Rothman, 2017; Rothman & Sheeran, 2020). During the grouping of potential MoAs identified from theories in Study 2, constructs from different theories often had the same or very similar definitions. Consistent with other findings (e.g., Nigg, Allegrante, & Ory, 2002; Sheeran et al., 2017), many constructs also had the same label but were defined differently or had different labels but the same definition in Study 2.

The MoA Ontology is part of efforts to reduce redundancy across behavioural theories and enable comparisons across theories. Previous work has synthesised constructs from different theories into integrative theories and frameworks (Cane, O'Connor, & Michie, 2012; Fishbein et al. 2001; Hagger & Hamilton, 2020; Michie et al., 2005; Rimer & Glanz, 2005). Compared to some frameworks, such as the Theoretical Domains Framework (TDF) with 14 broad domains (Cane et al., 2012; Michie et al., 2005), the MoA Ontology is much larger and more detailed. With its fewer domains, the TDF can be more accessible, e.g., easier to learn and apply. However, Study 1 suggested that there might be challenges to linking MoAs to BCTs, when MoAs and BCTs are very broadly defined. Therefore, the MoA Ontology provides a resource for synthesising detailed evidence about MoAs, e.g., precise BCT-MoA links. The TDF and the MoA Ontology could become more compatible resources for researchers in the future by mapping the ontology's upper-level classes onto the TDF. When using the TDF,

researchers could refer to the more granular classes in the MoA Ontology to capture MoAs at greater specificity where needed.

In parallel to the MoA Ontology, the Ontology-based Modelling System (OBMS) precisely represented 76 behavioural theories by labelling constructs ('entities') and specifying their relationships (West et al., 2019; Hale et al., 2020). For instance, in the representation of the Theory of Planned Behaviour (Azjen, 1985), the research team captured that 'attitude' positively influences 'intention' which positively influences 'behaviour'. These mappings provide a formal representation of which constructs influence behaviour and through which pathways (directly or through other constructs), making it easier to select potential MoAs for behaviour change interventions. While the OBMS outlines explicit relationships between constructs for each theory reviewed, the MoA Ontology presents a more precise and formal language for MoAs not restricted to particular theories. Thereby, both the OBMS and the ontology attempted to reduce ambiguity about constructs that can arise from using 'natural language' in theory descriptions (Hale et al., 2020).

In addition to the language for MoAs being used inconsistently, the same MoAs are often measured differently across interventions, and different MoAs may be assessed using the same measurements (Eisenberg et al., 2018; Hertwig, Wulff, & Mata, 2018). Using the same measurements for the same MoAs would lead to more efficient evidence accumulation about MoAs (Nielsen et al., 2018). Various research teams have created repositories including specific measurements for MoAs (e.g., Moser et al., 2011; Nielsen et al., 2018). Most recently, the Science of Behaviour Change Network has been conducting studies to systematically develop and validate measurements for three

broad MoA groups: (1) self-regulation, (2) stress resilience and stress reactivity and (3) interpersonal and social processes (Nielsen et al., 2018; Slep, Heyman, Mitnick, Lorber, & Beauchaine, 2018; Sumner et al., 2018). Some of the measurements have been mapped onto the 26 MoAs included in the Theories and Techniques (TaT) Project (Michie et al., 2018): https://theoryandtechniquetool.humanbehaviourchange.org/tool. These measurements could also be mapped onto relevant classes in the MoA Ontology, providing initial guidance on how to measure these classes. More measurements could be mapped onto the ontology's classes in the future, as and when they are developed and validated. Thereby, the ontology could support selecting and organising measurements for MoAs at different levels of specificity.

9.3   Strengths and limitations of the MoA Ontology and its development

A key strength of the MoA Ontology's development was the collaborative and international approach taken. Many ontologies are developed without a formal step to integrate domain expert feedback (Norris et al., 2021a). However, the MoA Ontology's stakeholder review (Study 6) enabled the systematic consideration of feedback from behavioural scientists from six countries to improve the MoA Ontology. In addition, by reusing classes from other ontologies during the MoA Ontology's development (Studies 3-7), this ontology avoided duplicating knowledge and is interoperable with other ontologies. Collaborating closely with a developer of the Emotion and Mental Functioning Ontologies (Hastings, Ceusters, Jensen, Mulligan, & Smith, 2012; Hastings, Ceusters, Smith, & Mulligan, 2011) ensured that classes were reused correctly from these ontologies (Studies 3-7). This collaboration also informed refinements to classes of the Emotion and Mental Functioning Ontologies. For instance, in Study 6, the

stakeholders provided feedback on classes reused from the Emotion and Mental Functioning Ontologies, which helped refine some class definitions to be more accessible.

The MoA Ontology extensively captures MoAs, as its development drew on several sources: (1) 83 behaviour theories, (2) relevant ontologies, (3) hypothesised MoAs in intervention reports and (4) the feedback of international behavioural scientists. However, the breadth and detail of the MoA Ontology might come at a cost to its usability. While the ontology was restructured in Study 4 to be more user-friendly and some classes were removed based on behavioural scientists' feedback in Study 6, this ontology remains the largest ontology part of the BCIO (e.g., Marques et al., 2020; Norris et al., 2020, 2021b). There were challenges to judging which classes in the MoA Ontology could be removed from the ontology to improve usability. To make such judgements, Study 4 developed criteria for selecting classes (e.g., excluding classes that specified a specific application of their parent class). These criteria could be refined through feedback from more behavioural scientists. Moreover, the ontology's users could provide feedback on which classes add to the ontology's complexity without capturing important distinctions between MoAs. In the meantime, user training can be developed to support new users in familiarising themselves with the MoA Ontology and practicing its applications, similar to the training offered for using the BCT Taxonomy v1 (Michie et al., 2013): https://www.bct-taxonomy.com. As shown in Studies 5 and 7, a detailed annotation manual to apply the MoA Ontology can also support researchers when using this ontology. This manual can be improved through the feedback of its users. Therefore, the latest version of this manual (Study 7) will be shared as an editable

document on the website that the Human Behaviour-Change Project (Michie et al., 2017) is developing to share its resources.

9.4 Implications of the MoA Ontology for theory, research and practice

The thesis studies and previous work revealed several gaps in our understanding of MoAs and their relationships to other parts of behaviour change interventions. Some of these gaps can be addressed by applying the MoA Ontology. The ontology can be used to: (1) improve the reporting of MoAs in behaviour change interventions, (2) appraise the reporting of MoAs in behaviour change intervention reports, (3) better specify MoAs in study protocols, (4) help synthesise evidence about MoAs in interventions, (5) develop evidence-based interventions, (6) create a clearer overview of evidence on MoAs and research gaps, (7) inform refinement of theories or models relating to behaviour change and (8) develop algorithms to extract or predict information about MoAs.

9.4.1 Improving the reporting of MoAs in behaviour change interventions

The MoA Ontology can support clearer and more consistent reporting of the MoAs in behaviour change interventions. When writing an intervention report, and specifying an MoA (e.g., a change in intention), report authors can search for the relevant class in the MoA Ontology (e.g., 'behaviour intention' defined as 'A mental disposition to commit to enact or not enact a behaviour'). Once the authors find the relevant class, they can use this class's label and definition for the MoA and cite the class's Uniform Resource Identifier (URI). Even when authors wish to use a different label for an MoA (e.g., to reflect the terminology used in a particular theory), referencing the corresponding

class's URI from the MoA Ontology allows report readers to look up the MoA's intended definition in the ontology. Therefore, report readers would have a clear understanding of what the MoA is.

If the MoA Ontology is used to describe MoAs in multiple intervention reports, it becomes easier to compare and synthesise evidence about MoAs across these reports. For instance, if two intervention reports include references to the same class (e.g., 'behaviour intention') as an MoA, the report readers can be certain that those interventions targeted the same MoA. In contrast, when MoAs are poorly described in reports (e.g., only the label provided), readers need to make assumptions about the MoA and are more likely to disagree about the nature of the MoA. As the evidence synthesis about MoAs from such reports will involve uncertainty, scoping or systematic reviews might not be capturing these interventions' MoAs correctly. The MoA Ontology provides a controlled vocabulary that can reduce ambiguity in reporting of MoAs, and thereby facilitate better understanding and evidence synthesis about MoAs.

9.4.2 Appraising the reporting of MoAs

For journal reviewers and editors, the MoA Ontology could become a resource for promoting clear reporting of MoAs. Journal editors could require that report authors use the classes of the MoA Ontology to describe MoAs, ensuring that key information about MoAs (i.e., their labels and definitions) is included in reports. As indicated, including this information in reports facilitates better evidence synthesis. In addition, organisations providing research grants could require applicants to specify their interventions' MoAs using the ontology. Based on such applications, these organisations would have a better overview of the types of interventions they are

funding (e.g., interventions targeting 'self-regulation process') and make strategic decisions on funding future interventions. For instance, an organisation may identify that behaviour change interventions targeting 'physical behavioural opportunity' (MoA) have not been funded often and so might allocate more funding to such interventions.

9.4.3   Developing and evaluating study protocols

When developing study protocols, researchers can use the MoA Ontology to specify which MoAs they are targeting and investigating in interventions. By applying the ontology to protocol development, researchers will be prompted to think clearly about which MoAs they are investigating from the outset. Accordingly, these researchers can ensure that the planned measurement tools for MoAs match their target MoAs. People appraising study protocols can also use the ontology to verify whether the MoAs of a planned intervention are well-specified.

9.4.4   Evidence synthesis about MoAs in behaviour change interventions

Researchers can use the MoA Ontology to code MoAs in behaviour change interventions (as per Studies 5 and 7) in scoping or systematic reviews. Based on the ontology's class definitions, researchers are more likely to correctly categorise MoAs of the same type, even if these MoAs are labelled differently in the reports. As the ontology includes granular classes, these classes' definitions can also help researchers precisely differentiate and categorise MoAs in intervention reports. By categorising MoAs more precisely using the ontology, reviewers can better detect which MoAs are frequently targeted in interventions that are effective at changing specific behaviours and those targeted in less effective interventions. The findings from such reviews can provide evidence for which MoAs are relevant targets for changing specific behaviours.

To synthesise more detailed information about interventions, researchers can use the MoA Ontology together with the other parts of the BCIO (Michie et al., 2017, 2021). For instance, by applying the BCT, MoA and Behaviour Ontologies in a systematic review, researchers can investigate which BCTs work through specific MoAs to change behaviours in interventions. The findings could reveal which BCTs are more likely to change specific MoAs to influence behaviour. Finding that some BCTs influence the same MoAs (e.g., 'self-regulation process') may suggest that these BCTs could have a complimentary influence on these MoAs. With additional parts of the BCIO (e.g., the Setting and Population Ontologies), reviewers can synthesise even more complex information about interventions: their BCTs, the delivery of their BCTs, their targeted MoAs and behaviours, and their target populations and settings. Such information can provide detailed guidance for the development of behaviour change interventions.

9.4.5   Developing interventions

When creating behaviour change interventions, designers often start with identifying a target behaviour, then the evidence about the influences on that behaviour and finally the BCTs that would work through those influences (Kok et al., 2016; Michie, Van Stralen, & West, 2011). Intervention designers could map the influences on behaviour to the classes of the MoA Ontology, providing them with precise definitions to conceptualise MoAs. To identify BCTs that are likely to influence these MoAs, the intervention designers can use evidence about BCT-MoA links, e.g., drawing on systematic reviews based on the MoA Ontology, expert consensus studies (e.g., Connell Bohlen et al., 2019) and successful interventions. Therefore, the MoA Ontology can support evidence-based intervention development.

9.4.6 Creating an overview of existing research and identifying research gaps

To provide an overview of the existing evidence about MoAs for intervention design and research gaps about MoAs, researchers could map the evidence about MoAs from intervention evaluations or reviews onto the MoA Ontology's classes. This mapping can serve as an 'evidence and gap map', visually representing what is known and unknown about MoAs (Britton et al., 2021; Snilstveit, Vojtkova, Bhavsar, Stevenson, & Gaarder, 2016). For classes with evidence available, the links to studies with relevant evidence (e.g., systematic reviews) can be provided, making this evidence easily accessible to intervention designers (Snilstveit et al., 2016). Identifying the MoA classes with little or no evidence available can help researchers identify which MoAs have been less investigated. Based on these findings, researchers can consider investigating less studied MoAs to enhance behaviour change intervention evidence. In addition, researchers would avoid repeatedly testing the same MoAs to change behaviour. Overall, a mapping based on the MoA Ontology can support a strategic approach to building a strong evidence base about MoAs (Snilstveit et al., 2016).

Future iterations of such an 'evidence and gap map' could show more detailed evidence regarding MoAs and their relationships to aspects of interventions, e.g., their links to BCTs. An example of such a mapping effort is the Theories and Techniques (TaT) Tool (Johnston et al., 2018). This tool visually presents evidence about the links between 74 BCTs and 26 MoAs (https://theoryandtechniquetool.humanbehaviourchange.org/tool) and gaps in evidence about these links. Some of MoA Ontology's could be used to expand this tool to represent the evidence and evidence gaps about BCT-MoA links. For instance, classes that are not captured by MoAs in the TaT Tool and have been found to link to BCTs in systematic reviews could be added to this tool.

9.4.7 Refining theories or models of behaviour change

Evidence synthesis that applied the MoA Ontology can precisely show the types of MoAs that influence behaviours, facilitating refinements to behavioural theories. Evidence about whether manipulating a specific MoA changes behaviour can support or disprove causal links between MoAs and behaviours. By referring to this evidence, theory authors can be more confident about which theoretical constructs influence behaviour and could remove constructs from theories that were consistently found not to influence behaviour (e.g., belief about severity of a threat). Drawing on theories that strongly predict behaviour, researchers make better predictions about behaviour change and develop interventions that are more likely to work, reducing research waste (Glanz & Bishop, 2010; Prestwich et al., 2014).

The evidence synthesised using the ontology could reveal overlaps in MoAs captured by different ontology classes and relevant constructs from behavioural theories. For instance, if several systematic reviews reveal that MoAs captured by two different, but closely related, ontology classes have the same strength and direction of influence on various behaviours, these classes might not be capturing different MoAs. This evidence can suggest that these classes (e.g., 'intrinsic motivation' and 'behavioural importance-based motivation') may not be distinct. Drawing on this evidence, authors of relevant theories could consider how to refine the theory's constructs.

9.4.8 Developing algorithms to extract or predict information about MoAs

A key advantage of the MoA Ontology over other classification system is being computer readable, meaning that its classes and structure can be 'understood' by algorithms that extract or predict information (Hastings & Schulz, 2012; Seppälä,

Schreiber, & Ruttenberg, 2014). For instance, the annotations based on the MoA Ontology and the ontology's structure can be used to develop algorithms that automate or partially automate the coding of MoAs in published protocols or reports (Hastings, Ceusters, Smith, & Mulligan, 2011; Michie et al., 2020). Through this application, the ontology could expedite the synthesis of evidence about MoAs and interventions, especially when compared to other methods of evidence synthesis, such as manual coding (Michie et al., 2017; Larsen et al., 2017). Similarly, in the future, prediction algorithms could be developed using the MoA Ontology and wider BCIO to hypothesise about 'likely' MoAs for interventions to change specific behaviours (e.g., Ganguly et al., 2021).

9.5   Future maintenance of the MoA Ontology

To ensure that ontologies reflect up-to-date scientific consensus and meet changing user needs, ontologies need to be regularly updated (Arp, Smith, & Spear, 2015; He et al., 2018; OBO Foundry, 2019c). For the MoA Ontology, its users will be able to provide feedback on the ontology through the Github portal, e.g., missing classes or class labels and definitions requiring greater clarity. Accordingly, those applying the MoA Ontology when reporting MoAs, synthesising evidence about MoAs and/or refining theories can provide feedback on improving this ontology. By integrating their feedback into the ontology, this ontology can become a better resource for these applications. Therefore, there will be a mutually beneficial relationship between the MoA Ontology and its applications, contributing to a more shared understanding about MoAs in behaviour change interventions.

9.6 Future research

As researchers unfamiliar with the MoA Ontology applied this ontology with lower inter-rater reliability than those familiar with it (Study 7), better training for new ontology users needs to be developed and then evaluated. The evaluation of such training could have several parts. One part could investigate whether the training supports new users in agreeing on which classes to use for MoAs in reports. To investigate this, pairs of new users could be randomly assigned to different training packages for the MoA Ontology: the training provided in Study 7 (as control) and the newly developed training. After receiving their training, these pairs could use the MoA Ontology to double code the same 50 intervention reports. For each pair, their coding's inter-rater reliability could be assessed. If the pair who received the new training package has higher inter-reliability than the control pair, this would suggest that the new training facilitates better agreement about the ontology's classes.

The second part of the evaluation could investigate whether new ontology users who receive training and an expert user (e.g., an ontology developer) agree on the application of the ontology's classes. To investigate this, two researchers who received the new training and an expert users could use the ontology to each annotate MoAs in 50 intervention reports. Their annotations' inter-rater reliability would not only show whether the training facilitates a shared understanding on applying the ontology's classes, but whether this understanding matches that of an expert user. Finally, to identify aspects of the training package that need improving, a qualitative evaluation could explore new users' experiences in applying the MoA Ontology following the training. Interviews could be conducted with new ontology users at two timepoints, after the training and after they applied the ontology to annotate MoAs in intervention

420

reports. The users could be asked whether there was any unclear or missing information in the training, or whether more support from experienced ontology users was needed during the training. Based on their responses, the training could be improved, e.g., by adding additional guided practice rounds.

Future studies should also investigate to what extend the MoA Ontology serves as a useful and usable resource for synthesising evidence about MoAs compared to other simpler classification systems. For instance, a study could investigate the application of the ontology in terms of its usability in a systematic review, compared to the use of the TDF (Cane et al., 2012; Michie et al., 2005). This study could include behavioural scientists with no prior experience using the ontology or TDF, matched in terms of their educational level and research experience. One group of researchers could apply the ontology to code MoAs in a systematic review, while the other group could apply the TDF for the same systematic review. These classification systems' usability could be investigated in terms of 'knowability' (e.g., understanding and remembering aspects of a system), 'operability' (e.g., the system's completeness and precision), and 'efficiency' (e.g., human effort, time and cost) (Alonso-Ríos, Vázquez-García, Mosqueira-Rey, & Moret-Bonillo, 2009). The 'knowability' dimension could be assessed through self-reported ease of learning and remembering categories in each system. The 'operability' dimension could be explored by independent and blinded researchers reviewing the final coding records based on each classification system, rating the scope and level of detail captured for MoAs in these records. Finally, the 'efficiency' of the classification systems could be evaluated by measuring the time and costs associated with learning and applying each system in the two systematic review processes. Such a comparison

could provide guidance on which classification system to select in future research projects, considering the projects' research questions, timeline and funding.

9.7   Conclusion

By drawing on a strong evidence base about MoAs, intervention designers can select MoAs that are likely to influence their target behaviours (Michie & Abraham, 2004; Hardeman et al., 2005; Nielsen et al., 2018; Sheeran et al., 2017). To develop such an evidence base and better communicate about MoAs, a shared language for MoAs is needed (Noar & Zimmerman, 2005). The MoA Ontology proposed in this thesis can serve as the starting point for such a language. This ontology was developed by drawing on behavioural theories, the reporting of MoAs, other ontologies and domain expert feedback, and therefore extensively captures MoAs in behaviour change interventions. As studies in the thesis applied principles for 'gold standard' ontologies to develop the MoA Ontology (OBO Foundry, 2019i; Wright et al., 2020), this ontology includes classes with clear labels and definitions and logical relationships. Based on the feedback of its users, the MoA Ontology can be refined to become increasingly useful and acceptable to its users. Moreover, as part of the wider BCIO (Michie et al., 2017, 2021), the MoA Ontology can be used to synthesise detailed evidence about how behaviour change interventions work through MoAs for specific behaviours across different contexts. This has the potential to improve our understanding of 'why' behaviour change interventions work and how we can develop more effective ones moving forward (Michie et al., 2017).

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Appendix

Appendix 2-1. Number of researcher-initiated discussion threads and comments in these threads for BCT-MoA links

BCT label	MoA label	No. of discussion threads	Presented to expert group	Total no. of comments in discussion threads	Avg. comments per discussion thread
Instruction on How to Perform the Behaviour	Intention	6*	All groups (Group B x2)	70	11.7
Social Support (Unspecified)	Attitudes towards the Behaviour	5	All groups	41	8.2
Social Support (Unspecified)	Values	2	Group B & Group D	31	15.5
Instruction on How to Perform the Behaviour	Self-image	2	Group D & Group E	25	12.5
Social Support (Unspecified)	General Attitudes and Beliefs	2	Group D & Group E	15	7.5
Social Comparison	Intention	1	Group C	23	23
Body Changes	Emotion	1	Group C	22	22
Behavioural Contract	Self-image	1	Group A	21	21
Instruction on How to Perform the Behaviour	Feedback Processes	1	Group C	21	21
Behavioural Practice/Rehearsal	Feedback Processes	1	Group C	19	19
Self-monitoring of Behaviour	Goals	1	Group A	19	19
Social Comparison	Beliefs about Capabilities	1	Group C	19	19
Social Support (Unspecified)	Emotion	1	Group B	19	19
Graded Tasks	Behavioural Regulation	1	Group C	18	18
Information about the Health Consequences	Goals	1	Group B	18	18
Pros and Cons	Memory, Attention, Decision Processes	1	Group C	18	18
Social Comparison	Emotion	1	Group C	18	18
Social Comparison	Goals	1	Group C	18	18
Conserving Mental Resources	Knowledge	1	Group E	17	17
Social Reward	Environmental Context/Resources	1	Group E	17	17
Social Support (Practical)	Motivation	1	Group C	17	17
Commitment	Behavioural Cueing	1	Group D	16	16
Pharmacological Support	Intention	1	Group B	16	16
Restructuring the Social Environment	Motivation	1	Group D	16	16
Self-talk	Self-image	1	Group B	15	15
Social Support (Unspecified)	Social Learning/Imitation	1	Group C	16	16
Behavioural Contract	Values	1	Group A	15	15

451

BCT label	MoA label	No. of discussion threads	Presented to expert group	Total no. of comments in discussion threads	Avg. comments per discussion thread
Comparative Imagining of Future Outcomes	Values	1	Group E	15	15
Feedback on Outcomes of Behaviour	Optimism	1	Group A	15	15
Framing/Reframing	Intention	1	Group C	15	15
Monitoring of Behaviour by Others Without Feedback	Intention	1	Group D	15	15
Monitoring Outcomes of Behaviour without Feedback	Knowledge	1	Group E	15	15
Reduce Negative Emotions	Self-image	1	Group C	15	15
Social Support (Emotional)	Social Learning/Imitation	1	Group D	15	15
Social Support (Unspecified)	Intention	1	Group E	15	15
Avoidance/Reduce Exposure to Cues	Intention	1	Group B	14	14
Goal Setting (Outcome)	Beliefs about Consequences	1	Group D	14	14
Instruction on How to Perform the Behaviour	Attitudes towards the Behaviour	1	Group D	14	14
Material Rewards (Behaviour)	Goals	1	Group B	14	14
Non-Specific Reward	Behavioural Cueing	1	Group B	14	14
Body Changes	Knowledge	1	Group C	13	13
Habit Formation	Memory, Attention, Decision Processes	1	Group A	13	13
Information about Other's Approval	Goals	1	Group D	13	13
Information about Social and Environmental Consequences	Self-image	1	Group E	13	13
Reward (Outcome)	Beliefs about Capabilities	1	Group E	13	13
Action Planning	Motivation	1	Group B	12	12
Biofeedback	Reinforcement	1	Group D	12	12
Pharmacological Support	Beliefs about Capabilities	1	Group B	12	12
Restructuring the Social Environment	Social/Professional Role/Identity	1	Group A	12	12
Behavioural Practice/Rehearsal	Behavioural Regulation	1	Group C	11	11
Feedback on Behaviour	Beliefs about Consequences	1	Group D	11	11
Goal Setting (Outcome)	Feedback Processes	1	Group E	11	11
Identification as Role Model	Emotion	1	Group A	11	11
Incentive (Outcome)	Beliefs about Capabilities	1	Group E	11	11

BCT label	MoA label	No. of discussion threads	Presented to expert group	Total no. of comments in discussion threads	Avg. comments per discussion thread
Material Rewards (Behaviour)	Emotion	1	Group B	11	11
Self-monitoring of Outcomes of Behaviour	Self-image	1	Group C	11	11
Social Support (Unspecified)	Beliefs about Capabilities	1	Group A	11	11
Verbal Persuasion about Capability	Behavioural Regulation	1	Group E	11	11
Adding Objects to the Environment	Needs	1	Group C	10	10
Biofeedback	Behavioural Cueing	1	Group D	10	10
Commitment	Social/Professional Role/Identity	1	Group D	10	10
Information about Antecedents	Reinforcement	1	Group E	10	10
Information about Other's Approval	Social Learning/Imitation	1	Group D	10	10
Information about Social and Environmental Consequences	Feedback Processes	1	Group E	10	10
Material Incentive	Behavioural Regulation	1	Group D	10	10
Pros and Cons	Optimism	1	Group C	10	10
Pros and Cons	Self-image	1	Group C	10	10
Social Comparison	Self-image	1	Group C	10	10
Social Support (Unspecified)	Self-image	1	Group B	10	10
Vicarious Consequences	Intention	1	Group A	10	10
Comparative Imagining of Future Outcomes	Attitudes towards the Behaviour	1	Group E	9	9
Credible Source	Emotion	1	Group D	9	9
Demonstration of the Behaviour	Feedback Processes	1	Group B	9	9
Demonstration of the Behaviour	Social/Professional Role/Identity	1	Group B	9	9
Feedback on Outcomes of Behaviour	Knowledge	1	Group A	9	9
Goal Setting (Behaviour)	Emotion	1	Group A	9	9
Information about the Health Consequences	Memory, Attention, Decision Processes	1	Group B	9	9
Monitoring of Behaviour by Others Without Feedback	Memory, Attention, Decision Processes	1	Group D	9	9
Pharmacological Support	Emotion	1	Group B	9	9
Review Outcome Goals	Optimism	1	Group B	9	9
Social Support (Emotional)	Values	1	Group D	9	9
Habit Reversal	Subjective Norms	1	Group D	8	8
Monitoring of Emotional Consequences	Values	1	Group A	8	8

BCT label	MoA label	No. of discussion threads	Presented to expert group	Total no. of comments in discussion threads	Avg. comments per discussion thread
Monitoring Outcomes of Behaviour without Feedback	Beliefs about Capabilities	1	Group E	8	8
Problem Solving	Emotion	1	Group E	8	8
Behavioural Contract	Social Influences	1	Group A	7	7
Demonstration of the Behaviour	Norms	1	Group B	7	7
Feedback on Behaviour	Self-image	1	Group D	7	7
Goal Setting (Outcome)	Attitudes towards the Behaviour	1	Group E	7	7
Information about Social and Environmental Consequences	General Attitudes and Beliefs	1	Group E	7	7
Monitoring of Emotional Consequences	Optimism	1	Group A	6	6
Restructuring the Social Environment	Emotion	1	Group A	6	6
Social Support (Unspecified)	Behavioural Cueing	1	Group A	6	6
Behaviour Substitution	Motivation	1	Group B	5	5
Information about Emotional Consequences	General Attitudes and Beliefs	1	Group A	5	5
Information about Emotional Consequences	Optimism	1	Group A	5	5
Salience of Consequences	Memory, Attention, Decision Processes	1	Group A	5	5
Self-monitoring of Behaviour	Reinforcement	1	Group A	5	5

Notes. * Five of the six discussion threads about link between 'Instruction on How to Perform the Behaviour (BCT)' and 'Intention (MoA)' were shown to all groups as the link with the overall highest disagreement across groups. The sixth discussion was presented to one group, in which this link came up as having been rated as highly uncertain.

Appendix 2-2. The themes and number of comments for expert-initiated discussion threads

Discussion thread no.	Themes	Group initiating discussion	Sum of no. comments in discussion threads	Included in analysis
1	Insufficient focus in the study on behaviour	Group A	6	Yes
2	Request to include BCT descriptions in the task	Group B	2	No
3	Concerns about evaluating BCTs insolation from their context	Group B	1	Yes
4	Concerns about assumption made to decide whether a MoA is relevant to a BCT	Group B	5	Yes
5	General reflections/concerns about task	Group C	10	Yes
6	Reflection Delphi method	Group C	5	No
7	Issues with Emotion as a MoA	Group E	6	Yes
8	Clarity of labels and definitions of MoA	Group E	19	Yes

Appendix 2-3. The discussion threads coded by two researchers to pilot and refine the coding framework

Discussion thread no.	Expert group	Type of discussion	BCT label	MoA label	Theme (initiated by experts)
1	Group A	Disagreement	Behavioural Contract	Values	
2	Group A	Disagreement	Feedback on Outcomes of Behaviour	Optimism	
3	Group A	Disagreement	Instruction on How to Perform the Behaviour	Intention	
4	Group A	Uncertainty	Information about Emotional Consequences	Optimism	
5	Group B	Disagreement	Demonstration of the Behaviour	Feedback Processes	
6	Group B	Disagreement	Social Support (Unspecified)	Emotions	
7	Group B	Uncertainty	Review Outcome Goals	Optimism	
8	Group B	Expert-initiated			Unseen affects in a business environment
9	Group C	Disagreement	Instruction on How to Perform the Behaviour	Feedback Processes	
10	Group C	Uncertainty	Behavioural Practice-Rehearsal	Behavioural Regulation	
11	Group C	Uncertainty	Body Changes	Knowledge	
12	Group C	Uncertainty	Social Support (Unspecified)	Attitude Towards the Behaviour	
13	Group D	Disagreement	Social Support (Unspecified)	Values	
14	Group D	Uncertainty	Instruction on how to Perform the Behaviour	Self-Image	
15	Group D	Uncertainty	Material Incentive	Behavioural Regulation	
16	Group D	Uncertainty	Social Support (Emotional)	Values	
17	Group E	Disagreement	Goal Setting (Outcome)	Feedback Processes	
18	Group E	Disagreement	Social Reward	Environmental Context-Resources	
19	Group E	Uncertainty	Comparative Imagining of Future Outcomes	Attitudes Towards the Behaviour	
20	Group E	Uncertainty	Information about the Social and Environmental Consequences	General Attitudes and Beliefs	

Appendix 3-1. MoA Identification Guidance from TaT Project

Mechanisms of action are constructs that represented the processes through which a behaviour change techniques might have its effect. Mechanisms of actions included:

1. States (momentary conditions such as fear, hunger or equilibrium),

2. Traits (stable conditions or disposition such as cognitive ability, skill or identity),

3. Stages (relatively stable conditions such as preparedness to change), and

4. Processes (sequences of events transforming, or preventing transformation, of states, stages or traits such as habituation or associative learning),

5. Some behaviours (e.g., avoidance function) and

6. Anything in the social and physical environment that was proposed to be able to be influenced and to influence the target behaviour (e.g., social norms).

Constructs were excluded as mechanisms of action if the construct definition was:

1. Overly broad (e.g., Personal and Cognitive Factors),

2. The outcome of a theory (e.g., a health consequence), unless specifically proposed to lead to a change in behaviour,

3. A demographic factor (e.g., Hollingshead Index),

4. A non-modifiable historical factor (e.g., prior experience),

5. Part of an intervention itself (e.g., Feedback on Behaviour), or

6. An effect modifier only (e.g., law/policy factors).

Appendix 3-2. Additional practical guidance to identify MoAs

1. Variables and values/measurements

1.1 As outlined in the Mechanism of Action (MoA) Identification Guidance, MoAs are changes in processes or variables. However, many theories do not specify MoAs a change in a process or variable. To judge whether a theoretical construct (e.g., self-efficacy) qualifies as an MoA, conceptualise the theoretical construct as referring to 'changes in' that variable (e.g., changes in 'self-efficacy').

1.2 Theory authors sometimes define an MoA as the value or measurement of that MoA. To judge whether a theoretical construct that is defined as a value/measurement actually refer to an MoA, consider the construct label and description in the reference book (Michie et al., 2014).

1.2.1 If an MoA is only captured by a construct defining its value/measurement, this construct should be judged to be MoAs (e.g., 'self-esteem' in the Pressure System Model).

2. MoAs related to physical and social environment

2.1 Theoretical constructs should be judged as MoAs, when they are defined as:

2.1.1 'Explicit interactions of the individual with the physical or social environment'

2.1.2 'Behaviours or dispositions of a group that affect behaviour' (e.g., 'injunctive norms' in the Social Norms Theory, or 'social norms' in the Social Consensus Model of Health Education)

2.1.3 'Exposure to a physical or social environment that explicitly guides behaviour or specifies means by which it guides behaviour' (e.g., 'cues' in the Self-Regulation Theory, affordance of the environment).

2.1.3.1 The means for guiding behaviour can be specified in the definition or label of the theoretical construct.

2.1.3.2 Examples of wording used to describe relationship between mechanism and behaviour: 'afford/allow', 'cue/guide'.

2.2 When constructs are simply defined as aspects of the environment that may or may not detected by the individual, they should not be judged to be MoAs (e.g., 'stimuli' in the PRIME Theory).

2.3 Some theories intended to define a 'perceived environment' (e.g., 'parent support' in the Problem Behaviour Theory is grouped under 'perceived environment'), but do not specify this in the theoretical constructs' definition or label. When there is evidence in the theory (based on the label, definition or grouping), these theoretical constructs should be judged to be MoAs.

3. Behavioural MoAs

3.1 When theories specify target behaviours, the other behavioural constructs in the theory can be 'preparatory behaviours' (e.g., drug abuse leading to risk behaviours) and thereby MoAs.

3.2 When theories do not specify clear target behaviours, it might be more difficult to identify whether a behaviour is an MoA or an outcome behaviour. When theoretical constructs only specify 'behaviour' without explaining whether or how these behaviours affect a target behaviour, these theoretical constructs should be judged as 'Not MoA', unless further information is found in the reference book (Michie et al., 2014) or original theory chapter/paper.

4.   Stage-related constructs

4.1 Theories use the word 'stages' to describe different types of constructs. These included: (1) processes that occur during specific time-points, (2) aggregates of processes and (3) the 'stages of change' of underlying variables (e.g., readiness to change, progress in behaviour change).

4.2 Theoretical constructs labelled and/or defined as stages should be judged as MoAs or compound MoAs, when they are defined as processes that occur during specific time-points (e.g., 'motivational phase' from Health Action Process Approach).

4.3 Theoretical constructs labelled and/or defined as stages should also be judged as MoAs or compound MoA, when they refer to aggregates of processes (e.g., 'stages of self-regulation processes' in the Self-Regulation Theory).

4.4 Theoretical constructs labelled and/or defined as stages of an underlying variable (e.g., readiness to change or behaviour change) in stage theories, such as the Transtheoretical Model of Behaviour Change, should be judged on a case-to-case basis.

4.4.1 Theoretical constructs labelled and/or defined as stages should be judged as MoAs, when the stages refer to a state of readiness to change OR stability of a change that has occurred. These constructs refer to the 'stages of change' variable itself.

4.4.2 As target behaviours are excluded from being MoAs, 'stage of change' constructs that include the target behaviour as a value (e.g., 'action stage') should not be judged as MoAs.

4.4.3 When the 'stage of change' involved behavioural readiness/change, they will not be judged as MoAs.

4.4.4 Theoretical constructs, such as pre-contemplative or contemplative stage, are values of the 'stage of change' variable. Therefore, these theoretical constructs should be judged as 'Not MoA.'

5. Stable traits and personality-related constructs

5.1 Theoretical constructs that refer to one of the 'Big Five' personality traits or are explicitly defined as unchangeable as 'Not MoA'. Unless otherwise specified, stable constructs should be judged as MoAs, since these can be manifested.

Appendix 3-3. Krippendorff's alpha of researchers' judgments on whether theoretical constructs qualify as MoAs

Sessions	Constructs	Krippendorff's alpha	LL95%*	UL95%*
1-2	1-20	0.432	-0.023	0.773
3-5	21-50	0.460	0.160	0.760
6	51-75	0.557	0.262	0.852
7	76-100	0.089	-0.236	0.414
8	100-125	0.385	0.043	0.727
9	125-150	0.299	-0.052	0.650
10	151-175	0.492	0.129	0.782
11	176-200	0.421	-0.007	0.752
12	201-225	0.638	0.396	0.879
13	226-250	0.201	-0.107	0.508
14	251-275	0.596	0.327	0.865
15	276-300	0.835	0.587	1.00
16	301-325	0.485	0.163	0.742
17	326-350	0.654	0.378	0.931
18	351-375	0.566	0.276	0.855
19	376-400	0.480	0.108	0.777
20	401-425	0.369	0.054	0.685
21	426-450	0.579	0.299	0.860
22	451-475	0.495	0.179	0.747
23	476-500	0.471	0.093	0.773
24	501-525	0.559	0.243	0.811
25	526-550	0.439	0.089	0.720
26	551-575	0.714	0.427	0.928
27	576-600	0.493	0.132	0.783
28	601-625	0.769	0.462	1.00
29	626-650	0.854	0.636	1.00
30	651-675	0.490	0.126	0.782
31	676-700	0.538	0.230	0.846
32	701-725	0.566	0.276	0.855
33	726-750	0.651	0.371	0.930
34	751-775	0.564	0.253	0.813
35	776-800	0.637	0.347	0.927
36	801-825	0.356	0.034	0.678
37	826-850	0.685	0.371	0.921

Sessions	Constructs	Krippendorff's alpha	LL95%*	UL95%*
38	851-875	0.853	0.633	1.00
39	876-900	0.472	0.143	0.736
40	901-925	0.839	0.596	1.00
41	926-950	0.703	0.405	0.926
42	951-975	0.376	0.030	0.723
43	976-1000	0.843	0.607	1.00
44	1001-1025	0.656	0.381	0.931
45	1026-1050	0.927	0.782	1.00
46	1051-1075	0.791	0.582	1.00
47	1076-1100	0.692	0.385	0.923
48	1101-1125	0.530	0.154	0.906
49	1126-1150	0.637	0.347	0.927
50	1151-1175	0.656	0.382	0.931
51	1176-1200	0.539	0.210	0.802
52	1201-1225	0.402	0.029	0.701
53	1226-1250	0.586	0.255	0.917
54	1251-1275	0.715	0.430	0.929
55	1276-1300	0.755	0.509	1.00
56	1301-1325	0.493	0.176	0.746
57	1326-1350	0.787	0.575	1.00
58	1351-1375	0.622	0.319	0.924
59	1376-1400	0.662	0.392	0.932
60	1401-1425	0.844	0.611	1.00
61	1426-1450	0.781	0.562	1.00
62	1451-1475	0.465*	0.130	0.732
63	1476-1500	0.790	0.475	1.00
64	1501-1525	0.716	0.433	0.929
65	1526-1550	0.554	0.256	0.851
66	1551-1575	0.573	0.289	0.858
67	1576-1600	0.861	0.652	1.00
68	1601-1625	0.707	0.413	0.927
69	1626-1650	0.763	0.448	1.00
70	1651-1675	0.680	0.361	0.920
71	1676-1700	0.724	0.447	0.931
72	1701-1733	0.510	0.237	0.782

Notes. *LL95% and UL%95 are the confidence intervals of the Krippendorf values, based on 10,000 bootstrap samples

Appendix 3-4. Cross-tabulation of judgements on theoretical constructs from the current study and the Theories and Techniques Project

		Current Study			
		MoA	Compound MoA	Not MoA	Total
TaT Project	MoA	866	111	260	1237
	Not MoA	45	32	409	496
	Total	911	143	669	1723

Appendix 3-5. The labels and definitions of MoAs judged to qualify as compound MoAs, and the theories they were extracted from

No.	Theory	Label	Definition
1	Social Action Theory (Ewart)	Mood/Arousal (Action Context)	State of mood or arousal present within oneself when the action takes place
2	I-Change Model	Social influence	Others' perception of the behaviour, observation of others carrying out the behaviour and the pressures or support from others to execute the behaviour
3	Model of Pro-Environmental Behavior	Value System	The moral, social, aesthetic, economic and religious concepts accepted either explicitly or implicitly by an individual or a particular society
4	Social Consensus Model of Health Education	Individual Knowledge	The information, understanding and skills of the individual
5	Problem Behaviour Theory	Personality proneness	A dynamic state that specifies the likelihood of occurrence of the problem behaviour from within the personality system; consists of lower value on academic achievement, higher value on independence, lower expectations of attaining both goals, greater social criticism, greater alienation, lower self-esteem, more external control, greater tolerance of deviance, less religiosity and greater positive vs. negative functions discrepancy.
6	Motivation-Opportunities-Abilities	Ability	Competence, capacity and other personal resources influencing how easy or difficult it is for the person to perform the behaviour, including habits, task knowledge, time and money
7	Needs-Opportunity-Abilities Model	Physical (ability)	The necessary health and fitness capability required to engage in the behaviour and the necessary license and permits to do so
8	Self-Regulation Theory	Stage of the self-regulation process	A set of distinct stages that characterise the processes by which people regulate or control their behaviour
9	Problem Behaviour Theory	Perceived environment	A subjective assessment of the external forces that influence an individual
10	Problem behaviour theory	Proximal structure (problem behaviour theory)	Component within the perceived environment system where variables characterise the social context in terms of the prevalence of models and support or approval for the problem behaviour
11	Health behaviour internalisation model	Behaviour-related need	A set of motivational variables related to a specific health behaviour that influences the internalisation process
12	Health Promotion Model	Interpersonal influence	Perception of the beliefs, attitudes and behaviours of others in relation to a behaviour
13	Goal directed theory	Motivational Process	Process relating to the impetus that gives purpose or direction to behaviour and operates at a conscious or unconscious level
14	Containment theory	Inner Containment	Factors involved in the regulation of the self such as self-control, self concept, the ability to tolerate frustration and resist diversions, etc.
15	CEOS Theory	Self-regulation	A set of processes by which one regulates or controls actions
16	Social Ecological Model of Behaviour Change	Social ecology	The social and physical settings contextualising behaviour as well as the interplay between human actors and external factors shaping their agency
17	CEOS Theory	Script	The complex set of strategies, commitments and evaluations that sum to progress action towards a goal; includes decisions to abandon or suspend action

18	Norm Activation Theory	Perception of need and responsibility	The first stage of developing altruistic behaviours; includes four sub-stages: awareness of need, perception that need can be relieved by action, recognition of own ability to provide relief, arousal of some sense of responsibility to respond
19	Theory of Triadic Influence	Attitudinal Influence	Health-related evaluation that originate in one's broader cultural environment and contribute to health-related decisions
20	COM-B	Reflective Motivation	Aspects of motivation that involve self-conscious mental propositional representations (evaluations and plans)
21	Self-Determination Theory	Motivation	The impetus that energises and directs people's actions, moving them to behave
22	Protection Motivation Theory	Threat appraisal	The overall evaluation of the rewards, severity of the threat and susceptibility to the threat
23	Reflective Impulsive Model	Reflective system	A system of information processing that involves reasoning and decision-making on the basis of propositional knowledge
24	PRIME Theory	Feeling	Sensation, emotion and/or drive state
25	CEOS Theory	Belief	Conceptualisation of aspects of the world, including both external and internal determinants
26	Health Action Process Approach (Reformulation)	Motivational phase	The stage of decision-making during which people form intentions to change their behaviour or to adopt a new behaviour
27	COM-B	Motivation	The brain processes that energise and direct behaviour
28	Integrated Theory of Drinking Behaviour	Perception and cognition	Thought and feeling about alcohol (e.g. anticipation around the positive and reinforcing effects, understanding of alcohol consumption in terms of its socially shared meanings)
29	Technology Acceptance Model	Adjustment (technology acceptance model)	Alteration in judgements following hands-on experience with the new system
30	Regulatory Fit Theory	Motivation	The impetus that gives purpose or direction to behaviour and operates at a conscious or unconscious level.
31	Self-Efficacy Theory	Capability	One's psychological and physical capacity to engage in the activity concerned
32	Ecological Model for Preventing Type 2 Diabetes	Cognitive factors	Range of intrapersonal determinants of behaviour; includes outcome expectations, self-efficacy, incentive, perceived susceptibility and severity and perceived benefits and costs
33	Integrated Theoretical Model for Alcohol and Other Drug Abuse Prevention	Efficacy Expectation	Expectation relating to self-efficacy and perceived outcome
34	Feedback Intervention Theory	Meta-task process	Feedback process relating to goals regarding the self (i.e. higher-level goal about the type of person someone wants to be), positioned at the higher end of a hierarchy of negative feedback loops
35	Social Development Model	Social Bonding	Process of bonding (attachment and commitment to, and belief in) with conventional society that prevents delinquent behaviour
36	Regulatory Fit Theory	Goal means	The methods used by an individual to achieve a goal
37	Information-Motivation-Behavioural Skills	Consistent AIDS prevention	The ability to routinely engage in protective behaviours against a disease
38	Goal directed theory	Commitment to role identities	An agreement or pledge to act in line with one's self-image, or the state or instance of being obligated or emotionally impelled to act in line with one's self-image
39	Action Theory Model of Consumption	Feedback	Information provided to a person or group regarding behaviour or performance (relating to goal attainment or failure; e.g. in the form of satisfaction/dissatisfaction)

40	Relapse Prevention Model	Abstinence violation effect	The negative cognitive and affective responses (i.e. guilt, shame) experienced by an individual after a return to substance use following a period of self-imposed abstinence
41	Information-Motivation-Behavioural Skills	Behavioural Skill	Objective and perceived ability or proficiency acquired through training and practice; the mechanism through which information and motivation exert an influence on behaviour
42	CEOS Theory	Belief and value	Moral, social, or aesthetic principle accepted by an individual or society as a guide to what is good, desirable or important
43	Theory of Triadic Influence	Social normative belief	Perception of what is normal and socially acceptable, together with one's inclination to comply with such perceptions
44	CEOS Theory	Feeling	Self-contained phenomenal experience attributed to internal states
45	Needs-Opportunity-Abilities Model	Motivation	The impetus that gives purpose or direction to behaviour and operates at a conscious or unconscious level; arises from needs and opportunities
46	Health Behaviour Goal Model	Action Control Process	Process that guides individuals through stages of progress towards the target behavioural state by controlling behavioural, cognitive or emotional obstacles to progression
47	Problem Behaviour Theory	Perceived environment system	System of psychological and social influences that comprise environmental characteristics (supports, influence, controls, models and expectations of others) that are capable of being cognised or perceived
48	Change Theory	Restraining force	Force that prevents change in the desired direction
49	Social Cognitive Theory	Environment	The set of external agent or condition (physical, biological, social and cultural) that influence the functions of an organism
50	Differential Association Theory	Need and value	A condition of tension resulting in deprivation of something required for survival, well-being or personal fulfillment (needs) and moral, social or aesthetic principles accepted as a guide to what is good, desirable or important (values)
51	Reflective Impulsive Model	Motivational Orientation	The mutual influence of changes in the distance (approach vs. avoidance) and valence (positive vs. negative) of mental representations
52	Social influence model of consumer participation	Value perception or motive (Individual level variables)	Individual reason for participating in the behaviour
53	CEOS Theory	Internal resource	Means by which a behaviour is facilitated or enabled from within the individual (i.e. what one can do independent of external resources)
54	Self-Determination Theory	Intrapersonal event	Initiating or regulating event that occurs within the individual, such as threats of guilt or self-administered feedback
55	PRIME Theory	Trait	Enduring disposition
56	Social Cognitive Theory	Basic Capabilities	The fundamental abilities by which human nature/functioning is defined in order to explain behaviour, thought and motivation
57	Social Consensus Model of Health Education	Social knowledge	The facts, information and skills that exist within social environments
58	Health Action Process Approach (Reformulation)	Volitional phase	The stage during which behavioural intentions are translated into actual behaviour
59	I-Change Model	Awareness factors	Factors that relate to awareness and recognition of a health risk (e.g. cognizance, knowledge, risk perceptions and cues to action)

60	Theory of Interpersonal Behaviour	Cue associated with the behaviour	Stimulus that serves to guide any behaviour, including special cases such as cognitive representations of the behaviour, or intentions
61	Social influence model of consumer participation	Social influence variables (group level variables)	Factors relating to the community and its members that influence behaviour (e.g. social identity and group norms)
62	Health Action Process Approach	Situational Barrier	Actual or perceived environmental factor that prevents performance of an intended behaviour
63	CEOS Theory	Physical and mental capacities	The physical and mental abilities of an individual to perform behaviours
64	Needs-Opportunity-Abilities Model	Behavioural Control	The extent to which one has control over one's behaviour
65	Model of Pro-Environmental Behavior	Environmental consciousness	A complex that is made up of environmental knowledge, values, and attitudes, together with emotional involvement
66	Systems Model of Health Behaviour Change	Behavioural repertoire	The sum total of potential behaviour or responses that one is capable of performing
67	CEOS Theory	Experienced need/desire	The condition of tension resulting in deprivation of something required for survival, well-being or personal fulfilment (needs) / strong feeling of wanting to have something or wishing for something to happen, as experienced by the person (desire)
68	CEOS Theory	Feedback	The process whereby behaviour sustains, amplifies or modifies the likelihood of subsequent behaviour
69	CEOS Theory	Operational process	Bottom up relational process that occurs without the need for, but is potentially influenced by, executive processes
70	Theory of Triadic Influence	Social influence	The way in which the attitudes, values and behaviours of others, with whom one shares a close social bond, influence one's health-related behaviour
71	Health Promotion Model	Behaviour-specific cognition and affect	Type of cognition and/or emotion that is specific to a particular behaviour
72	Integrated Theoretical Model for Alcohol and Other Drug Abuse Prevention	Environmental pressure	Pressure from the environment that will make behaviour change difficult (e.g. pro-drug role models and peer pressure)
73	CEOS Theory	Cue/Stimulus	Cue to perform a behaviour, arising from either the external environment, the performance of another behaviour, or from ideas appearing in consciousness
74	Pressure System Model	Resistance	An opposing force of motivation that acts to defy or withstand change; characterized by one's capability to change, locus of control and fixed impediments to change
75	Diffusion of Innovations	Uncertainty	The state or condition in which the potential consequences of a behaviour are unknown; a lack of clarity or confidence in one's ideas, decisions or intentions associated with a particular behaviour.
76	CEOS Theory	Change Mechanism	Natural or acquired process by which change is facilitated
77	Information-Motivation-Behavioural Skills Model of Adherence Behaviour	Behavioural Skill	Objective ability as well as perceived self-efficacy concerning the performance of the complex sequence of behaviours that are involved in adhering to HAART.
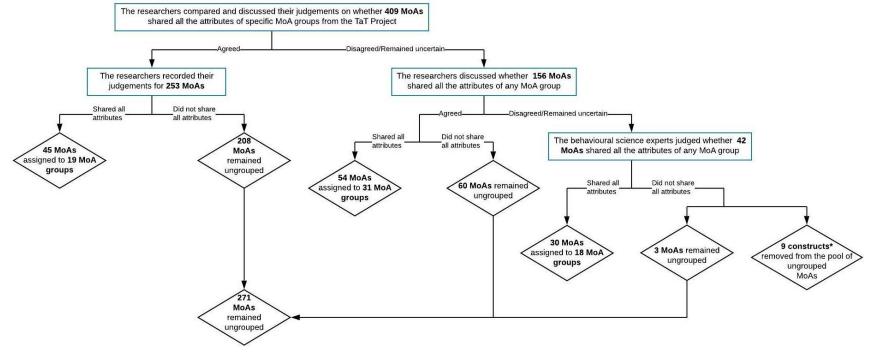
78	Transtheoretical Model of Behaviour Change	Consciousness Raising	The process of increasing awareness about the problem and improving the accuracy of information processing about the problem and about the self
79	CEOS Theory	Executive processes	Activities of the Executive System; conceptually-based and top-down
80	Problem Behaviour Theory	Instigation	Any circumstance that instigates the problem behaviour
81	Action Theory Model of Consumption	Belief and evaluation	Belief about and evaluation of the characteristics of a product or service, or of the consequences of engaging in a behaviour
82	CEOS Theory	Internal state	One's internal condition or status
83	Needs-Opportunity-Abilities Model	Ability	The internal capacity needed to engage in the behaviour; can refer to either people or households
84	Relapse Prevention Model	Negative emotional state	Negative feeling that can lead to a high risk of engaging in the problem behaviour (e.g. anger, anxiety or depression)
85	PRIME Theory	Drive State	A drive involves a motivational tension that is reduced by 'consummatory behaviour'
86	Social Ecological Model of Behaviour Change	Normative Belief and Motivation to comply	Belief about what important others think one should do, and one's willingness to exert physical or mental effort in order to act in accordance with those wishes
87	Goal setting theory	Task-relevant knowledge and strategy	Knowledge/ skill /strategy relevant to one's engagement in a specific task (i.e. that will aid goal achievement)
88	Containment theory	Outer containment	Aspects of the social world that are able to hold people within certain boundaries, such as a constant moral presence or the reinforcement of norms
89	Social Ecological Model of Behaviour Change	Constraint on agency	The physical, social, economic and/or time constraint limiting human capacity to act
90	Social Ecological Model of Behaviour Change	Ability	Competence or capacity to modify behaviour
91	Extended Parallel Processing Model	Perceived efficacy	Evaluation of the efficacy of a recommended threat-protective response, based on a combination of both perceptions of one's ability to implement that response and perceptions of the likelihood that enacting the response would successfully avert the threat
92	CEOS Theory	Operational input to executive processes	What is put in, taken in or operated on from the Operational System to Executive processes
93	Health Behaviour Goal Model	Regulatory Process	Interacting mechanism that act to maintain a stable state in a person
94	Health Behaviour Internalisation Model	Internalisation and self-regulation of new health behaviour	The process by which external attitudes, beliefs or other factors that exist in the social environment, and that are involved in regulating one's behaviour, are transformed into one's personal values or goals that are regulated by the self
95	Behavioural ecological Model of Adolescent AIDS Prevention	Family influence	The influence of one's family on behaviour
96	Social Cognitive Theory	Personal and cognitive factors	Factors relating to the individual and to forms of knowing and awareness

97	Norm Activation Theory	Assessment & Evaluation of Responses	Assessment of the outcomes of all possible response actions (including not acting) and evaluation of these outcomes in terms of potential costs and benefits
98	Action Theory Model of Consumption	Subjective Norm	The belief that significant others believe one should buy a particular product or not, includes perceived normative beliefs of others and one's felt need to comply with the expectations of others
99	PRIME Theory	Targeted emotion	An emotion attaching to a particular target object, event, situation, or characteristic
100	Integrated Theory of Health Behaviour Change	Self-Regulation	The process through which behaviour change is incorporated into one's everyday life.
101	Risk as Feelings Theory	Feeling	Affective state that includes emotions, drives and desires
102	Temporal Self-Regulation Theory	Motivational Sphere	The range of influences on intentional behaviour that relate to motivation
103	Systems Model of Health Behaviour Change	Personal health dynamic	Behaviour change process that involves the biological, physiological, and chemical processes related to health and disease
104	Problem Behaviour Theory	Support	The extent to which a person's parents and peers disapprove of or condone problem behaviour
105	Pressure System Model	Fixed impediment to change	Barrier that cannot be changed, that makes behaviour change difficult
106	Control Theory	Negative Feedback Loop	The entire set of processes involving input, standard, comparison, and output that together serve to bring sensed conditions into conformity with the standard
107	Problem Behaviour Theory	Personal control structure	Control structure within the personality system that is more proximal to the problem behaviour
108	Information-Motivation-Behavioural Skills	Group-specific skill	Prevention relevant skill that is pertinent only to certain groups of people (E.g. substance abuse status, gender, ethnicity)
109	Containment theory	Inner push	Internal factor that pushes someone towards a behaviour
110	CEOS Theory	Input	What is put in, taken in, or operated on by any process or system
111	Health Behaviour Goal Model	Feedforward mechanism	Information or control signal sent to a part of the body or other system in order to prepare it for future activity, guided by self-perceptions of one's ability to carry out the action and one's expectations regarding the possible consequences of the action
112	Pressure System Model	Motivation	The desire to change, defined by a person's beliefs about importance, beliefs about personal risk, and beliefs about the efficacy of change
113	COM-B	Capability	The individual's psychological and physical capacity to engage in the activity concerned
114	Theory of Interpersonal Behaviour	Social factor	The norm, role and/or general behavioural intention that derive from the relationship between an individual and other people
115	Prototype Willingness Model	Reasoned path	A decision making path that involves analytic processing
116	CEOS Theory	Intellectual/conceptual environment	How environmental conditions are conceptualised, including perceptions of norms and societal values
117	Integrated Theoretical Model for Alcohol and Other Drug Abuse Prevention	Intrapersonal factor	A factor that operates within oneself, including perceived severity, perceived susceptibility and behavioural options

118	Systems Model of Health Behaviour Change	Attitudinal variable	A factor that contains a value/emotional component, as well as a cognitive component
119	Social Action Theory (Ewart)	Capability	One's psychological and/or physical capacity to engage in the activity concerned
120	Containment theory	Resistance to deviancy	The degree to which one can act in opposition to, defy or withstand factors that promote deviancy
121	Ecological Model for Preventing Type 2 Diabetes	Social/interpersonal influence	The influence of others on one's behaviour (e.g. influence of family or peers)
122	Social Action Theory (Ewart)	Change Mechanism	A social-cognitive process (e.g. goal, expectation, strategy and capability) that determines the generation of desired action-outcome feedback loops
123	Problem Behaviour Theory	Personality	A set of enduring characteristics of individuals relating to their propensity to think in particular ways, experience emotions and motivational states and to exhibit behaviour patterns
124	Containment theory	Regulation of normative behaviour	A control process leading to maintentance of socially accepted behaviours
125	Feedback Intervention Theory	Strategy for eliminating the feedback-standard gap	A cognitive strategy employed to eliminate a perceived discrepancy between one's current behaviour and a standard that one is attempting to reach, regardless if the outcome falls above or below that standard
126	Self-Regulation Theory	Automatic processing	A mode of cognitive processing that does not require attention, can be carried out in parallel with other activities and is well established and difficult to change
127	Problem Behaviour Theory	Psychosocial proneness	A dynamic state that specifies the likelihood of occurrence of the problem behaviour from within the personality system; comprised of one's behavioural proneness, environmental proneness, and personality proneness
128	PRIME Theory	Habit	Process through which impulses are generated as a result of past associative learning
129	Problem Behaviour Theory	Distal structure	Component within the perceived environment system where variables serve mainly to characterise whether the social context in which an adolescent is located is more parent-and family-oriented or more friends- and peer-oriented
130	COM-B	Opportunity	The factors that lie outside the individual that make the behaviour possible or prompt it
131	Integrated Theory of Health Behaviour Change	Social Influence	The impact or influence others have on one's thoughts, feelings or behaviours
132	PRIME Theory	Internal environment	Sensation, perception, image, belief, feeling, drive state, state of arousal and/or frame of mind
133	Social Change Theory	Diffusion	Process through which change is spread to other groups within the community; occurs via social networks
134	Needs-Opportunity-Abilities Model	Opportunity	An external condition that facilitates the behaviour (e.g. the objective availability and accessibility of goods or services, or accessibility to the financial means needed for purchasing goods)
135	Integrative Model of Behavioural Prediction	Environmental constraint	A factor in the environment that prevents the behaviour from being carried out
136	Social Action Theory (Ewart)	Motivational Process	A set of processes through which one is encouraged to act by envisaging possible outcomes, evaluating capabilities and generating goals that guide and energise problem solving

137	Problem Behaviour Theory	Environmental proneness	A dynamic state that specifies the likelihood of occurrence of the problem behaviour from within the environmental system; consists of lower parental support and controls, lower friends controls, lower parent, friends compatibility, greater friends-than parents-influence, lower parental disapproval of problem behaviour and greater friends approval for and models of problem behaviour.
138	PRIME Theory	State	A disposition that are generated by current stimuli
139	Needs-Opportunity-Abilities Model	Need	An objective that people strive to achieve in order to improve or maintain their wellbeing or quality of life.
140	Social Ecological Model of Behaviour Change	Enabling factor	A necessary skill and/or ability for behaviour change
141	PRIME Theory	Emotion	A sensation and the interpretation of this sensation
142	Integrated Theory of Health Behaviour Change	Personal Perception	One's personal belief, comprised of self-efficacy, outcome expectancy, and goal congruence
143	Model of Pro-Environmental Behavior	Pro-environmental consciousness	A complex made up of environmentally related knowledge, values and attitudes and environmental attitudes
144	Problem Behaviour Theory	Control	Any circumstance that prevents the problem behaviour from occurring
145	Relapse Prevention Model	High risk situation	A situation that threatens perceived control and can trigger a lapse and increase the risk of relapse (e.g. negative emotional states, interpersonal conflict)
146	Self-Determination Theory	Basic need	A universal human psychological, growth-oriented need that underpins optimal motivation and wellness

Appendix 3-6. Overview of judgements on whether any ungrouped MoAs share all the attributes of their specific MoA groups in the TaT Project

Notes. *One construct was judged not to qualify as MoAs and eight were judged to be compound MoAs

Appendix 3-7. Final labels, definitions and constituent MoAs of MoA groups

No. Group	Group label	Theory	Label	Definition
1	Self-efficacy	Action Theory Model of Consumption	Perceived behavioural control	Belief about one's ability to carry out a behaviour, and the possible outcomes of that behaviour
1	Self-efficacy	AIDS Risk Reduction Model	Self-efficacy	Perception of one's ability to carry out health-protective behaviours
1	Self-efficacy	Behavioural ecological Model of Adolescent AIDS Prevention	Self-efficacy	The degree to which one is confident one can perform the behaviour
1	Self-efficacy	CEOS Theory	Perceived capacity (relatively stable)	The extent to which one perceives oneself to be capable of engaging in a behaviour
1	Self-efficacy	CEOS Theory	Self-efficacy (situational)	The moment to moment, subjective perception of one's capability for performance in a given setting or ability to attain desired results in a particular situation
1	Self-efficacy	Ecological Model for Preventing Type 2 Diabetes	Self-efficacy	Belief about whether one is capable of carrying out a behaviour or making a behaviour change
1	Self-efficacy	Extended Parallel Processing Model	Perceived self-efficacy	Perception of one's ability to take a recommended protective action
1	Self-efficacy	Feedback Intervention Theory	Self-efficacy	The belief in personal ability to successfully perform a task or engage in a behaviour
1	Self-efficacy	Goal directed theory	Self-efficacy with respect to means	Belief about one's confidence that one can use the resources or perform the methods (means) needed to achieve a goal
1	Self-efficacy	Goal setting theory	Self-efficacy (goal setting theory)	Belief about whether one is capable of attaining a goal or a particular performance outcome
1	Self-efficacy	Health Action Process Approach	Self-efficacy	Belief about one's ability to successfully carry out a behaviour
1	Self-efficacy	Health Action Process Approach (Reformulation)	Action self-efficacy (= pre-action self-efficacy)	Belief about one's ability to adopt a new behaviour

No. Group	Group label	Theory	Label	Definition
1	Self-efficacy	Health Action Process Approach (Reformulation)	Maintenance self-efficacy (= coping self-efficacy)	Belief regarding one's ability to maintain a newly adopted behaviour and to deal with any barriers to performing that behaviour that arise during long-term maintenance of the behaviour change
1	Self-efficacy	Health Action Process Approach (Reformulation)	Recovery self-efficacy	Belief about one's ability to address experiences of failure in a behaviour change attempt and to resume a behaviour following such a setback
1	Self-efficacy	Health Behaviour Goal Model	Perceived competence	The degree to which one is perceived to be capable of carrying out or adopting a behaviour
1	Self-efficacy	Health behaviour internalisation model	Self-efficacy	Related to the need for competence; the confidence that one has the capacity to act effectively to bring about desired results
1	Self-efficacy	Health Belief Model	Self-efficacy	Belief about whether or not one is capable of taking a health-protective action
1	Self-efficacy	Health Promotion Model	Perceived self-efficacy	Belief about one's ability to successfully carry out a behaviour
1	Self-efficacy	I-Change Model	Routine self-efficacy	The confidence to engage in a behaviour when carrying out routine activities
1	Self-efficacy	I-Change Model	Self-efficacy belief	Perception of one's ability and confidence to carry out the behaviour
1	Self-efficacy	I-Change Model	Situational self-efficacy	The confidence to engage in a behaviour when in certain situations or locations
1	Self-efficacy	I-Change Model	Social self-efficacy	The confidence to engage in a behaviour when there are social influences opposing that behaviour (e.g. when with friends)
1	Self-efficacy	I-Change Model	Stress self-efficacy	The confidence to engage in a behaviour when confronted with emotional and stressful situations
1	Self-efficacy	Information-Motivation-Behavioural Skills	Self-efficacy	Self-belief in one's ability to use one's skills effectively in order to carry out the behaviours
1	Self-efficacy	Information-Motivation-Behavioural Skills Model of Adherence Behaviour	Perceived self-efficacy	Belief about one's ability to carry out specific behaviours
1	Self-efficacy	Integrated Theoretical Model for Alcohol and Other Drug Abuse Prevention	Self-efficacy	Belief about one's ability to perform certain behaviours
1	Self-efficacy	Integrated Theory of Health Behaviour Change	Self-efficacy	The confidence in one's ability to successfully carry out the behaviour even under conditions of stress

No. Group	Group label	Theory	Label	Definition
1	Self-efficacy	Integrative Model of Behavioural Prediction	Efficacy Belief	Perception relating to one's possession of the necessary skills and abilities to perform the behaviour, even in the face of specific barriers or obstacles
1	Self-efficacy	Integrative Model of Behavioural Prediction	Self-efficacy	The belief that one can perform the behaviour, even under a number of difficult circumstances
1	Self-efficacy	Integrative Model of factors influencing smoking and health attitude and behaviour change	Self-efficacy	The feeling of possession of (or ability to acquire) control over the behaviour
1	Self-efficacy	Integrative Model of Health Attitude and Behaviour Change	Self-efficacy	Feeling that one possesses or can acquire control over the behaviour
1	Self-efficacy	Norm Activation Theory	Distinctive suitability	The feeling that there is a unique ability to respond due to specific skills, knowledge or availability; may elicit a responsibility to respond
1	Self-efficacy	Norm activation theory	Recognition of own ability to provide relief	The recognition that one is capable of performing the actions necessary to provide relief; may be influenced by one's overall sense of personal competence
1	Self-efficacy	Pressure System Model	Self-efficacy	The belief one has that one can accomplish a specified task
1	Self-efficacy	PRIME Theory	Self-efficacy	A belief in one's capability to enact a behaviour or achieve a particular outcome
1	Self-efficacy	Protection Motivation Theory	Self-efficacy	A person's belief about whether they are capable or incapable of performing the coping response
1	Self-efficacy	Relapse Prevention Model	Perceived control	The extent to which one feels one has control over maintaining abstinence or complying with other rules governing the target behaviour
1	Self-efficacy	Relapse Prevention Model	Self-efficacy	Belief about one's ability to cope with high risk situations
1	Self-efficacy	Self-Determination Theory	Perceived competence	Perceptions of one's ability to carry out a behaviour
1	Self-efficacy	Self-Efficacy Theory	Self-efficacy	Belief that one is capable of carrying out a specific behaviour that will lead to desired outcomes
1	Self-efficacy	Social Action Theory (Ewart)	Self-efficacy	Belief about whether or not one is capable of performing a recommended behaviour

No. Group	Group label	Theory	Label	Definition
1	Self-efficacy	Social Cognitive Theory	Perceived self-efficacy	Perceived judgement of one's ability to cope effectively in different circumstances
1	Self-efficacy	Social Ecological Model of Behaviour Change	Efficacy Belief	Belief about whether one has the skills and abilities to perform the behaviour, even in the face of barriers
1	Self-efficacy	Social Ecological Model of Behaviour Change	Self-efficacy	The belief in personal ability to successfully perform a task or engage in a behaviour
1	Self-efficacy	Technology Acceptance Model	Computer self-efficacy	One's perception of whether one is capable of performing a task using the technology
1	Self-efficacy	Theory of Planned Behaviour	Perceived behavioural control	The perceived ability to perform the behaviour
1	Self-efficacy	Theory of Triadic Influence	Self-efficacy	The sense that one has the skills and will to take charge of their health
1	Self-efficacy	Transcontextual Model of Motivation	Perceived behavioural control	One's belief about one's ability to carry out a behaviour
1	Self-efficacy	Transtheoretical Model of Behaviour Change	Self-efficacy	One's beliefs about one's ability to carry out a behaviour in any given situation
2	Need	CEOS Theory	Need	Imbalance, typically deficit of something required for survival, well-being or personal fulfilment
2	Need	Health behaviour internalisation model	Context	A behaviour-related need; the need one feels for a behaviour to take place in a context that is enjoyable
2	Need	Health behaviour internalisation model	Coping	A behaviour-related need; the need one feels to have available effective coping strategies, especially when one gives up a coping strategy for a health-related reason
2	Need	Health behaviour internalisation model	Need for competence	A behaviour-related need; the need one feels to be capable of engaging with and carrying out a behaviour well and with relative ease
2	Need	Health behaviour internalisation model	Ownership	A self-need; the need one feels to engage in a new behaviour for personal reasons, as opposed to reasons dictated by another
2	Need	Health Behaviour Internalisation Model	Preference	A behaviour-related need; the need for one's behaviours to be congruent with one's tastes and preferences
2	Need	Health behaviour internalisation model	Security	A self-need; the need one feels to establish a sense of security when faced with a personal health threat

No. Group	Group label	Theory	Label	Definition
2	Need	Health behaviour internalisation model	Self-determination	A self-need; the need one feels to possess a sense of personal agency and initiative in relation to adopting a new behaviour
2	Need	Health Behaviour Internalisation Model	Support	A self-need; the need one feels for family, friends or caregivers to give support to meet self-related and behaviour-related needs in a manner associated with the integration of a new behaviour with one's values and sense of self
2	Need	Information-Motivation-Behavioural Skills Model of Adherence Behaviour	Quality of life	The extent to which one obtains satisfaction from life; influenced by emotional, material, and physical well-being, engagement in interpersonal relations; opportunities for personal development, exercising rights and making self-determining lifestyle choices and participation in society
2	Need	Needs-Opportunity-Abilities Model	Need for beauty	Need for the ability to experience and enjoy beautiful things inside and around the home
2	Need	Needs-Opportunity-Abilities Model	Need for comfort	The need for everyday life to be easy and comfortable
2	Need	Needs-Opportunity-Abilities Model	Need for development/education	The need for an opportunity to receive a good education and to develop general knowledge
2	Need	Needs-Opportunity-Abilities Model	Need for Freedom/control	Need for the course of one to be able to control their life, and make individual decisions (e.g. about what one wants to do)
2	Need	Needs-Opportunity-Abilities Model	Need for health	Need for good health and adequate, accessible healthcare
2	Need	Needs-Opportunity-Abilities Model	Need for Labour	Need to have a good job that is enjoyable, and the ablility to perform that job well
2	Need	Needs-Opportunity-Abilities Model	Need for leisure time	Need for one to have sufficient time for leisure
2	Need	Needs-Opportunity-Abilities Model	Need for Nature/Environment	Need for the environment to provide clean air, water and soil, and healthy animals and plants
2	Need	Needs-Opportunity-Abilities Model	Need for Pleasure/arousal	Need for everyday life to provide experiences that are enjoyable and exciting
2	Need	Needs-Opportunity-Abilities Model	Need for privacy	Need for one to be oneself, do things for oneself and have one's own place

No. Group	Group label	Theory	Label	Definition
2	Need	Needs-Opportunity-Abilities Model	Need for safety	Need for personal safety and protection from crime and accidents both at home and outside
2	Need	Needs-Opportunity-Abilities Model	Need for social relation	Need for good relationships with family, friends and peers and the opportunity to improve these relationships
2	Need	Needs-Opportunity-Abilities Model	Need for status	The need to receive the appreciation of others due to personal skills, achievements or possessions
2	Need	Needs-Opportunity-Abilities Model	Need for work	The extent to which one has a good job that is enjoyable
2	Need	PRIME Theory	Need	Attraction to things on the basis of feelings of anticipated relief from actual or possible mental or physical discomfort
2	Need	Self-Determination Theory	Need for autonomy	The necessity of experiencing self-determination and volition rather than feeling governed by other forces
2	Need	Self-Determination Theory	Need for competence	The importance of experiencing oneself as able and effective in dealing with the environment
2	Need	Self-Determination Theory	Need for relatedness	The importance of caring for, being cared for by, and feeling connected to other people
2	Need	Social Ecological Model of Walking	Need for Accessibility	Need related to the pattern, quantity, quality, variety and proximity of activities present, as well as the connectivity between the uses (e.g. actual or perceived barriers to walking, number of destinations available to walk)
2	Need	Social Ecological Model of Walking	Need for comfort	Needed level of ease, convenience, and contentment
2	Need	Social Ecological Model of Walking	Need for Feasibility	Most basic need within the hierarchy, relates to one's personal ability or limits in relation to the behaviour
2	Need	Social Ecological Model of Walking	Need for safety	The need to feel safe from the threat of crime
2	Need	Terror Management Theory	Need for self-esteem	The requirement for a positive self-concept that influences behaviour
2	Need	Terror Management Theory	Self-esteem	The need to view oneself as valuable; serves as a buffer against anxiety

No. Group	Group label	Theory	Label	Definition
3	Intention	Ecological Model for Preventing Type 2 Diabetes	Behavioural Intention	A conscious decision to perform a behaviour
3	Intention	Extended Information Processing Model	Intention	Conscious decision relating to the performance of a behaviour
3	Intention	Health Action Process Approach (Reformulation)	Intention	A conscious decision to perform a behaviour
3	Intention	I-Change Model	Intention	A person's conscious plan or decision to perform a particular behavior
3	Intention	I-Change Model	Motivation	One's intention to carry out a particular type of behaviour; determined by attitudes, social influences and self-efficacy
3	Intention	Integrative Model of Behavioural Prediction	Intention	The expressed motivation to perform the behaviour
3	Intention	Integrative Model of factors influencing smoking and health attitude and behaviour change	Intention	Conscious decision relating to the performance of a behaviour
3	Intention	Integrative Model of Factors Influencing Smoking Behaviours	Intention	Conscious decision relating to the performance of a behaviour
3	Intention	Integrative Model of Factors Influencing Smoking Behaviours	Social motive	Intention to engage in a behaviour that is based on a striving for status, achievement, power, or connection with others and the maintenance of relationships
3	Intention	Integrative Model of Health Attitude and Behaviour Change	Intention	Plan to engage in a behaviour, predicted by social normative beliefs, attitudes and personality
3	Intention	Motivation-Opportunities-Abilities	Intention	A conscious decision to perform a behaviour
3	Intention	Needs-Opportunity-Abilities Model	Intention	A conscious decision to engage in the behaviour that occurs when the necessary levels of motivation and behavioural control are present

No. Group	Group label	Theory	Label	Definition
3	Intention	PRIME Theory	Plan/Intention	Mental representation of actions or action sequences, together with at least some degree of commitment to them and some form of mental representation of the starting conditions
3	Intention	Six Staged Model of Communication Effects	Intention	A conscious decision to pursue the behaviour change
3	Intention	Social Action Theory (Ewart)	Self-directive goal	Behavioural intention embedded in personal projects; guides people into activities and environments that affect their responses to behaviour change inducements
3	Intention	Social Ecological Model of Behaviour Change	Intention to change	A conscious decision to change a behaviour
3	Intention	Systems Model of Health Behaviour Change	Health intention	A self-conscious plan to engage or not engage in a given health behaviour
3	Intention	Technology Acceptance Model	Intention	A self-conscious plan to engage or not engage in a given behaviour
3	Intention	Temporal Self-Regulation Theory	Intention	Self-conscious plan to engage or not engage in a given behaviour; determined by beliefs about the extent to which significant others would approve of behavioural performance and valence of attitude toward the behaviour
3	Intention	Theory of Interpersonal Behaviour	Behavioural Intention	The thought process which is the direct behavioural antecedents of the act
3	Intention	Theory of Interpersonal Behaviour	General behavioural intention	Non-specific self-conscious plan to engage or not engage in a given behaviour
3	Intention	Theory of Interpersonal Behaviour	Specific behavioural intention	Clearly defined or identified intention that corresponds directly to particular acts
3	Intention	Theory of Planned Behaviour	Intention	The cognitive representation of one's readiness to perform the behaviour; considered to be the immediate antecedent of behaviour
3	Intention	Transcontextual Model of Motivation	Intention	Self-conscious plan to engage or not engage in a given behaviour, consisting of a mental representation of the behaviour associated with a feeling of imperative to engage in the behaviour

No. Group	Group label	Theory	Label	Definition
4	Knowledge	AIDS Risk Reduction Model	Knowledge	Knowledge of the behavioural risk factors associated with the disease or health risk
4	Knowledge	Behavioural ecological Model of Adolescent AIDS Prevention	Knowledge	Information and understanding of topics relevant to the behaviour
4	Knowledge	CEOS theory	Propositional knowledge	The abstract representation of knowledge, words or images
4	Knowledge	Diffusion of Innovations	Knowledge	Awareness and understanding of an innovation/behaviour
4	Knowledge	Extended Information Processing Model	Knowledge	A change in one's understanding as a result of receiving a message
4	Knowledge	I-Change Model	Knowledge	Factual information about the effects of risk behaviours and health threats.
4	Knowledge	Information-Motivation-Behavioural Skills	Information	Knowledge about the threat (e.g. means of transmission and prevention)
4	Knowledge	Information-Motivation-Behavioural Skills	Information about means of prevention	Specific knowledge about the processes by which a threat is prevented
4	Knowledge	Information-Motivation-Behavioural Skills	Information about means of transmission	Specific knowledge about the processes by which a threat is transmitted
4	Knowledge	Information-Motivation-Behavioural Skills Model of Adherence Behaviour	Information	Knowledge of highly active antiretroviral therapy (HAART) including knowledge about the regimen, correct HAART utilisation, side effects, drug interactions
4	Knowledge	Integrated Theory of Health Behaviour Change	Condition specific knowledge	Factual and condition-specific information, including one's perceptions regarding a specific condition or health behaviour
4	Knowledge	Integrated Theory of Health Behaviour Change	Knowledge	Factual and condition-specific information
4	Knowledge	Integrative Model of factors influencing smoking and health attitude and behaviour change	Knowledge (preparation)	Information and understanding of the behaviour, usually acquired by experience or by learning

No. Group	Group label	Theory	Label	Definition
4	Knowledge	Integrative Model of Factors Influencing Smoking Behaviours	Knowledge	Information about, and understanding of, smoking behaviour; usually acquired by experience or by learning
4	Knowledge	Integrative Model of Health Attitude and Behaviour Change	Information	Knowledge about facts or ideas gained through investigation, experience, or practice; the reduction in uncertainty provided by a message
4	Knowledge	Integrative Model of Health Attitude and Behaviour Change	Knowledge	Information and understanding of a specific topic or of the world in general, usually acquired by experience or by learning
4	Knowledge	Model of Pro-Environmental Behavior	Knowledge	Knowledge and awareness of the environmental problem and its causes, and ways in which one can act to lower one's impact on the problem
4	Knowledge	Model of Pro-Environmental Behavior	Knowledge	Knowledge about the causes and effects of ecological degradation
4	Knowledge	Reflective Impulsive Model	Associative Cluster	Cluster of elements that represents knowledge; can be arranged hierarchically and represents either concrete or abstract concepts or schemata
4	Knowledge	Reflective Impulsive Model	Noetic state of awareness	Knowledge that something is or is not the case
4	Knowledge	Six Staged Model of Communication Effects	Understanding of a message	The act of knowing and understanding the educational content (e.g. of a communication)
4	Knowledge	Social Action Theory (Ewart)	Declarative knowledge schema	Set of knowledge that represents facts and beliefs about the world and about oneself
4	Knowledge	Theory of Triadic Influence	Health related knowledge	Base of information relating to the causes of health threats and ways to avoid these threats
5	Attitude towards behaviour	AIDS Risk Reduction Model	Enjoyment value	Belief about whether health-protective behaviours (e.g. condom use) are more or less enjoyable than high-risk behaviours (e.g. unprotected sex)
5	Attitude towards behaviour	Aids risk reduction model	Problem perception (Labelling)	The stage at which one labels one's behaviours as problematic or risky

No. Group	Group label	Theory	Label	Definition
5	Attitude towards behaviour	Differential Association Theory	Attitude	A subjective belief and/or evaluation associated with the behaviour
5	Attitude towards behaviour	Ecological Model for Preventing Type 2 Diabetes	Perceived benefit	Belief about the benefits of a behaviour or behaviour change
5	Attitude towards behaviour	Extended Information Processing Model	Attitude	Change in one's positive/negative evaluation (e.g. about smoking) as a result of receiving a message
5	Attitude towards behaviour	I-Change Model	Attitude	The perceived cognitive and emotional advantage and/or disadvantage of the behaviour
5	Attitude towards behaviour	Information-Motivation-Behavioural Skills	Attitude	Belief and/or feeling of favourableness or unfavourableness in relation to a behaviour
5	Attitude towards behaviour	Integrative Model of Behavioural Prediction	Attitude	The overall feeling of favourableness or unfavourableness towards performing the behaviour
5	Attitude towards behaviour	Integrative Model of factors influencing smoking and health attitude and behaviour change	Attitude (preparation)	The general evaluation of the behaviour on a scale ranging from negative to positive, developed during preparation stage.
5	Attitude towards behaviour	Integrative Model of factors influencing smoking and health attitude and behaviour change	Belief (preparation)	Association of some characteristic or attribute, usually evaluative in nature, in relation to the behaviour
5	Attitude towards behaviour	Integrative Model of Factors Influencing Smoking Behaviours	Attitude	The general evaluation of performing the behaviour on a scale ranging from negative to positive
5	Attitude towards behaviour	Integrative Model of Health Attitude and Behaviour Change	Attitude	The general evaluation of the behaviour on a scale ranging from negative to positive

No. Group	Group label	Theory	Label	Definition
5	Attitude towards behaviour	Model of Pro-Environmental Behavior	Attitude	A general evaluation of pro-environmental behaviour on a scale ranging from negative to positive
5	Attitude towards behaviour	Motivation-Opportunities-Abilities	Attitude towards the behaviour	A general evaluation of the behaviour on a scale ranging from negative to positive; a function of beliefs and evaluations of outcome
5	Attitude towards behaviour	Social Ecological Model of Behaviour Change	Attitude	Belief about how favourable or unfavourable the behaviour is
5	Attitude towards behaviour	Technology Acceptance Model	Perceived ease of use	Belief about the level of effort required to use the technology
5	Attitude towards behaviour	Technology Acceptance Model	Perceived enjoyment	The extent to which engaging in a behaviour is perceived as enjoyable in its own right, regardless of external consequences
5	Attitude towards behaviour	Theory of Normative Social Behaviour	Benefit to oneself	Belief about whether engaging in the behaviour will be beneficial to oneself
5	Attitude towards behaviour	Theory of Planned Behaviour	Attitude	Favourable or unfavourable evaluation or appraisal of the behaviour
5	Attitude towards behaviour	Theory of Triadic Influence	Attitude	General evaluation of health-related behaviour ranging on a scale from negative to positive
5	Attitude towards behaviour	Transcontextual Model of Motivation	Attitude	Belief about/evaluation of a behaviour
6	Goal	CEOS Theory	Goal	Conceptually identified target; can be specific behavioural or outcome-based (which cannot be pursued directly, e.g. I want to be happy)
6	Goal	Feedback Intervention Theory	Standard	The goal one is aiming to achieve; desired end states
6	Goal	Goal framing theory	Background Goal	Goal that is not activated at a given moment
6	Goal	Goal framing theory	Gain goal	Goal relating to the improvement and protection of one's resources
6	Goal	Goal framing theory	Goal frame	A goal that is activated at a given moment in time
6	Goal	Goal framing theory	Hedonic goal	Goals relating to instantly feeling better
6	Goal	Goal framing theory	Normative goal	Goal to act in line with what is considered acceptable

No. Group	Group label	Theory	Label	Definition
6	Goal	Goal setting theory	Goal	The object or aim of action(s), for example, to attain a specific standard of proficiency, usually within a specified time limit
6	Goal	Goal setting theory	Personal Goal	Goal that one has set for oneself
6	Goal	Goal setting theory	Proximal Goal	Goal that are short term
6	Goal	Health Behaviour Goal Model	Higher order goal	Abstract goal relating to what one wants in life, generally associated with self-concept, and positioned at the higher end of a hierarchy of such goals
6	Goal	Health Behaviour Goal Model	Lower order goals	Concrete goals relating to the things one wants in life; generated as a result of more abstract goals relating to self concept, have a higher level of specificity, tend to relate to daily activities, and are at the lower end of a hierarchy of such goals
6	Goal	Integrated Theory of Health Behaviour Change	Goal Setting	A process that establishes specific, time-based behaviour targets that are measurable, achievable and realistic
6	Goal	Prototype Willingness Model	Behavioural Intention	Goals or goal states that are formulated after some deliberation or reasoning
6	Goal	Reflective Impulsive Model	Goal	A desired end state towards which one is striving
6	Goal	Self-Determination Theory	Extrinsic goal	Goal that is related to obtaining contingent approval or external signs of worth (e.g. attaining wealth or fame)
6	Goal	Self-Determination Theory	Goal	The end state toward which one is striving; the desired outcome of an activity or endeavour, which can be either extrinsic or intrinsic
6	Goal	Self-Determination Theory	Intrinsic Goal	Goal that is closely associated with basic need satisfaction (e.g., affiliation, personal growth)
6	Goal	Social Action Theory (Ewart)	Goal	The end state toward which one is striving; the purpose of an activity or endeavour, can be extrinsic or intrinsic
6	Goal	Social Action Theory (Ewart)	Shared Goal	Goal that are shared by others in a social relationship
7	Skill	AIDS Risk Reduction Model	Communication skill (AIDS risk reduction model)	The adequacy of one's verbal communication skill to assert desires for safe sex with an uncooperative partner

No. Group	Group label	Theory	Label	Definition
7	Skill	Behavioural ecological Model of Adolescent AIDS Prevention	Assertiveness/social skill	The assertiveness and/or communication skill necessary to engage in discourse regarding matters such as condom use and sexual history with a potential sexual partner
7	Skill	CEOS Theory	Skill	Ability or proficiency acquired through training and practice
7	Skill	Differential Association Theory	Technique	Practical skill and ability related to the performance of a behaviour; way of performing a behaviour, varying complexity from very simple to very complicated
7	Skill	I-Change Model	Skill	Abilities or proficiencies acquired through training and practice
7	Skill	Information-Motivation-Behavioural Skills	Acquisition of behaviourally relevant information	The ability to obtain accurate information about methods of preventing the threat
7	Skill	Information-Motivation-Behavioural Skills	Self- and Partner- reinforcement	The ability to reinforce oneself or one's sexual partner's safe sex practices
7	Skill	Information-Motivation-Behavioural Skills Model of Adherence Behaviour	Objective ability	Ability to perform a behaviour based on observable phenomena
7	Skill	Integrated Theoretical Model for Alcohol and Other Drug Abuse Prevention	Behavioural Skill	The ability that is necessary in order to execute the new behaviour effectively
7	Skill	Integrative Model of Behavioural Prediction	Skill	An ability or proficiency that facilitates performance of the behaviour
7	Skill	Integrative Model of factors influencing smoking and health attitude and behaviour change	Available behavioural alternative	Possession of the necessary coping skills to resist or cope with barriers
7	Skill	Integrative Model of Factors influencing smoking behaviours	Social competence	The level of skill in interpersonal relations, especially the ability to handle a variety of social situations effectively

No. Group	Group label	Theory	Label	Definition
7	Skill	Integrative Model of Health Attitude and Behaviour Change	Available behavioural alternative	Possession of the necessary coping skills to resist or cope with barriers
7	Skill	Social Action Theory (Ewart)	Procedural schema	Set of knowledge that represents the skills and routines for performing tasks
7	Skill	Social Development Model	Skill for Involvement	The extent to which one has the ability or proficiency (acquired through training and practice) to engage in the behaviour
7	Skill	Social Ecological Model of Behaviour Change	Skill	Ability or proficiency (acquired through training and practice) that is required to modify behaviour
7	Skill	Theory of Triadic Influence	Skill	Health-related ability or proficiency acquired through training and practice (i.e. in relation to performing health-related behaviours)
7	Skill	Theory of Triadic Influence	Social Competence	The extent of one's skill in interpersonal relationships, especially the ability to handle a wide variety of social situations effectively
8	Outcome Expectancy (no explicit evaluation)	CEOS Theory	Outcome Expectancy	Relatively stable belief about the likely consequences of a behaviour (i.e. perception about what will be achieved and/or lost by undertaking a behaviour)
8	Outcome Expectancy (no explicit evaluation)	Ecological Model for Preventing Type 2 Diabetes	Outcome expectation	Belief about the impact of current behaviour on health, and beliefs about whether behaviour change would be personally beneficial to one's health
8	Outcome Expectancy (no explicit evaluation)	Health Action Process Approach	Generalized Outcome Expectancy	General expectation about the outcomes of a behaviour
8	Outcome Expectancy (no explicit evaluation)	Health Action Process Approach	Outcome Expectancy	Belief about the likely consequences of a behaviour
8	Outcome Expectancy (no explicit evaluation)	Health Action Process Approach (Reformulation)	Outcome Expectancy	Belief about the consequences of a behaviour

No. Group	Group label	Theory	Label	Definition
8	Outcome Expectancy (no explicit evaluation)	I-Change Model	Cognitive/Rational pros & cons	One's cognition and belief about the positive and negative consequences that may result from carrying out the behaviour
8	Outcome Expectancy (no explicit evaluation)	Information-Motivation-Behavioural Skills Model of Adherence Behaviour	Belief	A propositional mental representation about possible outcomes of a behaviour
8	Outcome Expectancy (no explicit evaluation)	Integrative Model of Health Attitude and Behaviour Change	Expectancy	Belief about the probable consequences of behaviour
8	Outcome Expectancy (no explicit evaluation)	Risk as Feelings Theory	Anticipated outcome	Predicted outcome, including anticipatory emotion, of each risky response alternative
8	Outcome Expectancy (no explicit evaluation)	Social Action Theory (Ewart)	Expectation	Belief about future states of the world with associated subjective probabilities of their occurrence
8	Outcome Expectancy (no explicit evaluation)	Theory of Interpersonal Behaviour	Perceived consequence	A person's subjective perception of the consequences that are likely to arise from the adoption of a behaviour
8	Outcome Expectancy (no explicit evaluation)	Theory of Interpersonal Behaviour	Value of the consequences	A person's positive or negative feeling about the consequences of a behaviour
8	Outcome Expectancy (no explicit evaluation)	Theory of Normative Social Behaviour	Outcome expectation	Type of normative mechanism relating to expectations about the consequences of an action (includes benefits to oneself, benefits to others and anticipatory socialisation)
8	Outcome Expectancy (no explicit evaluation)	Theory of Planned Behaviour	Behavioural Belief	Belief about the likely outcomes or other attributes (e.g. cost) of the behaviour; assumed to determine attitude
8	Outcome Expectancy (no explicit evaluation)	Theory of Triadic Influence	Evaluation of consequences	Careful examination or appraisal of the health, financial and social consequences of health-related behaviour

No. Group	Group label	Theory	Label	Definition
8	Outcome Expectancy (no explicit evaluation)	Theory of Triadic Influence	Expectation about consequences	Belief about the health / financial consequences of a health-related behaviour
8	Outcome Expectancy (no explicit evaluation)	Value Belief Norm Theory	Belief in a new ecological paradigm	The view that human actions can have significant effects upon the environment and biosphere
9	Outcome expectancy (likelihood)	AIDS Risk Reduction Model	Response Efficacy	Perception of whether reducing risky behaviours and increasing low-risk behaviours will be effective in reducing one's risk of the disease or health risk
9	Outcome expectancy (likelihood)	Extended Parallel Processing Model	Response Efficacy	Perception of the likelihood that taking a particular action would be effective in averting a threat
9	Outcome expectancy (likelihood)	Goal directed theory	Instrumental Belief (outcome expectancy)	Judgement about the extent to which available means of goal achievement are likely to lead to actual goal achievement
9	Outcome expectancy (likelihood)	Health Belief Model	Perceived benefit	Belief about the relative effectiveness of known options for reducing a health threat, distinct from objective facts
9	Outcome expectancy (likelihood)	Health Promotion Model	Perceived benefit of action	Belief about the positive or reinforcing outcomes of engaging in a behaviour
9	Outcome expectancy (likelihood)	Integrated Theoretical Model for Alcohol and Other Drug Abuse Prevention	Outcome Expectation	A belief about whether behaviour change will lead to the desired outcome
9	Outcome expectancy (likelihood)	Integrated Theory of Health Behaviour Change	Outcome expectancy	The belief that carrying out the behaviour will lead to the desired results
9	Outcome expectancy (likelihood)	Pressure System Model	Belief about the efficacy of change	Perception of whether change will lead to the desired health outcome

No. Group	Group label	Theory	Label	Definition
9	Outcome expectancy (likelihood)	Protection Motivation Theory	Response Efficacy	Belief about how effective a coping response will be in averting the threat
9	Outcome expectancy (likelihood)	Relapse Prevention Model	Positive expectancy	Belief that engaging in the health risk behaviour will produce positive effects
9	Outcome expectancy (likelihood)	Risk as Feelings Theory	Subjective Probability	Subjective opinion of how likely the anticipated outcomes is to occur
9	Outcome expectancy (likelihood)	Self-Efficacy Theory	Outcome Expectancy	Belief about whether a certain behaviour will lead to desired outcomes
9	Outcome expectancy (likelihood)	Social Action Theory (Ewart)	Outcome Expectancy	Belief about whether or not a recommended action will lead to valued outcomes
9	Outcome expectancy (likelihood)	Technology Acceptance Model	Perceived usefulness	Belief about whether or not using the technology will enhance one's performance
9	Outcome expectancy (likelihood)	Temporal Self-Regulation Theory	Connectedness belief	Belief about the extent to which the behaviour is related to later outcomes, or perception of the likelihood of expected outcomes of the behaviour
9	Outcome expectancy (likelihood)	Theory of Normative Social Behaviour	Benefit to others	Belief about whether others engaging in the behaviour would benefit from doing so
10	Psychological capability	CEOS Theory	Self-control	Executive capacity to inhibit action tendencies
10	Psychological capability	COM-B	Psychological capability	The capacity to engage in the necessary thought processes for the behaviour
10	Psychological capability	General Theory of Deviant Behaviour	Ability to use controls and defences	The ability to defend oneself against, or to cope with, experiences that are self-devaluing
10	Psychological capability	Health Promotion Model	Self-regulatory ability	The ability or capacity to control one's own behaviour

No. Group	Group label	Theory	Label	Definition
10	Psychological capability	Information-Motivation-Behavioural Skills	Bringing up/negotiating AIDS prevention with partner	The ability to discuss and agree upon AIDS-preventative actions with a sexual partner, and to remove oneself from situations in which safe sex cannot be agreed upon
10	Psychological capability	Information-Motivation-Behavioural Skills	Self-acceptance of sexuality	The ability to acknowledge that one is sexually active and thus should consider AIDS prevention
10	Psychological capability	Information-Motivation-Behavioural Skills Model of Adherence Behaviour	Adherence behaviour	The ability to conform to a treatment regimen, especially one involving drug treatment as outlined by a health care provider
10	Psychological capability	Integrated Theory of Health Behaviour Change	Management of Emotions	The ability to appropriately managing one's emotions (coping)
10	Psychological capability	Needs-Opportunity-Abilities Model	Cognitive (ability)	The cognitive capability to engage in the behaviour
10	Psychological capability	Social Action Theory (Ewart)	Generative capability	A form of knowledge that allows one to envisage alternative goals and create novel action strategies
10	Psychological capability	Social Cognitive Theory	Forethought capability	The ability to regulate behaviour on the basis of the future
10	Psychological capability	Social Cognitive Theory	Self-reflective capability	The ability to analyse one's own experiences, thoughts and knowledge
10	Psychological capability	Social Cognitive Theory	Self-regulatory capability	The ability to motivate or regulate one's own behaviour on the basis of personal standards and evaluations of the behaviour
10	Psychological capability	Social Cognitive Theory	Symbolising capability	The capacity to use symbols
10	Psychological capability	Social Cognitive Theory	Vicarious capability	The ability to learn through observation
10	Psychological capability	Temporal Self-Regulation Theory	Self-regulatory capacity	Any state- or trait-like factor that influences one's ability to make efforts to regulate their behaviour (e.g. energy levels, executive functioning)
11	Belief	Action Theory Model of Consumption	Attitude	Psychological tendency that captures one's appraisal of a product or service judged to be instrumental in goal attainment
11	Belief	Affective events theory	Work Attitudes	General evaluations of work (i.e. job satisfaction)

No. Group	Group label	Theory	Label	Definition
11	Belief	Behavioural ecological Model of Adolescent AIDS Prevention	Attitude	A general evaluation of an object, person, group, issue or concept on a scale ranging from negative to positive
11	Belief	Extended Information Processing Model	Opinion/belief	Change in perception/belief as a result of a receiving a message
11	Belief	Integrated Theory of Health Behaviour Change	Belief	One's perception regarding a specific condition or health behaviour
11	Belief	Integrative Model of Factors influencing smoking behaviours	Belief	Propositional type of mental representation to which is attached a sense of adherence
11	Belief	Integrative Model of Health Attitude and Behaviour Change	Belief	Propositional type of mental representation to which is attached a sense of adherence
11	Belief	Motivation-Opportunities-Abilities	Belief	Association of some characteristic or attribute, evaluative in nature, towards the possible outcomes of engagement in the behaviour
11	Belief	PRIME Theory	Belief	A propositional mental representation (i.e. that can be expressed through language)
11	Belief	PRIME Theory	Evaluation	Belief about what is good or bad
11	Belief	Problem Behaviour Theory	Attitudinal Tolerance of Deviance	A belief that transgressions are not deemed to be wrong
11	Belief	Prototype Willingness Model	Attitude	A general evaluation of an object, person, group, issue or concept on a scale ranging from negative to positive
11	Belief	Social Consensus Model of Health Education	Individual attitude	The positive or negative evaluation/appraisal held by the individual
11	Belief	Social Consensus Model of Health Education	Individual Belief	An evaluation of attitude objects held by the individual
11	Belief	Technology Acceptance Model	Anchor	General belief about technology and technology use
12	Normative belief	Action Theory Model of Consumption	Normative belief	Perception of referent others' beliefs regarding whether or not one should perform a behaviour

No. Group	Group label	Theory	Label	Definition
12	Normative belief	Health Action Process Approach	Social outcome expectancy	Perception one has regarding whether important others believe that one should or should not perform a behaviour
12	Normative belief	Health Promotion Model	Norm	The perceived expectation of important others in relation to a behaviour
12	Normative belief	I-Change Model	Social norm belief	Perception of the norms that people have with respect to behaviours
12	Normative belief	Integrative Model of Behavioural Prediction	Normative Belief	Perception of social pressures or other's beliefs that one should or should not perform a behaviour
12	Normative belief	Integrative Model of Behavioural Prediction	Perceived norm	Perceived opinion of the 'normal' behaviour of others, including both perceptions of what others think one should do and perceptions of what others are doing
12	Normative belief	Motivation-Opportunities-Abilities	Social norm	The perception of what others want one to do
12	Normative belief	Prototype Willingness Model	Subjective Norm	Perception of what others are doing in relation to the behaviour
12	Normative belief	Social Ecological Model of Behaviour Change	Social norm	Belief about what others do and what others think one should do
12	Normative belief	Social Norms Theory	Perceived norm	Perception of what most other people within a social group believe and do
12	Normative belief	Technology Acceptance Model	Subjective Norm	One's perception of important others' beliefs about whether or not one should perform the behaviour
12	Normative belief	Theory of Normative Social Behaviour	Injunctive Norm	Perception of what important others expect one to do or approve of
12	Normative belief	Theory of Planned Behaviour	Normative Belief	Belief about the likelihood that important referent individuals or groups approve or disapprove of performing the behaviour; assumed to determine subjective norm
12	Normative belief	Theory of Triadic Influence	Perceived norm	Perception of the standard or range of values that represents the typical performance of a group or individual concerning a given behaviour
12	Normative belief	Transcontextual Model of Motivation	Subjective Norm	Perceived social pressure to engage in a behaviour from significant others

No. Group	Group label	Theory	Label	Definition
13	Reflective thinking	CEOS Theory	Analysis and Inference	The division of any entity into its component parts for the purpose of investigation (analysis) and a conclusion deduced from an earlier premise (inference)
13	Reflective thinking	CEOS Theory	Decisional balance	The moment to moment (i.e. situational) assessment of the value of a goal, whereby the long term net effects are considered against the immediate value
13	Reflective thinking	Goal directed theory	Intention to perform means	A conscious decision to use a certain method to achieve a goal
13	Reflective thinking	Integrated Theory of Health Behaviour Change	Reflective thinking	Type of thinking in which decisions are made (e.g. about complex problems) slowly and deliberately (i.e. not impulsively)
13	Reflective thinking	PRIME Theory	Analysis	Mental process by which beliefs are created from other beliefs according to a set of principles or rules (e.g. mental arithmetic)
13	Reflective thinking	PRIME Theory	Reflective change process	Change process that involves reflective thought
13	Reflective thinking	Prospect Theory	Cancellation	A process of information editing that disregards shared components of alternative prospects in order to simplify decision-making.
13	Reflective thinking	Prospect Theory	Combination	A process of simplifying prospects by combining the probabilities of identical outcomes, and evaluating them in this combined form
13	Reflective thinking	Prospect Theory	Detection of Dominance	A process of editing information to assess for any superior prospects and disregarding those that are inferior
13	Reflective thinking	Prospect Theory	Evaluation phase	A second stage of prospect evaluation where edited prospects are assessed and the prospect with the greatest value is chosen.
13	Reflective thinking	Prospect Theory	Simplification	A process of simplifying prospects by rounding probabilities and or outcomes, or by disregarding extremely unlikely outcomes
13	Reflective thinking	Reflective Impulsive Model	Noetic Decision	Decision made in the reflective system that draws upon syllogistic rules and evaluations of utility
13	Reflective thinking	Regulatory Fit Theory	Retrospective evaluation	The appraisal of the outcome of a previous choice
13	Reflective thinking	Self-Regulation Theory	Controlled processing	A mode of cognitive processing requiring focused attention and continuous decision making among alternate responses
14	Self-image	Goal directed theory	Self-schemata	The idea and/or belief one has about themselves

No. Group	Group label	Theory	Label	Definition
14	Self-image	Integrated Theory of Health Behaviour Change	Self-evaluation	One's conception and evaluation of oneself, including psychological and physical characteristics, qualities and skills
14	Self-image	Integrative Model of factors influencing smoking and health attitude and behaviour change	Self-image	The view or concept one holds of oneself
14	Self-image	Integrative Model of Factors influencing smoking behaviours	Self-image	One's own view or concept of oneself
14	Self-image	PRIME Theory	Self-attribute	Belief about one's characteristics (adjectives that apply to oneself)
14	Self-image	PRIME Theory	Self-feeling	Feeling about oneself
14	Self-image	PRIME Theory	Self-image	Image about oneself
14	Self-image	PRIME Theory	Self-label	Belief about the categories one belongs to (e.g. I am a vegetarian)
14	Self-image	PRIME Theory	Self-thought	Belief about oneself
14	Self-image	Systems Model of Health Behaviour Change	Perception of self	Belief relating to self-concept, self-image, value orientation and/or personality traits
14	Self-image	Theory of Interpersonal Behaviour	Self-concept	The traits and behaviours one attributes to oneself
14	Self-image	Theory of Interpersonal Behaviour	Self-image	A set of ideas about who one perceives oneself to be; includes self-esteem and ideas about the behaviours that are correct, appropriate or enjoyable
14	Self-image	Theory of Triadic Influence	Sense of self	Conception and evaluation of oneself
14	Self-image	Transtheoretical Model of Behaviour Change	Self-reevaluation	The process of cognitively and affectively assessing one's self-image in relation to the problem behaviour
15	Motivation	COM-B	Automatic motivation	Aspects of motivation that do not require reflective thought (involving emotions and impulses that arise from associative learning and/or innate dispositions)

No. Group	Group label	Theory	Label	Definition
15	Motivation	Extended Parallel Processing Model	Danger control process	The motivation to control the threat; initiated when one perceives that there is a high level of threat and that one is capable of taking effective action to avert that threat
15	Motivation	Extended parallel processing model	Protection motivation	The motivation to avert a threat to oneself
15	Motivation	Information-Motivation-Behavioural Skills	Motivation	The impetus that gives purpose or direction to initiate and maintain behaviours (e.g. threat-preventative behaviours)
15	Motivation	Information-Motivation-Behavioural Skills Model of Adherence Behaviour	Motivation	The impetus or 'trigger' that gives purpose or direction to initiate and maintain behaviours; comprises both personal motivation and social motivation to adhere to HAART
15	Motivation	Information-Motivation-Behavioural Skills Model of Adherence Behaviour	Personal motivation	The extent to which one is personally motivated towards adherence; arises from attitudes towards adherence
15	Motivation	Motivation-Opportunities-Abilities	Motivation	One's motivation (the impetus that gives purpose or direction to behaviour) to carry out the behaviour
15	Motivation	Protection Motivation Theory	Protection motivation	A motivational state that activates, sustains and/or directs behaviour
15	Motivation	Regulatory Fit Theory	Motivational Orientation	The specific concerns and interests of an individual that have motivated them to pursue the goal
15	Motivation	Self-Determination Theory	Extrinsic motivation	Motivation arising from consequences that are separate from the behaviour itself
15	Motivation	Self-Determination Theory	Intrinsic Motivation	Motivation to engage in an activity arising from the behaviour itself being interesting and enjoyable
15	Motivation	Social Learning Theory	Innate Drive	Motivation to act or respond that exists in an organism from birth and form the primary basis for the greater proportion of motivation (e.g. pain, hunger, thirst)
16	Social influence	Behavioural ecological Model of Adolescent AIDS Prevention	Family reaction	Response from family members that occur as a consequence of performing the behaviour

No. Group	Group label	Theory	Label	Definition
16	Social influence	Behavioural ecological Model of Adolescent AIDS Prevention	Peer influence	The influence of one's peers on behaviour
16	Social influence	Integrative Model of factors influencing smoking and health attitude and behaviour change	Family influence	The influence of one's family on one's smoking behaviour
16	Social influence	Integrative Model of factors influencing smoking and health attitude and behaviour change	Peer influence	The influence of people of the same status or rank on one's smoking behaviour
16	Social influence	Integrative Model of Factors Influencing Smoking Behaviours	Family influence	Influence of one's family on the development of smoking behaviour
16	Social influence	Integrative Model of Factors Influencing Smoking Behaviours	Peer influence	Influence of one's peers on the development of smoking behaviour (e.g. peer pressure)
16	Social influence	Problem Behaviour Theory	Friends control	Personal and social controls instigated by friends relating to the problem behaviour
16	Social influence	Problem Behaviour Theory	Friends modelling problem behaviour	The extent to which one's friends serve as examples for exhibiting the problem behaviour
16	Social influence	Problem Behaviour Theory	Peer influence	The influence of one's peers on the behaviour
16	Social influence	Relapse Prevention Model	Social pressure	The exertion of influence on a person or group by another person or group (e.g. being with others who are performing the behaviour)
16	Social influence	Systems Model of Health Behaviour Change	Personal socialization process	Behaviour change process that involves family and social dynamics which serve to teach individuals their role within the family and within broader social contexts
16	Social influence	Systems Model of Health Behaviour Change	Social Influence	The influence of others on behaviour (e.g. peer pressure/behaviour and parental modelling)

No. Group	Group label	Theory	Label	Definition
17	Evaluated outcome expectancy	Action Theory Model of Consumption	Anticipated emotion	Expectation of emotional consequences of achieving and not achieving a goal
17	Evaluated outcome expectancy	Health Behaviour Goal Model	Perceived emotional cost and benefit	Expectation regarding all possible emotional and well-being-related outcomes of a behaviour, positive or negative
17	Evaluated outcome expectancy	Health Behaviour Goal Model	Perceived health cost and benefit	Expectation regarding all possible health outcomes of a behaviour (i.e. positive or negative)
17	Evaluated outcome expectancy	I-Change Model	Pros & Cons(Advantage/Disadvantage)	The positive or negative consequence that a person associates as outcomes from his behaviour
17	Evaluated outcome expectancy	Information-Motivation-Behavioural Skills Model of Adherence Behaviour	Evaluation	Belief about the worth or desirability of the outcomes of HAART adherence (or non-adherence)
17	Evaluated outcome expectancy	Norm Activation Theory	Physical cost	Perceived physical cost and/or benefit associated with a line of action that includes effort expenditure, time loss, excitement and exhilaration
17	Evaluated outcome expectancy	Norm Activation Theory	Psychological cost	Perceived cost and/or benefit associated with a line of action that are guided by the consequences of a course of action to one's self-concept (e.g. loss of self-esteem or a sense of achievement)
17	Evaluated outcome expectancy	Rational Addiction Model	Marginal Utility	The perceived gain from an increase, or loss from a decrease, in the consumption of a good or service
17	Evaluated outcome expectancy	Self-Efficacy Theory	Incentive	The anticipated satisfaction of desired accomplishments and the negative appraisal of insufficient performance
17	Evaluated outcome expectancy	Social Ecological Model of Behaviour Change	Behavioural belief and its evaluative aspect	Belief about and evaluation of the possible outcomes of the behaviour
17	Evaluated outcome expectancy	Technology Acceptance Model	Image	The degree to which use of an innovation is perceived to enhance one's status among one's social group and influences
17	Evaluated outcome expectancy	Temporal Self-regulation Theory	Temporal valuation	The value attached to certain outcomes, incorporating the temporal distribution of outcomes

No. Group	Group label	Theory	Label	Definition
18	Perceived importance	AIDS Risk Reduction Model	Perceived importance of problem	Belief about the importance of behaviour change with respect to other ongoing problems
18	Perceived importance	CEOS Theory	Priority	The relative importance of engaging in a particular goal, when compared with other life goals; can be overall and/or at any particular point in time
18	Perceived importance	Goal directed theory	Ego preoccupation	The extent to which one perceives an intention or decision to be personally important, and the level of commitment to that intention or decision
18	Perceived importance	Goal setting theory	Importance (Goal Setting Theory)	The level to which goal attainment has import or significance; is carried with great or serious consequences; is weighty, momentous, grave, significant.
18	Perceived importance	Problem Behaviour Theory	Value on affection	Degree of positive or negative value placed on feelings of tenderness and attachment
18	Perceived importance	Regulatory Fit Theory	Value from fit	Degree of positive or negative value attaching to good regulatory fit
18	Perceived importance	Social influence model of consumer participation	Entertainment value	The value derived from from fun and relaxation through playing or otherwise interacting with others
18	Perceived importance	Social influence model of consumer participation	Maintaining interpersonal interconnectivity	The value one gets from establishing and maintaining contact with other people such as social support, friendship, and intimacy
18	Perceived importance	Social influence model of consumer participation	Social enhancement	The value one derives from gaining acceptance and approval of others, and the enhancement of one's social status within the community on account of one's contributions to it.
18	Perceived importance	Temporal Self-Regulation Theory	Value	The sense of worth, usefulness or importance attached to an outcome
18	Perceived importance	Terror Management Health Model	Relevance of Behaviour for Meaning and Self-esteem	The perceived importance of the health behaviour for maintaining meaning and value of the self
19	Perceived influence	Ecological Model for Preventing Type 2 Diabetes	Social norm	Perception of whether important others are supportive of one's behaviour/behaviour change
19	Perceived influence	Health Action Process Approach	Perceived social support	Perception of support from others for engaging in the behaviour

No. Group	Group label	Theory	Label	Definition
19	Perceived influence	Health Behaviour Goal Model	Social Influence	Expectation regarding how one's social environment might respond to the adoption of a new behaviour
19	Perceived influence	Health Promotion Model	Social Support	Perceived emotional encouragement and practical support from others for a behaviour
19	Perceived influence	I-Change Model	Social Pressure/support belief	The extent to which one feels pressure or support from others to execute the behaviour
19	Perceived influence	Information-Motivation-Behavioural Skills Model of Adherence Behaviour	Perceived Social Support	One's perception of the provision of assistance or comfort from others to help them cope with a variety of biological, psychological and social stressors; can be practical, informational or emotional
19	Perceived influence	Integrative Model of factors influencing smoking and health attitude and behaviour change	Social normative belief	A perception relating to social norms, influences and pressures
19	Perceived influence	Integrative Model of Health Attitude and Behaviour Change	Social normative belief	Perception related to social norms, influences and pressures
19	Perceived influence	Problem Behaviour Theory	Parent-friends influence	Perceived influence of one's friends and parents on the behaviour
19	Perceived influence	Systems Model of Health Behaviour Change	Perception of social influence	Belief regarding the influence of others on one's behaviour
19	Perceived influence	Theory of Planned Behaviour	Subjective norm	The perceived social pressure to perform or not to perform the behaviour
20	Goal pursuit	Action Theory Model of Consumption	Trying	A sub-type of action involving cognitive, affective and physical processes that join sequentially, interactively or in parallel to cause the bodily movements making up goal-directed behaviours
20	Goal pursuit	Goal directed theory	Effort	The intensity and duration of thought, planning and activity expended in attempting to achieve a goal

No. Group	Group label	Theory	Label	Definition
20	Goal pursuit	Goal directed theory	Instrumental act	The process by which attempts are made to perform the means chosen to achieve a goal; consist of planning, monitoring and guidance and control processes
20	Goal pursuit	Goal setting theory	Directive function	The process by which goals direct attention and effort towards goal-relevant activities and away from goal-irrelevant activities
20	Goal pursuit	Goal setting theory	Energising function	An increase in effort invested in a task resulting from perceived difficulty of that task
20	Goal pursuit	Goal setting theory	Persistence	The state of maintaining a course of action or keeping at a task and finishing it despite the obstacles or effort involved
20	Goal pursuit	Regulatory Fit Theory	Eagerness means	A type of goal means that have good regulatory fit with a promotion focused orientation; involves looking for means of advancement that support progress from a current state to a better state
20	Goal pursuit	Regulatory Fit Theory	Strength of Engagement	The extent to which people are absorbed or involved in their goal pursuit or decision making process
20	Goal pursuit	Regulatory Fit Theory	Vigilance means	A type of goal means that have good regulatory fit with a prevention focused orientation; involves being careful to maintain a current satisfactory state against a worse state
20	Goal pursuit	Technology Acceptance Model	Compliance	The performance of a particular behaviour in order to achieve a goal or avoid a punishment
21	Perceived severity	AIDS Risk Reduction Model	Belief about the undesirability of AIDS	A perception about the extent to which AIDS is undesirable
21	Perceived severity	Ecological Model for Preventing Type 2 Diabetes	Perceived severity	Perception about the severity of the consequences and/or experience of the disease
21	Perceived severity	Extended Parallel Processing Model	Perceived severity	Perception of the seriousness of a threat

No. Group	Group label	Theory	Label	Definition
21	Perceived severity	Health Action Process Approach	Perceived severity	Belief about the degree of harm associated with an outcome
21	Perceived severity	Health Action Process Approach (Reformulation)	Perceived severity	Perception of the degree of harm associated with an outcome
21	Perceived severity	Health Belief Model	Perceived severity	Perception of the seriousness of the disease both in terms of the emotional arousal elicited by thoughts of the disease and the anticipated difficulties that could be created by the disease
21	Perceived severity	Integrated Theoretical Model for Alcohol and Other Drug Abuse Prevention	Perceived Severity/ Severity of the Problem	A perception of how serious a health-risk is
21	Perceived severity	Pressure System Model	Belief about importance	Perception of how important the health condition to be avoided is
21	Perceived severity	Protection Motivation Theory	Severity	The appraised seriousness of the threat
21	Perceived severity	Terror Management Health Model	Relevance of behaviour for threat of creatureliness	The perceived importance of the health behaviour for reminders of threats associated with the creatureliness (a reminder of physicality) of the body
22	Perceived susceptibility	AIDS Risk Reduction Model	Perceived Susceptibility to HIV	Perception of one's personal risk of HIV
22	Perceived susceptibility	Ecological Model for Preventing Type 2 Diabetes	Perceived susceptibility	A subjective estimate of the likelihood of personally contracting the disease
22	Perceived susceptibility	Extended Parallel Processing Model	Perceived susceptibility	Perception of the likelihood that one is vulnerable to a threat
22	Perceived susceptibility	Health Action Process Approach	Perceived vulnerability	Belief relating to one's susceptibility to an outcome
22	Perceived susceptibility	Health Action Process Approach (Reformulation)	Perceived vulnerability	Perception of one's susceptibility to an outcome
22	Perceived susceptibility	Health Belief Model	Perceived susceptibility	The extent to which one believes one is at risk of contracting a particular disease or developing a particular health problem

No. Group	Group label	Theory	Label	Definition
22	Perceived susceptibility	Integrated Theoretical Model for Alcohol and Other Drug Abuse Prevention	Perceived Susceptibility/ Personal Susceptibility	Perception relating to the likelihood that one could experience the health threat
22	Perceived susceptibility	Pressure System Model	Belief about personal risk	Perception of one's personal risk of experiencing the health condition
22	Perceived susceptibility	Protection Motivation Theory	Vulnerability	One's perceived susceptibility to the threat
22	Perceived susceptibility	Prototype willingness model	Perception of vulnerability	Belief about the extent to which one is at risk from the risky behaviour
23	Value	Integrative Model of factors influencing smoking and health attitude and behaviour change	Value (preparation)	Moral, social or aesthetic principle accepted by an individual or society as a guide to what is good, desirable or important
23	Value	Integrative Model of Factors Influencing Smoking Behaviours	Value	Moral, social, or aesthetic principle accepted by an individual or society as a guide to what is good, desirable or important
23	Value	Model of Pro-Environmental Behavior	Value	Moral, social, or aesthetic principle accepted by an individual or society as a guide to what is good, desirable or important
23	Value	PRIME Theory	Value	Evaluation of broadly defined attributes of abstract concepts (e.g. justice)
23	Value	Problem Behaviour Theory	Value on academic achievement	Degree of positive or negative value placed on achieving educational goals
23	Value	Problem Behaviour Theory	Value on independence	Degree of positive or negative value placed on personal autonomy and unconventionality
23	Value	Theory of Triadic Influence	Health related value	Moral, social or aesthetic principle that concern one's health
23	Value	Value Belief Norm Theory	Altruistic value	Moral, social or aesthetic principle that stems from an apparently unselfish concern for others

No. Group	Group label	Theory	Label	Definition
23	Value	Value Belief Norm Theory	Egoistic value	Moral, social or aesthetic principle that stems from self-interest/self-enhancement motives
23	Value	Value Belief Norm Theory	Traditional value	Moral, social or aesthetic principle that stems from a set of social customs or other ethnic or family practices handed down from generation to generation (e.g. duty, family loyalty)
24	Choice and decision making	Diffusion of Innovations	Contingent innovation-decision	A choice to adopt or reject an innovation/behaviour that can only be made after a prior decision to adopt or reject
24	Choice and decision making	Diffusion of Innovations	Decision	The choice of whether to adopt or reject an innovation/behaviour
24	Choice and decision making	Diffusion of Innovations	Optional innovation-decision	Choice to adopt or reject an innovation/behaviour that are made by an individual, independent of the decisions made by other members within the social system
24	Choice and decision making	Goal directed theory	Choice among means	A decision to use a specific method or resource for goal achievement that has optimum or at least satisfactory levels of instrumentality, self-efficacy and affect
24	Choice and decision making	Goal directed theory	Decision with respect to means	Decision about how best to achieve a goal that are based on an appraisal of the relevant resources or methods (means) for goal achievement that are available
24	Choice and decision making	Integrated Theory of Health Behaviour Change	Decision making	The cognitive process of choosing between two or more alternatives
24	Choice and decision making	PRIME Theory	Choice	A process whereby alternative course of action are imagined and one of them selected through a process of reflective analysis
24	Choice and decision making	Prospect Theory	Choice	The selection of one prospect over another or others
24	Choice and decision making	Reflective Impulsive Model	Behavioural Decision	A decision made based on a feasibility assessment of the behaviour and the desirability of its possible outcomes
25	Drive	CEOS Theory	Drive	Generalised state of readiness precipitating or motivating courses of action
25	Drive	Differential Association Theory	Drive	Generalised state of readiness precipitating or motivating courses of action

No. Group	Group label	Theory	Label	Definition
25	Drive	Health behaviour internalisation model	External regulation	The drive to perform a behaviour to gain some reward or avoid some negative contingency, arising from either environmental circumstances or from another person
25	Drive	Social Learning Theory	Acquired drive	An elaboration of innate drives, serves as a façade behind which the functions of the underlying innate drives are hidden (e.g. fear, appetite)
25	Drive	Social Learning Theory	Drive	The motivation or desire to act or respond, a covert stimulus that triggers action
25	Drive	Transcontextual Model of Motivation	External regulation	The drive to perform a behaviour to gain some reward or avoid some negative contingency
25	Drive	Transcontextual Model of Motivation	Identified regulation	The drive to perform a behaviour because of the importance one ascribes to the behaviour
25	Drive	Transcontextual Model of Motivation	Intrinsic Motivation	The drive to perform a behaviour because the behaviour is consistent with other goals and values
25	Drive	Transcontextual Model of Motivation	Introjected regulation	The drive to perform a behaviour out of a sense of guilt or obligation or a need to prove something
26	Injunctive Norm	Consumption as Social Practices	Standard of comfort, cleanliness and convenience	A set of socially constructed, culturally shared and relatively stable social standards regarding acceptable levels of hygiene, etc.
26	Injunctive Norm	Differential Association Theory	Definition of legal codes	Favourable or unfavourable view on legal codes that is shared by members of a group (e.g. view on whether laws should be adhered to or violated).
26	Injunctive Norm	Focus Theory of Normative Conduct	Injunctive Norm	What is perceived as typically approved or disapproved of within a culture; the perceived moral rules of a group
26	Injunctive Norm	Focus Theory of Normative Conduct	Personal norm	Belief and/or value regarding what is appropriate and morally correct behaviour for oneself, involving personal expectations of self-criticism or self-approval following pro- or anti-norm actions
26	Injunctive Norm	Norm Activation Theory	Social norm	A norm relating to what is deemed to be acceptable behaviour in a group or society
26	Injunctive Norm	Social Consensus Model of Health Education	Social norm	The social expectation that groups maintain to define appropriate behaviour

No. Group	Group label	Theory	Label	Definition
26	Injunctive Norm	Social Norms Theory	Injunctive Norm	Socially determined consensual standard that describe one's attitudes, beliefs and morals in relation to a given situation (i.e. what most people think is 'right' to do)
26	Injunctive Norm	Theory of Interpersonal Behaviour	Norm	Belief that certain behaviours are correct, appropriate or desirable and other behaviours are incorrect, inappropriate, immoral or undesirable
26	Injunctive Norm	Theory of Interpersonal Behaviour	Role	Set of behaviours that is considered appropriate for persons holding particular positions in a group
27	Act-related affect	AIDS Risk Reduction Model	Aversive emotional state	Distress and other negative emotional state associated with behaviours that are perceived to be problematic
27	Act-related affect	Feedback Intervention Theory	Affective Process	An emotional reaction that is triggered by the presentation of feedback on one's performance on a task
27	Act-related affect	Feedback Intervention Theory	Feedback intervention-induced affect	An emotional reaction that is triggered by the presentation of feedback on one's performance on a task
27	Act-related affect	Health Promotion Model	Activity-related affect	The feeling or emotion experienced before, during or after a behaviour
27	Act-related affect	Health Promotion Model	Act-related (activity-related affect)	Emotional response to the behaviour itself
27	Act-related affect	Health Promotion Model	Self-related (activity-related affect)	Emotional response to oneself engaging in the behaviour
27	Act-related affect	I-Change Model	Emotional Pros & Cons	One's positive and negative feelings about the positive and negative consequences that may result from carrying out the behaviour
27	Act-related affect	Theory of Interpersonal Behaviour	Affect	The positive or negative emotion felt by the person at the idea of performing the act
28	Descriptive norm	Diffusion of Innovations	System norm	Established behaviour pattern for people within a social system
28	Descriptive norm	Focus Theory of Normative Conduct	Descriptive norm	What is perceived as typically done; what is perceived as 'normal' within a culture
28	Descriptive norm	Focus Theory of Normative Conduct	Provincial Norm	A sub-type of norm about what is perceived as typically done or 'normal' in a specific environment

No. Group	Group label	Theory	Label	Definition
28	Descriptive norm	Goal framing theory	Smart norm	Standard representing the typical performance of a group or a person and that are abstract, as opposed to concrete
28	Descriptive norm	PRIME Theory	Norm	A standard or range of values that represents the typical performance of a group against which comparisons can be made
28	Descriptive norm	Social norms theory	Actual norm	The real attitude held and behaviours exhibited by the majority of other people within a social group
28	Descriptive norm	Social norms theory	Descriptive norm	Socially determined consensual standards relating to the prevalence of the behaviour (i.e. perceptions of what most people actually do)
28	Descriptive norm	Theory of Normative Social Behaviour	Descriptive norm	Individual belief about the prevalence of a behaviour
29	Social learning	CEOS Theory	Imitation	The process of copying the behaviour of another person, group, or object, intentionally or unintentionally
29	Social learning	Diffusion of Innovations	Modelling	The process by which one or more individuals or other entities serve as examples that others will emulate
29	Social learning	Health Promotion Model	Modelling	Vicarious learning through observation of others' behaviour
29	Social learning	PRIME Theory	Imitation	A process by which thoughts, feelings and motivational states observed in others are internalised and replicated without the need for conscious awareness
29	Social learning	Protection Motivation Theory	Observational Learning	The acquisition of information, skills or behaviour through watching the performance of others
29	Social learning	Six Staged Model of Communication Effects	Role-Modelling	The process of emulating a behaviour displayed by another individual whom one identifies with or admires
29	Social learning	Social Learning Theory	Copying	Form of imitation that occurs when an observer seeks to optimize the accuracy of his/her behaviour to that of a model, whereby one brings one's behaviour to approximate that of a model and where one knows that this act is an acceptable replication of the model act; includes contingent rewards based on sameness and differences cues which are based on the closeness of the match between a model's and an observer's behavior

No. Group	Group label	Theory	Label	Definition
29	Social learning	Theory of Triadic Influence	Social learning	Process through which one's health-related behaviours can be shaped by observing and imitating the attitudes and behaviours of others to whom one is closely bonded
30	Motivation to comply	Action Theory Model of Consumption	Motivation to comply	A felt need to comply with the expectations of others
30	Motivation to comply	Information-Motivation-Behavioural Skills Model of Adherence Behaviour	Motivation to comply	Willingness to agree with referent others' opinions
30	Motivation to comply	Information-Motivation-Behavioural Skills Model of Adherence Behaviour	Social motivation	Motivation to engage in the behaviour arising from perceived social support from important others and willingness to comply with such others
30	Motivation to comply	Integrative Model of Behavioural Prediction	Motivation to comply	The extent to which a person feels pressure to act in accordance with those norms
30	Motivation to comply	Social influence model of consumer participation	We-intention	Commitment to engage in joint action with others
30	Motivation to comply	Systems Model of Health Behaviour Change	Motivation to comply (with social influence)	Willingness to exert physical or mental effort in order to act in accordance with others; can be exhibited either as conformity or rebellion/nonconformity
30	Motivation to comply	Theory of Planned Behaviour	Motivation to comply	The extent to which one cares about the approval or disapproval of referent individuals or groups
30	Motivation to comply	Theory of Triadic Influence	Motivation to comply	Willingness to exert physical or mental effort in order to act in accordance with others' normative beliefs
31	Planning	Action Theory Model of Consumption	Implementation Intention	A commitment to act that includes particular memory processes and specific execution rules; Has two forms: a contingent one focusing on a specific event happening and a forthcoming response (e.g., I will do X, if event Y occurs), and a planning one (i.e. one decides where, when, and how to act so as to achieve a goal)
31	Planning	CEOS Theory	Action schemata	Operationally controlled sub-components of scripts, which serve to guide action

No. Group	Group label	Theory	Label	Definition
31	Planning	Goal directed theory	Planning	The formulation of a mental representation of an intended action, such as an utterance or a complex movement, that is presumed to guide the individual in carrying out that action
31	Planning	Health Action Process Approach	Action plan	Detailed specification of how to perform an intended behaviour
31	Planning	Health Action Process Approach (Reformulation)	Action planning	The process by which detailed specifications of how to perform an intended behaviour are formed
31	Planning	I-Change Model	Action plan	The specific plan of a person to translate an intention into behaviour, including preparation plan, coping plan and plan enactment
31	Planning	Social Action Theory (Ewart)	Problem solving (strategy)	Strategy that provide guides for action in different circumstances
31	Planning	Social Action Theory (Ewart)	Process dimension	Processes by which action scripts are created or modified (i.e. by which one can transition to a new action state, thus changing behaviour)
32	Arousal	CEOS Theory	Arousal	The process by which systems are activated in preparation for either increased processing or action, or the level of such activation
32	Arousal	Classical Conditioning	Alertness	A state relating to the degree to which one is attending to information and ready for action
32	Arousal	Differential Association Theory	Motive	Physiological or psychological arousal that directs energy and attention towards a goal
32	Arousal	Feedback Intervention Theory	Arousal	A state of alertness and readiness for action
32	Arousal	PRIME Theory	Arousal	A generalised level of energy imparted to the motivational system
32	Arousal	Reflective Impulsive Model	Arousal	A state of alertness and readiness for action
32	Arousal	Self-Efficacy Theory	Emotion arousal	A state of excitement or energy expenditure linked to an emotion; elicited by stressful or demanding situations
33	Feeling	Affective events theory	Affective Reaction	Emotional reaction to an event

No. Group	Group label	Theory	Label	Definition
33	Feeling	CEOS Theory	Affect	An internal feeling state that can be positive (occurs when a goal has been attained, a source of threat has been avoided or the individual is satisfied with the current state of affairs) or negative (occurs when processes are under strain or otherwise out of balance)
33	Feeling	General Theory of Deviant Behaviour	Self-attitude	Positive and negative emotional experiences that result from perceptions and evaluations of one's own attributes and behaviour
33	Feeling	Goal directed theory	Affect towards means	Feeling toward the available resources and methods (means) for goal achievement
33	Feeling	Health Promotion Model	Context-related (activity-related affect)	Emotional response to the environment in which the behaviour occurs
33	Feeling	Rational Addiction Model	Stress	Negative emotion state caused by events (e.g. divorce, bereavement)
33	Feeling	Relapse Prevention Model	Cognitive dissonance	The experience of feeling conflict and guilt due to simultaneous contradictory beliefs, values, or ideas
34	Future-oriented negative feeling	Extended Parallel Processing Model	Fear	A negatively valenced emotion that is accompanied by a high level of arousal and elicited by a threat that is perceived to be significant and personally relevant
34	Future-oriented negative feeling	Feedback Intervention Theory	Anxiety	A mood state characterised by apprehension and somatic symptoms of tension in which an individual anticipates impending danger, catastrophe or misfortune
34	Future-oriented negative feeling	PRIME Theory	Anxiety	Negative emotion, feeling agitated by anticipated negative events
34	Future-oriented negative feeling	Protection Motivation Theory	Fear Arousal	The elicitation of fear caused by the detection of an imminent threat
34	Future-oriented negative feeling	Technology Acceptance Model	Computer anxiety	The level of apprehension or fear felt when faced with the possibility of using technology
34	Future-oriented negative feeling	Terror Management Theory	Anxiety	A mood state characterised by apprehension and somatic symptoms of tension in which one anticipates impending danger, catastrophe or misfortune
34	Future-oriented negative feeling	Terror Management Theory	Terror	A mood state characterised by intense and overwhelming fear

No. Group	Group label	Theory	Label	Definition
35	Group identity	Social Identity Theory	Self-reference	The process by which social groups provide their members with an identification of themselves in social terms
35	Group identity	Social Identity Theory	Social identity	An aspect of an individual's self-image that derives from the social categories to which he/she perceives him/herself as belonging; given by social groups to their members, based upon comparisons against members of other groups
35	Group identity	Social influence model of consumer participation	Cognitive component (of social identity)	Self-awareness in categorising oneself as a member of the group
35	Group identity	Social influence model of consumer participation	Evaluative component (of social identity)	An appraisal of self-worth based on membership of the group
35	Group identity	Social influence model of consumer participation	Social Identity	Sense of identification with, and membership of, the virtual community
35	Group identity	Theory of Normative Social Behaviour	Group Identity	A type of normative mechanism relating to one's social network that is construed in terms of aspirations to emulate referent others and the extent to which one perceives similarity between oneself and those referents
35	Group identity	Theory of Normative Social Behaviour	Similarity	The extent to which one perceives oneself to be similar to referent others
36	Perceived context	Health Action Process Approach	Perceived environment	Perception of the environment in which one exists
36	Perceived context	Health Promotion Model	Perceived situational influence	Perception of the environment in which a behaviour takes place, specifically how compatible or incompatible one feels one is with that environment
36	Perceived context	Social Ecological Model of Walking	Pleasurability	The level of appeal that a setting provides with respect to the experience of the behaviour
36	Perceived context	Systems Model of Health Behaviour Change	Perception of environmental factors	Belief about the variables in one's environment such as those that describe the health care system or the work environment
36	Perceived context	Technology Acceptance Model	Perception of external control	A belief about whether external resources are available to support the behaviour
36	Perceived context	Transcontextual Model of Motivation	Perceived autonomy support	The extent to which there is perceived to be environmental support in relation to independence and self-determination in an individual

No. Group	Group label	Theory	Label	Definition
36	Perceived context	Transtheoretical Model of Behaviour Change	Social Liberation	The process of noticing social, policy or environmental changes that facilitate health behaviour change
37	Self-regulation and control	CEOS Theory	Self-regulation	An activity of the Executive system that is designed to constrain or change the patterns of behaviour, particularly where this requires action in opposition to operationally generated action tendencies
37	Self-regulation and control	Health Action Process Approach	Action control	A self-regulatory process involved in the maintenance of a newly adopted behaviour (change), includes self-monitoring of behaviour
37	Self-regulation and control	Health Action Process Approach (Reformulation)	Action Control	A self-regulatory process involved in the maintenance of a newly adopted behaviour (change), includes self-monitoring of behaviour
37	Self-regulation and control	Health Behaviour Internalisation Model	Integrated self-regulation	The self-management of behaviour driven by the congruency between the behaviour and one's values and sense of self
37	Self-regulation and control	PRIME Theory	Inhibition	Blockade of action schemas
37	Self-regulation and Control	PRIME Theory	Self-control	A process whereby intentions are enacted in the face of desires or impulses arising from other sources
37	Self-regulation and control	Self-Regulation Theory	Self-regulation/self-regulatory process	The process by which people regulate or control their behaviour
38	Social interaction	Behavioural ecological Model of Adolescent AIDS Prevention	General community reaction	Response from the community in which one lives or works as a consequence of performing the behaviour
38	Social interaction	Differential Association Theory	Differential association	The balance of one's association with, or isolation from, criminal or non-criminal groups.
38	Social interaction	Integrated Theoretical Model for Alcohol and Other Drug Abuse Prevention	Interpersonal situation	Social interaction that will either facilitate or make behaviour change difficult (e.g. peer interaction, communication with parents or teachers and drug-avoiding socialising)
38	Social interaction	Integrated Theory of Drinking Behaviour	Social interaction	Social encounters with important others that may facilitate or hinder the behaviour

No. Group	Group label	Theory	Label	Definition
38	Social interaction	Social Action Theory (Ewart)	Social interaction process	Process that involves reciprocal stimulation or response between two or more individuals
38	Social interaction	Social Development Model	Association with non-delinquent peers	The act of associating with peer groups who do not violate social rules or conventions
38	Social interaction	Theory of Triadic Influence	Social Bonding	Process through which one establishes an affective relation between individuals
39	Associative learning	CEOS Theory	Conditioning	The process by which certain kinds of experience make operationally generated actions more or less likely
39	Associative learning	Integrative Model of Factors Influencing Smoking and Health Attitude and Behaviour Change	Habituation	The process through which smoking becomes habitual, through the repeated pairing of smoking with social and physiological reinforcement
39	Associative learning	PRIME Theory	Associative Learning	A process whereby patterns of brain activity representing perceptions, emotions or response organisation become linked so that, when a particular pattern occurs, another is made more likely to occur
39	Associative learning	PRIME Theory	Classical Conditioning	The process by which a stimulus acquires motivational significance as a result of being paired with one that already has that significance
39	Associative learning	PRIME Theory	Habituation	Reduced responsiveness as a result of repeated or continuing exposure to a stimulus
39	Associative learning	Social Learning Theory	Discrimination	The process by which people learn to distinguish between appropriate responses to similar but different cues depending on whether a generalised response is rewarded or not
40	Attention	CEOS Theory	Attention	The process by which executive processes become engaged with stimuli
40	Attention	Extended Information Processing Model	Attention	The extent to which people attend to the information being presented
40	Attention	Feedback Intervention Theory	Attention to the self	The direction of thought towards self-oriented higher-level goals

No. Group	Group label	Theory	Label	Definition
40	Attention	Feedback Intervention Theory	Locus of attention	The focus of one's attention one out of many goals a person may have at any given moment
40	Attention	Focus Theory of Normative Conduct	Norm focus	The degree to which attention is attracted to or focused on a norm at any given moment
40	Attention	Integrative Model of Health Attitude and Behaviour Change	Attention/Attend	The act of directing attention to a person, location, object or event which is presumed to increase processing of the attended information and make it more prominent in conscious awareness
41	Attributional process	Pressure System Model	Locus of Control	The extent to which one attributes valued outcomes or reinforcement to either internal or external circumstances.
41	Attributional process	Problem Behaviour Theory	Locus of Control	The extent to which one attributes valued outcomes or reinforcement to either internal or external circumstances.
41	Attributional process	Self-Regulation Theory	Attributional process	Process relating to assigning causality for events, which may include internal/external attribution
41	Attributional process	Self-Regulation Theory	External attribution	Attributing discrepancies (between the information about one's own behaviour gathered during the self- monitoring stage and one's standards for that behaviour) to an external cause
41	Attributional process	Self-Regulation Theory	Internal attribution	Attributing discrepancies (between the information about one's own behaviour gathered during the self- monitoring stage and one's standards for that behaviour) to an aspect of the individual
41	Attributional process	Value Belief Norm Theory	Ascription of responsibility	The belief that one's own actions have contributed to, or could alleviate, negative consequences to others
42	Memory	CEOS Theory	Associative Memory	Any experienced association linked to a remembered object or event
42	Memory	CEOS Theory	Episodic memory	A memory for specific, personally experienced events that happened at a particular time or place
42	Memory	CEOS Theory	Semantic memory	The set of associations generated by an object or idea, which in total constitute its meaning (implies more than consciously synthesised meaning)
42	Memory	Extended Information Processing Model	Memory	The retention of message content such that it can be reproduced or recalled

No. Group	Group label	Theory	Label	Definition
42	Memory	Extended Information Processing Model	Retention	The extent to which new information or knowledge is retained as a result of receiving a message
42	Memory	PRIME Theory	Memory	The process of storing and regenerating images and thoughts
43	Perceived barriers	Ecological Model for Preventing Type 2 Diabetes	Perceived cost	Belief about the costs of a behaviour or behaviour change
43	Perceived barriers	Health Belief Model	Perceived barrier	Belief about the negative aspects of taking health-protective action (e.g. inconvenience, expense, discomfort)
43	Perceived barriers	Health Promotion Model	Perceived barrier to action	Belief about barriers (e.g. lack of resources) to engaging in a behaviour, and personal cost associated with engaging in the behaviour
43	Perceived barriers	Protection Motivation Theory	Response Cost	The perceived cost associated with the protective behaviour (e.g. the amount of work involved in implementing the recommendation)
43	Perceived barriers	Systems Model of Health Behaviour Change	Belief about incentives/barriers for health behaviour	Perception about what will enhance or serve as a motive for, as well as what will restrict or impede, the behaviour (e.g. availability of programs)
43	Perceived barriers	Theory of Planned Behaviour	Control Belief	Belief about the presence or absence of factors that can facilitate or impede performance of the behaviour; assumed to determine perceived behavioural control
44	Perceived threat	Health Action Process Approach	Threat perception	Belief about the threat posed by a health risk; based on an interplay between perceptions of risk and severity
44	Perceived threat	Health Action Process Approach (Reformulation)	Risk perception	Perception of the threat posed by a health risk; based on an interplay between perceptions of risk and severity
44	Perceived threat	Health Belief Model	Perceived threat	A perception of the threat posed by a disease or health problem, based on one's perceived susceptibility to, and the perceived severity of, a disease or health problem
44	Perceived threat	I-Change Model	Risk perception	One's subjective assessment of the level of risk associated with a particular hazard, including severity and susceptibility

No. Group	Group label	Theory	Label	Definition
44	Perceived threat	Social Consensus Model of Health Education	Personal relevance	The extent to which a health threat is perceived to be relevant to an individual; determined by perceptions about the severity of the threat and personal susceptibility to it
44	Perceived threat	Value Belief Norm Theory	Awareness of consequences	The belief that environmental conditions pose threats to other people, other species and the biosphere
45	Perception	CEOS Theory	Perception	The process or result of becoming consciously aware of something by means of the senses
45	Perception	Control Theory	Perception	The process through which one makes perceptions about the current situation
45	Perception	Integrative Model of Factors Influencing Smoking Behaviours	Perceived physiological effect	Perceived sensation in the body resulting from smoking
45	Perception	PRIME Theory	Perception	Sensation together with their interpretation
45	Perception	Reflective Impulsive Model	Perception	Detection of a relevant stimulus linked directly to behaviour
45	Perception	Six staged model of communication effects	Perception of message relevance	The perception of a message as relevant or not relevant
46	Reinforcement	Behavioural ecological Model of Adolescent AIDS Prevention	Peer/social reaction	Response of individuals or social groups that occurs as a consequence of the behaviour and reinforces subsequent behaviours
46	Reinforcement	Integrative model of factors influencing smoking and health attitude and behaviour change	Physiological reinforcement for smoking	The process by which the sensations experienced as a result of smoking reinforce the behaviour (i.e. increase the frequency or probability of smoking)
46	Reinforcement	Integrative Model of Factors Influencing Smoking Behaviours	Social reinforcement	Positive interpersonal stimulus such as verbal praise, a smile, touch or other sign of approval that is received as a result of behaviour and increases the frequency of the behaviour that immediately precedes it
46	Reinforcement	Operant Learning Theory	Operant conditioning	A type of learning in which behaviour change occurs as a function of the consequences of behaviour

No. Group	Group label	Theory	Label	Definition
46	Reinforcement	PRIME Theory	Operant conditioning	The process by which a response becomes more or less likely as a result of stimuli that follow it
46	Reinforcement	Social Development Model	Reinforcement for Involvement	A contingency whereby interaction or involvement is rewarded to increase the frequency or probability of further involvement
47	Self-esteem	AIDS Risk Reduction Model	Global Self-esteem	The degree to which the qualities and characteristics contained within one's self-concept are perceived to be positive
47	Self-esteem	Pressure System Model	Self-esteem	The degree to which the qualities and characteristics contained in one's self-concept are perceived to be positive
47	Self-esteem	PRIME Theory	Self-esteem	The degree to which the qualities and characteristics contained in one's self-concept are perceived to be positive
47	Self-esteem	Problem Behaviour Theory	Self-esteem	The degree to which the qualities and characteristics contained in one's self-concept are perceived to be positive
47	Self-esteem	Social Identity Theory	Self-esteem	The degree to which the qualities and characteristics contained in one's self-concept are perceived to be positive
47	Self-esteem	Social influence model of consumer participation	Self-referent value	Value relating to the sense of worth, usefulness or importance primarily involving and referring to one's personal self
48	Social opportunity	COM-B	Social opportunity	Opportunity afforded by the social environment
48	Social opportunity	Needs-Opportunity-Abilities Model	Need for social justice	The extent to which the environment provides equal opportunities and the right to own and do things
48	Social opportunity	Problem Behaviour Theory	Parental Control	Personal and social control instigated by parents relating to the problem behaviour
48	Social opportunity	Problem Behaviour Theory	Social control	Characteristic of the social environment that serve to reduce proneness to problem behaviour
48	Social opportunity	Social Development Model	Opportunity for involvement	The extent to which one has the opportunity for social involvement which influences the behaviour
48	Social opportunity	Social Ecological Model of Behaviour Change	Social (constraint)	A restriction relating to society that limits human capacity to act

No. Group	Group label	Theory	Label	Definition
49	Support from social network	Integrative Model of factors influencing smoking and health attitude and behaviour change	Social reinforcement	Positive interpersonal stimulus such as verbal praise, a smile, touch or other sign of approval that increases the frequency of the behaviour that immediately precedes it
49	Support from social network	Problem Behaviour Theory	Friends approval of problem behaviour	The extent to which one's friends believe that the problem behaviour is good or acceptable
49	Support from social network	Problem Behaviour Theory	Friends support	Support or approval shown by friends for the problem behaviour
49	Support from social network	Problem Behaviour Theory	Parent approval of problem behaviour	The extent to which one's parents believe that the problem behaviour is good or acceptable
49	Support from social network	Problem Behaviour Theory	Parental support	Support or approval shown by parents for the problem behaviour
49	Support from social network	Theory of Normative Social Behaviour	Social Approval	Positive appraisal and acceptance by one's social group for the behaviour from important referents
50	Subjective decisional balance	Ecological Model for Preventing Type 2 Diabetes	Incentive	The extent to which perceived consequences of behaviour change are personally valued
50	Subjective decisional balance	Integrative Model of Behavioural Prediction	Behavioural Belief	Evaluation of the possible outcomes of the behaviour (e.g. belief that the behaviour will lead to positive outcomes and prevent negative ones)
50	Subjective decisional balance	Integrative Model of Behavioural Prediction	Evaluative aspect	Appraisal about how desirable or undesirable the outcomes of a behaviour will be
50	Subjective decisional balance	Motivation-Opportunities-Abilities	Evaluation of outcomes	Positive or negative belief about the consequences of engaging in the behaviour
50	Subjective decisional balance	Norm activation theory	Social cost	A social cost and benefit associated with a line of action that is guided by social norms and includes anticipations of praise, blame, promotion and prosecution from those in one's social network
50	Subjective decisional balance	Prospect Theory	Subjective value	The extent to which one perceives an outcome as valuable; may be strictly positive, strictly negative or neither

No. Group	Group label	Theory	Label	Definition
51	Appraisal of alternatives	Action Theory Model of Consumption	Desirability and feasibility of goals	An assessment of the relative appeal and practicability of a variety of goals
51	Appraisal of alternatives	Goal directed theory	Appraisal of Means	An evaluation of the resources or methods (means) that are available to facilitate goal achievement
51	Appraisal of alternatives	Prospect Theory	Coding	The process through which outcomes are sorted into gains or losses
51	Appraisal of alternatives	Prospect Theory	Editing phase	Stage at which a preliminary analysis of available prospects is conducted, and options are organised and reformulated
51	Appraisal of alternatives	Risk as Feelings Theory	Cognitive evaluation	Evaluation of risky alternatives at a cognitive level (based largely on the probability and desirability of associated consequences)
51	Appraisal of alternatives	Transtheoretical Model of Behaviour Change	Decisional balance	The process through which the pros and cons of behaviour change are evaluated
52	Commitment	AIDS Risk Reduction Model	Commitment to change	The decision-making process to reach a firm decision to reduce high risk behaviour and increase low risk behaviour
52	Commitment	CEOS Theory	Commitment	Executive strategy that imposes rules, whereby one feels more obligated or emotionally impelled to engage in a behaviour
52	Commitment	Goal directed theory	Commitment (to a goal and to the means for goal attainment)	The 'binding' of someone to a decision to try to achieve a goal and to use certain means to do so
52	Commitment	Health Promotion Model	Commitment to plan of action	The state or quality of being dedicated to carrying out a particular behaviour in a particular context despite any competing desires; includes the formation of strategies for successfully performing the behaviour
52	Commitment	Relapse Prevention Model	Commitment	The extent of one's dedication to abstinence
53	Introjected regulation	Norm Activation Theory	Accountability	The feeling that there is a responsibility to respond because one is made liable for the outcomes of the person in need
53	Introjected regulation	Norm Activation Theory	Activation of norms	The point at which there is a heightened sense of obligation to respond to need based on previously established norms.

No. Group	Group label	Theory	Label	Definition
53	Introjected regulation	Norm Activation Theory	Arousal of some sense of responsibility to respond	The elicitation of a feeling of a sense of obligation to help a person in need, may occur in response to various conditions
53	Introjected regulation	Norm Activation Theory	Causal responsibility	The feeling that there is a responsibility to respond when one is at fault for causing another person's need
53	Introjected regulation	Value Belief Norm Theory	Personal moral norm	The perception that one is personally obligated to act
54	Locus of causality	Relapse prevention model	Personal attribution (relapse prevention model)	An inference in which one blames oneself as being the cause of the relapse
54	Locus of causality	Self-Determination Theory	Perceived locus of causality	Mental representation of the degree to which one's behaviour is regulated by one's true self
54	Locus of causality	Self-Regulation Theory	Perception of control	The extent to which one believes that one's behaviour is under one's own control
54	Locus of causality	Theory of Triadic Influence	Self determination	A sense of control of one's behaviours by internal convictions and decisions rather than by external demands
54	Locus of causality	Transcontextual Model of Motivation	Autonomous motivation/locus of causality	The relative degree of independence [of the behaviour] perceived by the individual
55	Sensation	CEOS Theory	Sensation	Unit of experience referring to the aspects of sensory inputs that is reacted to by Operational processes (c/f perception where there is conscious awareness)
55	Sensation	Integrative Model of Factors Influencing Smoking and Health Attitude and Behaviour Change	Physiological reaction to smoking	The physical sensation experienced as a result of smoking
55	Sensation	PRIME Theory	Discomfort	Unpleasant sensation arsing from senses, images or thoughts
55	Sensation	PRIME Theory	Pain	Aversive sensation arsing from pain receptors
55	Sensation	PRIME Theory	Sensation	Feeling arising from senses or imagined experiences, without interpretation
56	Reference value	Control Theory	Principle control	The reference value at the second highest level of the hierarchical system that serves as a guiding principle to describe how people self-regulate with respect to system concepts

No. Group	Group label	Theory	Label	Definition
56	Reference value	Control Theory	Program control	The reference value at the third highest level of the hierarchical system that specifies a course of action required, and that is particularly important for self-regulation
56	Reference value	Control Theory	Reference value	The standard against which one's current behaviour is compared (e.g. a desired behaviour or state)
56	Reference value	Control Theory	System concept	The reference value at the highest level of the hierarchical system that represents the desired self-image
56	Reference value	Social Action Theory (Ewart)	Self-standard	Level of quality against which one judges one's efforts towards goal attainment
57	Self-administered strategy	CEOS Theory	Restructuring personal environments	Actions to change the rules and/or structure of one's own personal environment, including the other actors who are part of it
57	Self-administered strategy	Integrated Theory of Health Behaviour Change	Self-Monitoring	A strategy in which individuals keep a personal behaviour record, typically in connection with efforts to change or regulate the self
57	Self-administered strategy	Reflective Impulsive Model	Avoidance	The practice or instance of increasing the distance between oneself and the environment or removal of the aspect of the environment altogether
57	Self-administered strategy	Self-Regulation Theory	Self-Reinforcement	Process by which one self-administers a reward (either tangible or internal) for attaining a goal
57	Self-administered strategy	Transtheoretical Model of Behaviour Change	Stimulus Control	The process through which the environment is restructured (e.g. by the individual) such that cues for problem behaviours are reduced and cues for healthier behaviours increased
58	Socially shared norm	AIDS Risk Reduction Model	Social norm	A socially determined consensual standards that indicates (a) what behaviours are considered typical in a given context and (b) what behaviours are considered proper in the context
58	Socially shared norm	Social change theory	Norm	Shared rule and expectation that govern everyday life
58	Socially shared norm	Social Consensus Model of Health Education	Consensual belief	A shared agreement of certain beliefs within one's social network

No. Group	Group label	Theory	Label	Definition
58	Socially shared norm	Social Consensus Model of Health Education	Social belief	Socially shared body of tenets held by a group
58	Socially shared norm	Social influence model of consumer participation	Mutual agreement	Mutual understanding among group members to engage in the behaviour
59	Addiction	Information-Motivation-Behavioural Skills Model of Adherence Behaviour	Substance use/Addiction	A chronic condition involving a repeated powerful motivation to engage in a rewarding behaviour, acquired as a result of engaging in that behaviour, that has significant potential for unintended harm
59	Addiction	PRIME Theory	Addiction	A chronic condition involving a repeated powerful motivation to engage in a rewarding behaviour, acquired as a result of engaging in that behaviour, that has significant potential for unintended harm
59	Addiction	Rational Addiction Model	Addiction (harmful vs beneficial)	A process in which the current consumption of a product increases its future consumption.
59	Addiction	Rational Addiction Model	Adjacent complementarity	The process of becoming addicted to a substance that results from past consumption of the substance raising the marginal utility of current consumption, and the current consumption raising the marginal utility of future consumption (i.e. similar to the idea of classic reinforcement)
60	Awareness	Extended Information Processing Model	Awareness	One's consciousness of a persuasive message
60	Awareness	Integrative Model of Health Attitude and Behaviour Change	Awareness	A consciousness of internal or external events or experiences
60	Awareness	Norm Activation Theory	Awareness of need	Awareness of the possible or actual deprivation of a necessary or wanted resource of another individual, group, or entity
60	Awareness	Reflective Impulsive Model	Experiential state of awareness	Experience of a feeling with a distinct phenomenal quality without necessarily knowing it's origin e.g. a feeling of knowing
61	Desire	Action Theory Model of Consumption	Desire	A feeling of want or need

No. Group	Group label	Theory	Label	Definition
61	Desire	PRIME Theory	Motive/desire	Mental representation of different entities and the degree of attraction attached to them
61	Desire	PRIME Theory	Want	Attraction to things on the basis of feelings of anticipated pleasure of satisfaction attached to them
61	Desire	Social influence model of consumer participation	Desire	Feeling of wanting or needing to engage in the behaviour
62	Positive feeling	Behavioural ecological Model of Adolescent AIDS Prevention	Sexual Pleasure	Positive feelings associated with sexual activities
62	Positive feeling	Feedback Intervention Theory	Pleasantness	A conscious, hedonic state, typically deemed highly desirable, that is experienced when an event is congruent with one's goals or is associated with pleasure
62	Positive feeling	PRIME Theory	Happiness	Positive emotion, feeling of wellbeing
62	Positive feeling	PRIME Theory	Pleasure	Sensation of enjoyment
63	Financial availability	Integrated Theory of Drinking Behaviour	Economic Availability	The extent to which it is financially viable to access alcohol (i.e. the retail price of alcohol in relation to disposable income)
63	Financial availability	Needs-Opportunity-Abilities Model	Financial (ability)	The financial element required for engaging in behaviour (e.g. income, credit, loans)
63	Financial availability	Needs-Opportunity-Abilities Model	Need for money	Need for financial means to buy and do things that are necessary and enjoyable
63	Financial availability	Social Ecological Model of Behaviour Change	Economic (constraint)	Financial restriction limiting human capacity to act
64	Intention formation	Action Theory Model of Consumption	Goal intention	A consciously made decision to pursue a desired end state
64	Intention formation	Health Action Process Approach	Intention formation	The process by which a conscious decision is made to perform the behaviour
64	Intention formation	Integrated Theory of Health Behaviour Change	Planning	The action or process of forming or arranging an intention to do something

No. Group	Group label	Theory	Label	Definition
64	Intention formation	Systems Model of Health Behaviour Change	Intention formation process	The process by which a self-conscious plan to engage or not engage in a given health behaviour is formed
65	Monitoring	CEOS Theory	Reflection/Evaluation	Process by which executive processes provide feedback in relation to goal achievement or the appropriateness of goals or strategies
65	Monitoring	Goal directed theory	Guidance and control processes	The evaluation of barriers to goal achievement, failures to make progress towards a goal and perceived external factors that may prevent goal achievement
65	Monitoring	Health Action Process Approach (Reformulation)	Coping planning	The anticipation of potential barriers to action and the generation of behavioural options to overcome these barriers
65	Monitoring	Self-Regulation Theory	Evaluation in respect to goals	The view of one's behaviour with respect to short-term and/or long-term desired end states
66	Rule	CEOS Theory	Rule/plan	A self-imposed standard, guideline and/or restriction on executive-driven behaviour
66	Rule	PRIME Theory	Personal rule	Imperative about what we do and not do
66	Rule	Self-Regulation Theory	Standard	The personal rule by which one judges one's own behaviour
66	Rule	Theory of Interpersonal Behaviour	Rule of behaviour	A guideline or standard that determines how a person behaves in specific social situations
67	Urge	CEOS Theory	Action Tendency	Urge that, if not inhibited, results in some form of behaviour (expressive or instrumental); required to allow for interruption and thus modification of the pathway between the ways inputs are processed and outputs
67	Urge	CEOS Theory	Urge/Impulse to Act	Subjective feeling of impulse to engage in an action that arises when the impulse is not immediately acted upon
67	Urge	PRIME Theory	Impulse	Organised action schemas that are the immediate precursors to responses
67	Urge	PRIME Theory	Urge	A subjective feeling of impulse to engage in an action that arises when the impulse is not immediately acted upon
68	Capability	COM-B	Physical capability	Physical capacity to engage in the activity concerned

No. Group	Group label	Theory	Label	Definition
68	Capability	I-Change Model	Ability factor	Factor relating to one's capability of undertaking a given behaviour
68	Capability	Information-Motivation-Behavioural Skills	Public Prevention Act	The ability to carry out disease relevant protective behaviours that must be performed out in the open or not in completely private settings (e.g. purchasing condoms and undergoing HIV testing)
68	Capability	Pressure System Model	Capability to change	The ability or capacity to make a change in the behaviour
69	Discrepancy resolution	Feedback Intervention Theory	Changing the standard	A strategy for reducing the discrepancy between one's current state and goal state, whereby one changes the goal state or the standard for goal achievement
69	Discrepancy resolution	Feedback Intervention Theory	Rejecting the Feedback	A strategy for reducing the discrepancy between one's current state and goal state, whereby one dismisses the feedback that indicates such a discrepancy exists (i.e. reduces the perceived, not actual, discrepancy)
69	Discrepancy resolution	Integrated Theory of Health Behaviour Change	Goal congruence	The resolution of confusion and anxiety arising from any competing demands associated with one's health goals
69	Discrepancy resolution	PRIME Theory	Dissonance Reduction	The process by which a person reduces the uncomfortable psychological state that results from inconsistency among elements of a cognitive system
70	Heuristic	Information-Motivation-Behavioural Skills Model of Adherence Behaviour	Adherence-related heuristic	Strategy for problem solving/decision-making that provide an efficient means for making somewhat automatic decisions regarding the behaviour
70	Heuristic	Prospect Theory	Certainty effect	The tendency to overweight outcomes considered to be certain compared to outcomes that are presented as probabilistic
70	Heuristic	Prospect Theory	Isolation effect	The tendency to ignore the shared characteristics of presented alternatives and focus on the differences between them in order to simplify choices.
70	Heuristic	Prototype Willingness Model	Social reaction path	A heuristically-based decision making path that is image-based and involves more heuristic processing
71	Learning	Classical Conditioning	Conditioned reflex	A learned stimulus-response association
71	Learning	Differential Association Theory	Learning	The process of acquiring new and relatively enduring information, behaviour patterns, or abilities, characterised by modification of behaviour as a result of practice, study or experience

No. Group	Group label	Theory	Label	Definition
71	Learning	Integrative Model of factors influencing smoking and health attitude and behaviour change	Learning	Feature of the experimentation phase in which one learns how to handle the cigarette, how to inhale correctly, and what the different effects are under different conditions
71	Learning	Social Learning Theory	Generalisation	The process by which the effects of learning in one situation are transferred to another
72	Physical opportunity	COM-B	Physical Opportunity	Opportunity afforded by the physical environment
72	Physical opportunity	Integrated Theory of Drinking Behaviour	Physical Availability	The extent to which alcohol is physically available (e.g. proximity to stores selling alcohol)
72	Physical opportunity	Social Ecological Model of Behaviour Change	Physical (constraint)	Physical restriction limiting human capacity to act
72	Physical opportunity	Social Ecological Model of Walking	Affordance	The environmental property that allows the behaviour to occur
73	Social embeddedness	Differential Association Theory	Intensity	The intensity of one's association with criminal or non-criminal groups (e.g. group prestige, emotions associated with specific groups).
73	Social embeddedness	Integrated Theory of Drinking Behaviour	Social Integration	The degree to which one is embedded in, or part of, a social network (e.g. connectedness, bonding)
73	Social embeddedness	Social Development Model	Attachment	The extent to which one is attached to conventional society
73	Social embeddedness	Social influence model of consumer participation	Affective component (of social identity)	A sense of attachment and involvement in the group
74	Stimulus	Relapse Prevention Model	Covert Antecedent	Event, circumstance or stimulus that precedes a relapse, that is not directly observable
74	Stimulus	Self-Determination Theory	External regulation	The regulation of behaviour by external factors (e.g., rewards and punishments)
74	Stimulus	Self-Regulation Theory	Cue	Stimulus that arises from the person's cognitions and/or goals and serves to guide behaviour by signalling likely consequences

No. Group	Group label	Theory	Label	Definition
74	Stimulus	Social Learning Theory	Cue	Stimulus that serves to guide behaviour, determines when/where a person will respond, and which response he/she will make
75	Temporal orientation	Rational Addiction Model	Future-oriented	An attitude characterised by a focus on long-term goals and outcomes
75	Temporal orientation	Rational Addiction Model	Myopia	Near-sightedness such that one is more present-focused than future-oriented
75	Temporal orientation	Rational Addiction Model	Present-oriented	An attitude characterised by a focus on short-term benefits and outcomes
75	Temporal orientation	Rational Addiction Model	Time preference	The extent to which one's attitude is present or future-oriented
76	Expectation about social relatedness	Problem Behaviour Theory	Expectation for academic achievement	High or low expectations one holds in relation to academic recognition
76	Expectation about social relatedness	Problem Behaviour Theory	Expectation for affection	High or low expectations one holds in relation to experiencing feelings of tenderness and attachment
76	Expectation about social relatedness	Problem Behaviour Theory	Expectation for independence	A high or low expectation one holds in relation to personal autonomy and unconventionality
77	Feedback mechanism	Control Theory	Comparator	The mechanism through which perceived current conditions are compared against a particular standard
77	Feedback mechanism	Health Behaviour Goal Model	Feedback mechanism	Process whereby current behaviour is compared against an emotional or behavioural standard in order to modify subsequent goal-directed behaviour
77	Feedback mechanism	Self-Regulation Theory	Self-evaluation	The process of appraising behaviour gathered during the self-monitoring stage and comparing against the set standards for that behaviour
78	Image	CEOS Theory	Image	A visual representation of objects or events
78	Image	PRIME Theory	Image	Iconic mental representation (i.e. one that represents images and other sensory experiences)
78	Image	PRIME Theory	Mental Representation	Image (not necessarily visual) and propositions representing states of the internal and external environment

No. Group	Group label	Theory	Label	Definition
79	Learning associated with presented pattern	Operant Learning Theory	Operant Extinction	The process in which reinforcement for an operation behaviour has stopped and the frequency of that behaviour decreases
79	Learning associated with presented pattern	PRIME Theory	Sensitisation	An increase in magnitude of a response as a result of continued or repeated exposure to the stimulus
79	Learning associated with presented pattern	Social Learning Theory	Extinction	The decrease in the tendency for a response to be performed when it repeatedly goes without reward
80	Perceived health	Information-Motivation-Behavioural Skills Model of Adherence Behaviour	Subjective health	Individual perceptions relating to one's health
80	Perceived health	Systems Model of Health Behaviour Change	Health Belief	Perception of one's health, specifically relating to susceptibility / vulnerability; arises from perception of health status
80	Perceived health	Systems Model of Health Behaviour Change	Perception of Health Status	Belief regarding the current state of one's health
81	Satisfaction	Goal setting theory	Satisfaction	The state or fact of being contented, pleased, gratified
81	Satisfaction	PRIME Theory	Satisfaction	Sensation of contentment or fulfilment
81	Satisfaction	Rational Addiction Model	Utility	The total satisfaction received from consuming a good or service
82	Selection of peers	Integrative Model of factors influencing smoking and health attitude and behaviour change	Selection of peers	The choice of people you consider yourself equal/very similar to in terms of status/ability
82	Selection of peers	Integrative Model of factors influencing smoking and health attitude and behaviour change	Selection of significant others	The selection of individuals who have substantial influence on one's behaviour or self-opinion

No. Group	Group label	Theory	Label	Definition
82	Selection of peers	Integrative Model of Factors Influencing Smoking Behaviours	Selection of peers	The choice of people you consider yourself equal/very similar to in terms of status/ability
83	Action script	CEOS Theory	Action script (Strategy)	Cognitive structure that directs the implementation of a goal or other chosen action
83	Action script	Social Action Theory (Ewart)	Action script	A scripted behaviour chain in which one behaviour within a sequence reinforces the previous action and guides the next
83	Action script	Social Action Theory (Ewart)	Goal structure	Cluster of action scripts directed toward some greater goal
84	Categorisation	Reflective Impulsive model	Propositional categorisation	Categorisation through which semantic concepts emerge from the impulsive system
84	Categorisation	Social Consensus Model of Health Education	Stereotype	A set of cognitive generalisations about the qualities and characteristics of the members of a particular group or social category
84	Categorisation	Social Identity Theory	Social categorisation	The process of using cognitive tools that serve to provide order and classification to the social environment
85	Energy state	CEOS Theory	Fatigue	A usually transient state of discomfort and loss of efficiency as a normal reaction to emotional strain, physical exertion, boredom or lack of rest
85	Energy state	Feedback Intervention Theory	Depletion of cognitive resources	The reduction in cognitive resources that occurs as a result of directing attention to higher-level, self-oriented goals
85	Energy state	PRIME Theory	Mental energy/ego depletion	Mental energy needed for the exercise of self-control
86	False belief about social groups	Social Norms Theory	False Consensus	The tendency to incorrectly assume that one's behaviours and thoughts are more widely shared by the majority of other members of the group than is actually the case
86	False belief about social groups	Social Norms Theory	False uniqueness	The tendency to incorrectly believe that one's thoughts or behaviours are more unique than those of one's peers

No. Group	Group label	Theory	Label	Definition
86	False belief about social groups	Social Norms Theory	Pluralistic ignorance	The state of affairs in which the majority of members of a group believe that the majority of their peers think or act differently to themselves (i.e. the majority falsely believe themselves to be in the minority)
87	Feeling towards stimulus	PRIME Theory	Disliking	Feeling negative about something
87	Feeling towards stimulus	PRIME Theory	Liking	Feeling positive about something
87	Feeling towards stimulus	Regulatory Fit Theory	Value (theory of regulatory fit)	An experience of the attraction toward or repulsion from something whose intensity is a function of the strength of hedonic pleasure or pain and the strength of engagement
88	Interpersonal dynamic	Relapse Prevention Model	Interpersonal conflict	On-going or recent conflict in an interpersonal relationship such as a marriage or friendship
88	Interpersonal dynamic	Social influence model of consumer participation	Mutual accommodation	Inclination to mutually accommodate participants' schedules, preferences and commitments with others' in order to be able to engage in group action.
88	Interpersonal dynamic	Transtheoretical Model of Behaviour Change	Helping relationship	Relationship characterised by openness, trust and empathy, which is supportive with regard to the problem behaviour and health behaviour change
89	Schema	Reflective Impulsive Model	Propositional representation	Representation that connects one or more elements through the instantiation of relational schemata to which a truth value is attached
89	Schema	Reflective Impulsive Model	Relational schemata	Mental representation that connects knowledge in the reflective system
89	Schema	Terror Management Theory	Cultural worldview/cultural drama	A mental framework within which one can imbue the universe with order, predictability, meaning and permanence
90	Communication	Behavioural ecological Model of Adolescent AIDS Prevention	Communication with others	The transmission of information between oneself and another, or multiple others
90	Communication	Differential Association Theory	Communication	The transmission of information from one person or source to another, which may be by verbal (oral or written) or nonverbal means
91	Comprehension	Integrative Model of Health Attitude and Behaviour Change	Comprehension	The process of understanding communications, objects, events, or situations with respect to meaning, significance, relationships, or general principles

No. Group	Group label	Theory	Label	Definition
91	Comprehension	Six Staged Model of Communication Effects	Comprehension	Learning process through which the educational content (e.g. of a communication) is understood
92	Feedback	Regulatory Fit Theory	Regulatory Fit	An experiential phenomenon whereby the manner of one's engagement in an activity sustains one's goal orientation or interests regarding that activity
92	Feedback	Theory of Triadic Influence	Feedback	Process by which personal experiences provide information for, and influence, future behaviours
93	Habit	Motivation-Opportunities-Abilities	Habit	A routine that allows specific behaviours to be performed automatically with minimal conscious effort
93	Habit	Theory of Interpersonal Behaviour	Habit	A well-learned behaviour or automatic sequence of behaviours that is relatively situation specific and over time has become motorically reflexive and independent of motivational or cognitive influence; Reflected by the number of times a person has previously performed the act
94	Self-monitoring	Self-Regulation Theory	Self-Monitoring	A self-observational process of assessing current behaviour
94	Self-monitoring	Theory of Interpersonal Behaviour	Self-Monitoring	A process involving self-observation and self-control with the aim of maintaining situation-appropriate behaviour
95	Service availability	Information-Motivation-Behavioural Skills Model of Adherence Behaviour	Access to medical care	The extent to which one can obtain health-related services
95	Service availability	Six Staged Model of Communication Effects	Availability and accessibility of necessary service	The extent to which relevant service (e.g. family planning service) is easily available/accessible
96	Temporal constraint	Needs-Opportunity-Abilities Model	Temporal (ability)	The availability of time in which to engage in behaviour
96	Temporal constraint	Social Ecological Model of Behaviour Change	Time (constraint)	Time restriction limiting human capacity to act
97	Behavioural option	Health Promotion Model	Competing demand	Alternative behaviour that intrude into a person's thoughts one has no control over (e.g. childcare responsibilities)

No. Group	Group label	Theory	Label	Definition
97	Behavioural option	Health Promotion Model	Competing preference	An alternative behaviour that interludes consciousness over which one has control, but that has highly reinforcing properties
98	Inference	PRIME Theory	Inference	Mental process by which beliefs are created using deduction and induction
98	Inference	Reflective Impulsive Model	Syllogistic rule	Applying a rule that describes the transfer of truth from a premise to a conclusion
99	Interdependent script	Social Action Theory (Ewart)	Interlinked scripts	Scripted behaviour (i.e. action) chains that have become connected; occurs among people in close social relationships
99	Interdependent script	Social Action Theory (Ewart)	Social Interdependence	A state in which action scripts are interlinked, meaning that someone in a close social relationship has the potential to influence another's action sequences
100	Motivational orientation	Regulatory Fit Theory	Prevention focus	A motivational orientation that is concerned with the presence or absence of negative outcomes
100	Motivational orientation	Regulatory Fit Theory	Promotion focus	A motivational orientation that is concerned with the presence or absence of positive outcomes
101	Present negative feeling	PRIME Theory	Depression	Negative emotion, feeling low in oneself
101	Present negative feeling	PRIME Theory	Sadness	Negative emotion, feeling miserable or low
102	Observation of others	I-Change Model	Social modelling belief	Observation of others carrying out the behaviour
102	Observation of others	Self-Efficacy Theory	Vicarious experience (of mastery)	Observation of others successfully performing the behaviour or engaging in threatening activities without the expected adverse consequences
103	Perceived availability of behavioural options	General Theory of Deviant Behaviour	Perceived availability of alternative, self-enhancing deviant behaviour pattern	Perception of the availability of alternative behaviour patterns that enhance one's evaluations of oneself but that deviate significantly from what is considered appropriate or typical for a social group
103	Perceived availability of behavioural options	General Theory of Deviant Behaviour	Perceived availability of alternative, self-enhancing normative behaviour patterns	Perception of the availability of alternative behaviour patterns that enhance one's evaluations of oneself and are in line with the standards of typical behaviour for other individuals, groups or society
104	Repression of information	Model of Pro-Environmental Behavior	Prevention of learning by existing values	A process by which existing values prevent or reduce the acquisition of new information

No. Group	Group label	Theory	Label	Definition
104	Repression of information	Terror Management Health Model	Threat-avoidance outcome	Reaction aimed at minimising attention to the health danger or suppressing the threatening cognitions with which the health threat is associated

Appendix 3-8. The label and definitions of ungrouped MoAs, and theories these were extracted from

No.	Theory	Ungrouped MoA label	Ungrouped MoA definition
1	Transtheoretical Model of Behaviour Change	Self-liberation	The process through which one comes to believe in one's ability to change a particular behaviour and one's commitment to act on that belief
2	Norm Activation Theory	Personal norm	Norm related to one's self-concept
3	CEOS Theory	Approach	A basic preconsciously generated reaction to a stimulus as potentially desirable
4	Terror Management Theory	Faith in the cultural drama	Maintaining loyalty, belief and trust in the reality, significance and permanence of cultural drama
5	Integrated Theory of Health Behaviour Change	Plan enactment	The process of putting plans into action
6	Extended Parallel Processing Model	Defensive motivation	The process by which one becomes motivated to cope with feelings of fear
7	Social Learning Theory	Innate reward	Events producing a reduction in drive (e.g. lessened hunger)
8	Social Influence Model of Consumer Participation	Self-discovery	Value involving personal understanding gained through interacting with others
9	Reflective Impulsive Model	Approach	The practice or instance of decreasing the distance between oneself and an aspect of the environment
10	Terror Management Health Model	Non-conscious death thought activation	The arousal of death-related cognitions that are outside of one's conscious awareness
11	Self-Determination Theory	Introjection	The process whereby an external regulation is "partially" internalised such that it essentially retains its original form, and thus is not accepted as one's own (e.g. Contingent self-esteem and ego-involvement)
12	Feedback Intervention Theory	Task-learning process	Feedback process (i.e. the perception of a discrepancy between one's current outcome and one's desired end state and one's efforts to reduce that discrepancy) relating to the specific details of a focal task, positioned at the lower end of a hierarchy of negative feedback loops
13	Prototype willingness model	Behavioural willingness	Openness to engaging in the risky behaviour
14	The perceived difficulty of understanding, using or performing an innovation/behaviour	Complexity	The perceived difficulty of understanding, using or performing an innovation/behaviour
15	Change Theory	Unfreezing	Overcoming inner resistance to change such that one is ready to change, 'breaking the habit'
16	Theory of Interpersonal Behaviour	Goal	The outcome of a combination or sequence of a number of acts
17	Extended Information Processing Model	Acceptance/yielding	The extent to which the content of a message is accepted and retained

No.	Theory	Ungrouped MoA label	Ungrouped MoA definition
18	Problem Behaviour Theory	Behavioural proneness	A dynamic state that specifies the likelihood of occurrence of the problem behaviour from within the behavioural system; consists of higher involvement in other problem behaviours than the one being predicted or explained, and lower involvement in conventional behaviour.
19	Health Action Process Approach	Felt Social Pressure	Perception of the expectations of others
20	Feedback Intervention Theory	Task-motivation process	Negative feedback process (i.e. the perception of a discrepancy between one's current behaviour and one's desired end state and one's efforts to reduce that discrepancy) that relates to a focal task
21	Transtheoretical Model of Behaviour Change	Counter conditioning	The process of adopting healthier behaviours as substitutes for problem behaviours
22	Goal directed theory	Monitoring activity	The assessment of how successful the methods of goal achievement a person has chosen will be, and consideration of whether additional contingencies, barriers or facilitators should be factored into decision-making.
23	Reflective Impulsive Model	Intending	Process that monitors the impulsive system for information, enabling the behavioural implementation of the decision.
24	Social influence model of consumer participation	Purposive value	Value derived from achieving an instrumental or informational goal
25	Self-Efficacy Theory	Performance accomplishment	The extent to which prior experiences of performing the behaviour have been successful
26	Problem Behaviour Theory	Conventional behaviour structure	Interconnected set of conventional behaviours
27	Extended Information Processing Model	Comprehension (and memory)	The extent to which the message is understood and remembered
28	Social Action Theory (Ewart)	Action-outcome feedback loop	A representation in which self-regulation is a condition of a self-sustaining, dynamic equilibrium between self-protective activities and their experienced biologic, emotional, and social consequences
29	Social Norms Theory	Misperception	The perception of the discrepancy between perceived norms and actual norms
30	Norm Activation Theory	Specific norm	Activated norm that relate to different possible courses of action
31	Social Action Theory (Weber)	Self-Interest	Behaviour or a state of mind that does not take the interests of others into account
32	Integrative Model of Health Attitude and Behaviour Change	Exposure	The action of noticing the information in a message
33	Self-Determination Theory	Identification	The process of identifying with the importance of a behaviour and accepting responsibility for regulating the behaviour
34	Technology Acceptance Model	Computer playfulness	The level of cognitive spontaneity in interactions with technology; represents the intrinsic motivation associated with using any new system

No.	Theory	Ungrouped MoA label	Ungrouped MoA definition
35	Terror Management Theory	Sense of value within the cultural drama	Maintaining a sense of worth, usefulness or importance within one's cultural worldview
36	Consumption as Social Practices	Discursive and practical consciousness	The awareness with which individuals think and talk and act; a body of knowledge that both enables individuals to act (practical) and is an ongoing development of ideas and possibilities, anchored in knowledge, values and experiences (discursive)
37	Rational Addiction Model	Rationality	The extent to which one seeks to maximise utility continuously over time
38	Information-Motivation-Behavioural Skills Model of Adherence Behaviour	Implicit theory	Complex set of beliefs that require cognitive effort to apply to the behaviour
39	Health Behaviour Internalisation Model	Self-need	A set of motivational variables related to one's sense of self that influences the internalisation process
40	Theory of Normative Social Behaviour	Normative mechanism	Process through which the influence of descriptive norms on behaviours is heightened
41	Prospect Theory	Reference point	One's current level of assets
42	Transtheoretical Model of Behaviour Change	Dramatic relief	The process of experiencing and releasing feelings about the problem and the solution
43	Self-Efficacy Theory	Cognitive appraisal of efficacy information	The cognitive evaluation of information relating to the belief that one is capable of carrying out a specific behaviour that will lead to desired outcomes
44	Technology Acceptance Model	Voluntariness	The extent to which one perceives the behaviour to be mandatory
45	Integrative Model of Health Attitude and Behaviour Change	Acceptance	The process of accepting the information
46	Problem Behaviour Theory	Religiosity	The level of one's involvement with religion, whereby a low level of involvement suggests an absence of internalisation of the moral perspective of the main conventional instituion in society
47	Self-Determination Theory	Internalisation	The process through which one acquires a belief, value, or behavioural regulation and progressively transforms and organizes it into a personal value or goal
48	Action Theory Model of Consumption	Moral imperative	An action that is necessary because is is the 'right thing' to do in a moral sense
49	PRIME Theory	Identity	Mental representations of the self as one is or aspires to be and feelings associated with these
50	Transtheoretical Model of Behaviour Change	Temptation	A desire, or stimulus that creates a desire, to carry out the problem behaviour(s)
51	Social Action Theory (Ewart)	Personal project	A large clusters of action scripts that relate to the achievement of a superordinate goal (e.g. achieving social standing, acquiring financial wealth)
52	General Theory of Deviant Behaviour	Valued Quality or Success	The extent to which one possesses the attributes that they value and has achieved the successes that they value
53	Social influence model of consumer participation	Group norm	A set of goals, values, beliefs and conventions of the group's members

No.	Theory	Ungrouped MoA label	Ungrouped MoA definition
54	CEOS theory	Self re-orientation	Process by which an attempt is made to modify the value placed on a particular behaviour by operational processes
55	Terror Management Health Model	Conscious death thought activation	The arousal of death-related cognitions that are within one's conscious awareness
56	Goal setting theory	Commitment	An agreement or pledge to achieve a goal in the future, or the state or instance of being obligated or emotionally impelled to achieve a goal
57	Integrative Model of Health attitude and Behaviour Change	Weight	A process of attributing a degree of importance to attitudes and social normative beliefs
58	Six Staged Model of Communication Effects	Pros and cons of behaviour change	Decisional balance constructed by individuals relating to the relative advantages and disadvantages of alternative behaviours
59	Integrative Model of Factors Influencing Smoking and Health Attitude and Behaviour Change	'Weight'	Weight assigned to beliefs based on the value attributed to a relevant object or to the anticipated consequences of a relevant action
60	Relapse Prevention Model	Coping response	Response that allows an individual to cope with high risk situations (e.g. assertiveness in coping with social pressure)
61	Motivation-Opportunities-Abilities	Opportunity	A relevant, i.e., facilitating or impeding, contextual condition influencing how easy or difficult it is to perform the behaviour. (e.g. for people to recycle, it matters whether recycling bins are in place)
62	AIDS Risk Reduction Model	Help-seeking	The process of searching for solutions to problems associated with risky health behaviours
63	Model of Pro-Environmental Behavior	Internal Incentive	An internal reward that reinforces anticipating positive consequences
64	Temporal Self-Regulation Theory	Ambient Temporal Contingency	The cost and benefit of a specific behaviour, and their level of immediacy, in the social or physical environment
65	Technology Acceptance Model	Result demonstrability (technology acceptance model)	The extent to which the results of using the technology are tangible, allowing for the attribution of improved job performance to technology use
66	Diffusion of Innovations	Relative advantage	The perceived added benefit of a new innovation/behaviour over the innovation/behaviour that it follows
67	Health Promotion Model	Immediate competing demand and preference	Alternative behavioural option that intrudes into one's thoughts immediately prior to engaging in a behaviour
68	CEOS Theory	Frame	The assumption (implicit or explicit) as to what is relevant to the topic
69	Norm Activation Theory	Denial of the state of need	The refusal to believe that a need exists
70	Feedback Intervention Theory	Hypothesis (Feedback Intervention Theory)	New standard for the components of a task that is generated and tested for success in improving performance on that task

No.	Theory	Ungrouped MoA label	Ungrouped MoA definition
71	Theory of Normative Social Behaviour	Aspiration	Hope or ambition to emulate referent others
72	Norm Activation Theory	Denial of responsibility to respond	The refusal to believe that there is a responsibility to respond
73	Protection Motivation Theory	Intrinsic reward	Positive physical and/or psychological reinforcer for the maladaptive response (e.g. bodily pleasure, satisfaction)
74	Prospect Theory	Loss	Perceived negative decrease from the reference point
75	Prototype Willingness Model	Risk prototype	Image or cognitive representation of the 'type' of person that engages in risk behaviours
76	Theory of Normative Social Behaviour	Anticipatory socialization	The process by which one takes on the values of the group to which one aspires but does not belong
77	AIDS Risk Reduction Model	Information-seeking	The process of gathering ideas and others' opinions about ways to change risky health behaviours
78	Change Theory	Group standard	The value, belief, norm and/or behaviour shared by a group
79	Feedback Intervention Theory	Resolving feedback-self discrepancies	Process by which one aims to resolve apparent discrepancies between current outcomes and the goal towards which one is striving
80	Problem Behaviour Theory	Alienation	The sense of meaninglessness in everyday roles and isolation from others
81	Problem Behaviour Theory	Social criticism	The rejection of societal norms, values, and practices
82	Needs-Opportunity-Abilities Model	Spatial (ability)	The availability of space in which to store goods and the distance between the home and shops and services
83	Norm Activation Theory	Cost & benefit	The advantage and/or disadvantage of pursuing a line of action that can be social, physical, psychological or moral
84	Integrated Theoretical Model for Alcohol and Other Drug Abuse Prevention	Behavioural option	Perceived alternative to the behaviour in question
85	Diffusion of Innovations	Persuasion	The formation of a positive or negative opinion about an innovation/behaviour
86	Transtheoretical Model of Behaviour Change	Environmental reevaluation	The process of cognitively and affectively assessing the ways in which a personal behaviour might have an impact on the social environment
87	Regulatory Fit Theory	Prospective evaluation	The appraisal of the outcome of a future choice
88	Prospect Theory	Gain	Perceived positive increase from the reference point
89	Temporal self-regulation theory	Perceived temporal proximity	The extent to which the outcome is believed to be immediate or non-immediate, whereby the greater the proximity, the higher the valuation
90	Social Development Model	Commitment	The extent to which one is dedicated to conventional society
91	Social Consensus Model of Health Education	Social consensus	The general agreement or understanding of knowledge, beliefs, social meanings and social norms that exist within social environments
92	Self-Determination Theory	Internalisation	Incorporation of important others' beliefs about the behaviour into one's own belief system
93	Social Development Model	Belief	One's belief in conventional society

No.	Theory	Ungrouped MoA label	Ungrouped MoA definition
94	Technology Acceptance Model	Objective usability	The actual amount of effort needed to perform a task using a system
95	CEOS Theory	Desirability	The extent to which action is evaluated as being worth pursuing (i.e. the extent to which one is motivated to act)
96	CEOS Theory	Avoid	A basic preconsciously generated reaction to a stimulus as potentially threatening
97	Prospect Theory	Mental segregation	A process by which the riskless component is separated from the risky component
98	Norm Activation Theory	Assessment, Evaluation & Reassessment	Stage of the norm activation process that contains two sub-stages: assessment and evaluation of responses, and reassessment and redefinition of the situation
99	Goal directed theory	Script	Sequence of behaviours that is expected in a given situation
100	Information-Motivation-Behavioural Skills	Social norm	Perception of others' beliefs about threat prevention
101	Action Theory Model of Consumption	Social identity process	Method of processing information based on the awareness of one's place in a group, emotional attachment to the group, and the value placed on being a member of that group
102	Action Theory Model of Consumption	Somatic marker process	Non-conscious preference bias arising from previous emotional experiences associated with relevant behaviours
103	Norm Activation Theory	Denial of suitability of norms	The refusal to believe that norms apply; may occur through consideration of additional alternative actions that could modify the outcome of one's cost-benefit analysis
104	Integrative Model of Health Attitude and Behaviour Change	Consistency	The level of consistency in one's behaviour, opinions and attitudes, the need for which can motivate changes in feelings, beliefs or behaviour
105	CEOS Theory	Achievability	The extent to which an identified goal is perceived to be achievable by the individual
106	Social Action Theory (Ewart)	Strategy	Programme of action designed to achieve a goal or accomplish a task
107	Social influence model of consumer participation	Group-referent value	Value relating to the sense of worth, usefulness or importance attached to the self in relation to other group members
108	Model of Pro-Environmental Behavior	Emotional involvement	The extent to which we have an affective relationship with the natural world
109	Goal directed theory	Emotional commitment	The level of certainty that one's decision to try to use certain means to achieve a goal is correct
110	Reflective Impulsive Model	Spreading activation	Process through which the impulsive system activates behavioural schemata
111	Prospect Theory	Decision weight	The impact of the probability on the total value of a prospect assigned
112	PRIME Theory	Generalised emotion	Emotion not focused on a particular object but just experienced
113	Social Change Theory	Economic condition	Status of a financial position within a specific period of time
114	Problem Behaviour Theory	Parent-friends compatibility	Perceived compatibility between parents' and friends' expectations

No.	Theory	Ungrouped MoA label	Ungrouped MoA definition
115	Behavioural ecological Model of Adolescent AIDS Prevention	Hassle	Inconvenience relating to the desired behaviour
116	CEOS theory	Task difficulty (perceived)	Perception of how much work or skill the task involves
117	Integrative Model of Health Attitude and Behaviour Change	Evaluation	The expected consequence of an action or object
118	Norm Activation Theory	Reassessment & redefinition of the situation	Process of evaluation that occurs when the moral costs of not responding to the need, and the balance of the costs of response actions, are both high
119	Social Identity Theory	Intergroup comparison	Process in which evaluation of one's own group is determined with reference to specific other groups through social comparisons in terms of value-laden attributes and characteristics
120	Norm Activation Theory	Moral Cost	A specific type of psychological costs and benefits that relate to one's self-perception of how one responds to the welfare of others (e.g. perception of personal kindness and responsibility)
121	Protection Motivation Theory	Coping appraisal	The cognitive evaluation of factors that influence a person's ability to cope with a threat
122	Prospect Theory	Edited prospect	The prospect left to choose from after the editing phase
123	Integrative Model of Health Attitude and Behaviour Change	Value	The weight placed upon the attributes of an object
124	Extended Parallel Processing Model	Fear-control process	The process initiated when one has high perceptions of threat but low perceptions of one's ability to take action that would effectively avert that threat; involves a motivation to cope with fear
125	Technology Acceptance Model	Job relevance	The perception of how applicable a technology is to one's job
126	Goal directed theory	Cognitive representation	Mental depiction of oneself trying to perform a behaviour
127	Extended Parallel Processing Model	Maladaptive change	Dysfunctional strategy used to reduce fear in relation to a threat (e.g. denial, defensive avoidance)
128	Social Action Theory (Ewart)	Cognitive control schema	A type of procedural mental representation that influences behavioural choices by increasing temptation avoidance-related self-efficacy
129	CEOS theory	Vigilance	The action or state of the executive directing attention to ensure that appropriate actions are undertaken when required
130	Diffusion of Innovations	Confirmation	Seeking reinforcement for a decision to adopt or reject an innovation/behaviour
131	Social Identity Theory	Intergroup differentiation	Process in which pressures to evaluate one's own group positively through in-group/out-group comparisons lead social groups to attempt to differentiate themselves from each other
132	Technology Acceptance Model	Identification	A belief that performing a behaviour increases one's social status in a group because important others in the group believe that the behaviour should be performed

No.	Theory	Ungrouped MoA label	Ungrouped MoA definition
133	Diffusion of Innovations	Collective innovation-decision	Choice to adopt or reject an innovation/behaviour that is made by consensus amongst the members of a social system
134	Social Action Theory (Ewart)	Conjoint competence	The ability of people in a social relationship to collaborate in problem solving
135	Six Staged Model of Communication Effects	Identification	The process through which one begins to see oneself in the role of another person and empathises with the circumstances of that person
136	Six staged model of communication effects	Parasocial interaction	The degree to which an audience or individual develops a perceived interpersonal relationship with a media character
137	General Theory of Deviant Behaviour	Self-esteem motive	The desire to maintain or increase positive emotions that arise from self-evaluation, and to reduce negative emotions of the same type
138	Social Learning Theory	Anticipatory response	The process through which responses that are temporally more proximal to a reward will, wherever possible, become earlier in the sequence than they were originally
139	Health Behaviour Goal Model	Personal goal structure	A set of specific goals relating to what one feels is important in life, arranged hierarchically from the more concrete at the lower end to the more abstract at the higher end
140	Reflective Impulsive Model	Behavioural Schemata	A mental representation of incoming physiological or psychological stimuli that gives rise to a behaviour
141	Six Staged Model of Communication Effects	Self-efficacy	The degree to which one believes that one can control one's future
142	CEOS theory	Proposition	The smallest unit of meaningful thought; Network of interconnected propositions for propositional knowledge
143	Diffusion of Innovations	Compatibility	The extent to which a new innovation/behaviour can co-exist with the existing needs and values of a potential adopter of that innovation/behaviour
144	Health Behaviour Internalisation Model	Introjected self-regulation	The self-management of behaviour driven by a sense of guilt, obligation, anxiety, or a need to prove something, often experienced as being conflicted or controlled
145	Health Action Process Approach	Perceived norm	A perception of whether the behaviour is in line with that of referent others
146	Motivation-Opportunities-Abilities	Task Knowledge	A set of facts, skills and/or information about how to accurately perform the behaviour
147	Diffusion of Innovations	Authority innovation-decision	A choice to adopt or reject an innovation/behaviour that are made by relatively few individuals within a social system who possess power, status or technical expertise. Other individuals within the system have no choice over adoption and simply implement the decision.
148	Technology Acceptance Model	Output quality (Technology Acceptance Model)	The perception of how well a technology performs job-relevant tasks
149	Differential Association Theory	Rationalisation	Justification of the behaviour with excuses and explanations

No.	Theory	Ungrouped MoA label	Ungrouped MoA definition
150	Norm activation theory	Perception that need can be relieved by action	The recognition that action can be taken in response to the need
151	Theory of Interpersonal Behaviour	Contractual Arrangement	A specific plan made between individuals
152	Social Consensus Model of Health Education	Social meaning	An image and/or interpretation that social groups attach to behaviour
153	General Theory of Deviant Behaviour	Perceived cause of negative self-attitudes	Perception of the causes of any negative emotions one feels as a result of self-evaluation

Appendix 4-1. Guidelines for writing definitions for ontologies

No.	Guidelines for writing ontological definitions
1	Conform to conventions
	A definition should define a class and not the label used for that class. For instance, a definition for 'mammal' should specify 'an animal' as its parent class and not 'a term that refers to an animal' (Seppälä, Ruttenberg, & Smith, 2017).
	A definition should not include the label it is defining or its near synonyms (Seppälä et al., 2017).
	Definitions should only include commas as punctuation mark and, if the first letter of the definition is capitalised, a period (Michie, West & Hastings, 2019; Seppälä et al., 2017).
	Nouns can be 'count' (e.g., egg') or 'mass' (e.g., 'information') depending on whether they can be written in a plural form. If a term is a count noun, it should start with an article ('a', 'an' or 'the') (Seppälä et al., 2017).
	For mass nouns (e.g., water, tissue), portions of the noun that can be counted (e.g. portion of tissue) should be specified (Arp et al., 2015).
	Definitions in an ontology should have consistent typographical conventions (e.g. italicized sections) and editorial guidelines. Common nouns (universals and classes) should be italicized (Seppälä et al., 2017).
2	Principles of good practice
	No two classes should have the same definition in the ontology (Seppälä et al., 2017).
	Each class should only have one definition, although ontology developers may provide further clarifications for a definition (Seppälä et al., 2017).
	A class's definition should be clearer and simpler than the terms they define and avoid technical language where possible (Michie et al., 2019; Seppälä et al., 2017).
	A class's label and definition should not be circular: class's label or synonyms for that label should not be used in its definition (Michie et al., 2019; Seppälä et al., 2017).
	Class definitions should not include subjective statements or evaluations, e.g., 'delicious' (Seppälä et al., 2017).
	To refer to other classes in the ontology, the labels specified in the ontology should be used (Seppälä et al., 2017).
	Circularity should also be avoided between definitions in an ontology, so two or more classes are not defined in terms of one another (Seppälä et al., 2017).
	Definitions should avoid having other definitions nested within them (i.e., define additional classes) (Seppälä et al., 2017). If there is a term used in a definition that needs defining itself, another class should be created to define this term in the ontology. For instance, in the definition of 'cell measurement', an ontology should not define a 'cell'. Instead, the ontology should include a separate class and definition for 'cell' (Seppälä et al., 2017).
3	Use the genus-differentia form

Avoid categorizers: As the genus categorises a defined entity, definitions should not include expressions that additionally categorise an entity, such as 'type of' or 'sort of' (Seppälä et al., 2017).

4	Use appropriate degree of generality

Avoid generalizing expressions: As definitions should make general statements, ontology developers should avoid generalizing expressions (e.g., 'usually' and 'generally') (Seppälä et al., 2017).

Avoid examples and lists: The ontology developers should avoid examples, expressions for examples ('such as', 'etc.') and listing components of an entity (e.g., listing the types of questions to define a questionnaire). Examples and additional information about the entity can be included as a separate annotation and/or a curator's note (Seppälä et al., 2017).

Avoid indexical and deictic terms: Definitions should not use expressions, such as 'today', 'here' and 'this' when these refer to the definition author or the ontology itself. These expressions often result in a use/mention confusion or include non-defining attributes (Seppälä et al., 2017).

5	Abbreviations and acronyms

Acronyms should be avoided (Arp et al., 2015).

If abbreviations and acronyms are used, they should be defined, and the full form of abbreviations should be provided as an editor's note (Seppälä et al., 2017).

6	Avoid negative terms

A class should not be defined in terms of what it is not (i.e., using negative terms), unless the defined class is inherently negative (Seppälä et al., 2017). For instance, 'mineral' should not be defined as 'composed of matter other than plant or animal' (p. 92, Seppälä et al., 2017). However, as being a 'bachelor' is the absence of a certain condition (i.e., being married), it can be defined as 'a man who is not married' (p. 92, Seppälä et al., 2017).

7	Match textual and logical definitions

The logical definitions (e.g., infection has_part bacteria) and the textual definitions should match, although logical definitions can have additional axioms that support reasoning (Seppälä et al., 2017).

Proofreading definitions: The ontology developers need to check the spelling and grammar of definitions (Seppälä et al., 2017).

References

Michie, S., West, R., & Hastings, J. (2019). Creating ontological definitions for use in science. Qeios. doi: 10.32388/ygif9b

Seppälä, S., Ruttenberg, A., & Smith, B. (2017). Guidelines for writing definitions in ontologies. *Ciência da Informação*, 46(1).

Appendix 4-2. The labels and definitions of MoA classes identified from MoA groups

No.	MoA group label	MoA group definition	MoA class label (If imported, URI)	MoA class definition	Parent class from existing ontology
1	Addiction	A chronic condition involving a repeated powerful motivation to engage in a rewarding behaviour, acquired as a result of engaging in that behaviour that has significant potential for unintended harm.	Addiction (Addiction Ontology, in prep)	A chronic acquired mental disorder involving repeated abnormally powerful motivation to engage in a behaviour despite risk or experience of harm.	Mental disposition
2	Feeling	An affective state that includes emotions and desires.	Affective process MFOEM:000195	Any process that has positive or negative valence.	Mental process
3	Arousal	A state of alertness and readiness for action.	Arousal MF:0000012	Physiological and psychological state of being awake or reactive to stimuli.	Mental process
4	Attention	The extent to which one attends to information.	Attending MF:0000018	A mental process whereby relevant aspects of our mental experience are focused on specific targets.	Mental process
5	Attributional process	A process relating to assigning causality for events which may include internal/external attribution.	Appraisal of causal agency MFOEM:000075	An appraisal that represents an evaluation of who or what caused an event.	Appraisal
6	Belief	An association of some characteristic or attribute, usually evaluative in nature, with an attitude object.	Belief MF:0000041	A disposition to mental processes that represent some proposition X to be true.	Bodily disposition
7	Choice and decision making	The cognitive process of choosing between two or more alternatives.	Judging MF:0000006	A mental process during which a decision is made and the outcome of which is a belief or opinion.	Mental process
8	Communication	The transmission of information between people.	Communication MF:0000040	An interpersonal process that involves as participant at least two linguistically capable organisms, one of whom produces an utterance that is well-formed in a given language and the other of whom perceives and understands that utterance by virtue of their recognition of the meaning of the utterance through their knowledge of the language	Interpersonal process
9	Desire	A feeling of want or need (e.g., to engage in the behaviour).	Wanting MF:0000045	A mental process that involves thinking about a level of performance of a behaviour that does not currently obtain	Mental process

No.	MoA group label	MoA group definition	MoA class label (If imported, URI)	MoA class definition	Parent class from existing ontology
				together with a desire for that level of performance of a behaviour to obtain.	
10	Learning	The acquisition of novel information, behaviours or abilities based on experience.	Learning GO:0007612	Any process in an organism in which a relatively long-lasting adaptive behavioural change occurs as the result of experience.	Mental process
11	Memory	The process of retaining content such that it can be recalled.	Memory GO:0007613	The activities involved in the mental information processing system that receives (registers), modifies, stores, and retrieves informational stimuli.	Mental disposition
12	Observation of others	The process of watching someone else's behaviour.	Observational learning GO:0098597	Learning that occurs through observing the behaviour of others.	Learning
13	Perception	The process or result of becoming consciously aware of something by means of the senses.	Perception MF:0000019	A mental process which is a) produced by a causal process (for example involving light rays or air vibrations) involving a part of the environment of the organism, and b) is experienced by the organism as being so caused, and c) in which the relevant part of the environment is thereby represented to the organism.	Mental process
14	Planning	The process by which detailed specifications of how to perform an intended behaviour are formed.	Planning MF:0000027	A mental process that involves mentally manipulating representations of steps in an imagined process which has some objective, e.g. to bring about a desired state of affairs. The outcome of this mental process is a plan which has the potential to be followed to bring about the desired outcome.	Mental process
15	Present negative affect	An emotional state of unhappiness, ranging in intensity from mild to extreme.	Sadness MFOEM:000056	A negative emotion felt when an event is appraised as unpleasant, obstructive to one's goals and concerns, and one feels unable to cope with it or modify it.	Emotion process
16	Satisfaction	Sensation of contentment or fulfilment.	Contentment MFOEM:000047	A pleasant emotion, which can be defined as a milder form of joy.	Happiness
17	Sensation	A feeling arising from senses or imagined experiences, without interpretation of meaning.	Perception MF:0000019	A mental process which is a) produced by a causal process (for example involving light rays or air vibrations) involving a part of the environment of the organism, and b) is experienced by the organism as being so caused, and c) in	Mental process

No.	MoA group label	MoA group definition	MoA class label (If imported, URI)	MoA class definition	Parent class from existing ontology
				which the relevant part of the environment is thereby represented to the organism.	
18	Social learning	A process by which thoughts, feelings, and motivational states observed in others are internalised and replicated without the need for conscious awareness.	Observational learning GO:0098597	Learning that occurs through observing the behaviour of others.	Learning
19	Action script	The mental road map of an end state which contains basic actions, and their temporal and causal relations.	Action script	A cognitive representation that guides a sequence of behaviours.	Cognitive representation
20	Appraisal of alternatives	The cognitive evaluation of the nature and significance of two or more options.	Evaluating multiple options	A cognitive process that gives rise to an evaluation and comparison of the nature and significance of two or more options.	Cognitive process
21	Associative learning	A process whereby patterns of brain activity representing perceptions, emotions or response organization become linked so that when a particular pattern occurs, another is made more likely to occur.	Associative learning	Learning concerning the association between two or more stimuli or between a stimulus and a response.	Learning
22	Attitude towards behaviour	A favourable or unfavourable evaluation or appraisal of a behaviour.	Attitude towards behaviour	A cognitive representation which represents an overall evaluation of the impact of the possible outcomes of a behaviour to the organism.	Cognitive representation
23	Awareness	A consciousness of something.	Awareness	A mental disposition to be conscious of events, objects or sensory patterns.	Mental disposition
24	Intention formation	The process by which a conscious decision is made to perform a behaviour.	Behavioural intention formation	A cognitive process that brings into being a behavioural intention.	Cognitive process
25	Behavioural option	Perception of behaviours that are available as another choice instead of the planned or currently engaged behaviour.	Attending disrupted by behavioural alternatives	A mental process whereby relevant aspects of our mental experience become focused on a behaviour other than the currently planned or engaged in course of action.	Attending
26	Perceived barriers	Belief about the negative aspects of taking health protective action.	Belief about barriers	A belief about the existence of factors that could restrict or impede the person from engaging in a behaviour.	Belief
27	Capability	The possession of able qualities to carry out a behaviour.	Capability	A bodily disposition that is realised by the bearer engaging in a particular behaviour when appropriate circumstances occur.	Bodily disposition

No.	MoA group label	MoA group definition	MoA class label (If imported, URI)	MoA class definition	Parent class from existing ontology
28	Categorisation	The process by which objects, events, people, or experiences are grouped into classes on the basis of (a) characteristics shared by members of the same class and (b) features distinguishing the members of one class from those of another.	Mental categorising	A mental process in which objects, events, people, or experiences are grouped into cognitive representations of classes, on the basis of features shared by members of the same class and features distinguishing the members of one class from those of another.	Mental process
29	Commitment	A cognitive agreement or pledge to attain a goal in the future.	Commitment making	A mental process by which one decides to pursue a goal and develops a sense of being obligated or emotionally impelled to act upon that goal.	Mental process
30	Comprehension	The act of understanding something, especially the meaning of a communication.	Comprehension	A cognitive process that creates a representation of the meaning and significance of a communication, object, event or situation.	Cognitive process
31	Descriptive norm	A standard that describes how people typically behave in a given situation.	Descriptive norm	A belief regarding the prevalence of performance of a given behaviour by people within a group.	Belief
32	Discrepancy resolution	A psychological process of settling a perceived incompatibility between two cognitive states.	Dissonance reduction process	A mental process through which a perceived inconsistency between two concurrently held cognitive representations is reduced.	Mental process
33	Evaluated outcome expectancy	The outcome (e.g., cognitive or emotional) associated with specific end states.	Belief about the desirability of consequences of behaviour	A belief about the desirability or worth of the possible outcomes of a behaviour.	Belief
34	Feedback mechanism	A process whereby current behaviour is compared against an emotional or behavioural standard in order to modify subsequent goal-directed behaviour.	Mentally comparing against a standard	A mental process in which current conditions are compared against a particular reference level	Mental process
35	Financial availability	The extend that one has the financial means to make the behaviour possible or facilitate it.	Financial opportunity	A quality of a person's social and physical environment regarding whether the person has sufficient financial resources to engage in a behaviour.	Quality
36	Goal	The end state towards which one is striving.	Goal	A cognitive representation of the end state to which one is striving.	Cognitive representation
37	Group identity	Processing of information about self-based on social identify (e.g., group membership).	Social identity	A cognitive representation relating to how one perceives oneself as belonging to a social group.	Cognitive representation
38	Goal pursuit	The action of striving towards goal achievement or engagement in goal directed behaviours.	Goal pursuit process	A bodily process in which attempts are made to achieve a desired end state.	Bodily process

No.	MoA group label	MoA group definition	MoA class label (If imported, URI)	MoA class definition	Parent class from existing ontology
39	Habit	A well learned behaviour or automatic sequence of behaviours that is independent of cognitive influence.	Habitual behaviour	A behaviour that is well-learned and can be in automatic sequence with other behaviours and has become reflexive over time.	Behaviour
40	Heuristic	An experience-based strategy for solving a problem or making a decision that often provides an efficient means of finding an answer.	Heuristic process	A mental process that uses simple rules and associations learnt from experience to make judgements.	Mental process
41	Image	A mental representation of objects or events.	Mental image	A cognitive representation that resembles the experience of perceiving some object or event but occurs when the relevant object or event is not actually present to the senses.	Cognitive representation
42	Inference	The process to reach a conclusion by evaluating an earlier premise according to specific rules.	Inference	A mental process that involves applying rules to a set of premises to reach a conclusion.	Mental process
43	Injunctive norm	A standard that describes how people should behave in a given situation, irrespective of how people typically behave in the setting.	Injunctive norm	A belief regarding whether a behaviour is appropriate and correct for people who belong to a particular social group.	Belief
44	Intention	A conscious decision to perform a behaviour.	Intention	A cognitive representation of one's plan to engage or not engage in a particular behaviour.	Cognitive representation
45	Interdependent script	A state in which two or more people have interlinked sequences of behaviour that rely on or react with one another such that one cannot change without affecting the other.	Interdependent action script	A disposition to an interpersonal process in which a sequence of behaviour in one individual elicits a sequence of behaviour in at least one other individual with whom the first is in a close relationship.	Disposition
46	Introjected regulation	The drive to perform a behaviour out of a sense of guilt or obligation or a need to prove something.	Appraisal of obligation to respond	An appraisal that represents an evaluation of how much one is personally obliged to respond to an event or person in need.	Appraisal
47	Knowledge	Information and understanding of a specific topic or the world in general, usual acquired through experience and/or learning.	Knowledge	A cognitive representation of the nature of the world, or a specific aspect of the world, that corresponds to the actual state of the world and is acquired through experience or learning.	Cognitive representation

No.	MoA group label	MoA group definition	MoA class label (If imported, URI)	MoA class definition	Parent class from existing ontology
48	Locus of causality	Mental representation of the degree to which one's behaviour is regulated by one's true self.	Perceived self-determination of behaviour	A cognitive representation of the degree to which one's behaviour is controlled by one's internal convictions rather than external demands.	Cognitive representation
49	Monitoring	The evaluation of chosen methods for goal achievement, and consideration of whether additional methods should be used.	Evaluation of goal achievement	A mental process which evaluates the appropriateness of current goal attainment strategies given one's progress towards goal achievement.	Mental process
50	Motivation	The impetus that gives purpose or direction to behaviour.	Motivation	A mental process that energises and directs behaviour.	Mental process
51	Motivation to comply	The extent to which one is willing to exert physical or mental effort to act in accordance with others.	Motivation to comply	A mental disposition to consider the likely approval of referent others for a course of action during decision making.	Mental disposition
52	Motivational orientation	A state that directs the perception of specific valence of outcomes (positive or negative).	Motivational orientation	A mental disposition for motivation to be guided by a focus on the presence or absence of outcomes of a certain valence.	Mental disposition
53	Need	Objective that people strive to achieve in order to improve or maintain their wellbeing or quality of life.	Need	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining a particular state.	Cognitive representation
54	Normative belief	An individual's perceived belief of others regarding performing a behaviour.	Normative belief	A belief about whether important others think one should perform a behaviour.	Belief
55	Outcome expectancy (no explicit evaluation)	Belief about the consequences of behaviour which are not explicitly appraised.	Belief about consequences of behaviour	A belief about the outcomes resulting from a behaviour.	Belief
56	Outcome expectancy (likelihood)	Belief about whether a certain behaviour will lead to desired outcomes (also response efficacy).	Belief about likelihood of consequences of behaviour	A belief about the likelihood a particular behaviour will result in particular outcomes.	Belief
57	Perceived availability of behavioural options	Awareness of alternative behaviours that could be carried out.	Belief about the availability of behavioural options	A belief about having the option of performing different behaviours.	Belief

No.	MoA group label	MoA group definition	MoA class label (If imported, URI)	MoA class definition	Parent class from existing ontology
58	Perceived context	Perception of the environment/context.	Belief about one's environment	A belief about the nature of the immediate physical and social settings in which people live, including culture and the people and institutions with whom they interact.	Belief
59	Perceived health	Perception/belief regarding the current state of one's health.	Belief about own health	A belief regarding the state of one's health.	Belief
60	Perceived importance	The significance one ascribes to the achieving an end state.	Importance of goal attainment	A cognitive representation of the significance of successfully meeting a goal.	Cognitive representation
61	Perceived influence	The perceived influence of others on one's behaviour.	Belief about social influence processes	A belief about whether or how others will attempt to use social influence processes to affect the person's behaviour.	Belief
62	Perceived severity	Perception of how serious or severe a threat or health risk is.	Belief about severity	A belief about how serious the harm associated with an outcome could be.	Belief
63	Perceived susceptibility	Perception of vulnerability to the threat.	Belief about susceptibility	A belief about how vulnerable one is to a threat.	Belief
64	Perceived threat	Perception of the threat posed by a disease or a health problem, based on one's perceived susceptibility to, and the perceived severity of a disease or health problem.	Belief about threat	A belief about the nature of a potential harm.	Belief
65	Physical opportunity	The affordance of a physical environment that allows people to carry out a particular behaviour.	Physical opportunity	A quality of the physical environment that makes a behaviour possible or facilitates it.	Quality
66	Psychological capability	A psychological ability, talent, or facility that a person can put to constructive use.	Psychological capability	A mental disposition that is realised in mental processes relating to ability to perform a behaviour.	Capability
67	Reference value	A specified level of an end state that is compared to the level of the current state.	Desired standard	A cognitive representation of a desired state that serves as a reference level.	Cognitive representation
68	Reflective thinking	A type of thinking in which decisions are made (e.g., about complex problems) slowly and deliberately (i.e., not impulsively).	Reflective thinking	Thinking that involves generation of inferences based on syllogistic reasoning or decision making based on the evaluation of anticipated consequences or the construction of propositional representations.	Thinking

No.	MoA group label	MoA group definition	MoA class label (If imported, URI)	MoA class definition	Parent class from existing ontology
69	Schema	A collection of basic knowledge about a concept or entity that serves as a guide to perception, interpretation, imagination, or problem solving.	Cognitive schema	An aggregate of cognitive representations about a concept or entity that serves to guide to perceiving or responding to a complex situation or set of stimuli.	Aggregate of cognitive representations
70	Selection of peers	The selection of people within one's social network.	Judging as potential peer	Judging whether an individual or individuals should be considered as a person of the same status or rank.	Judging
71	Self-administered strategy	A program of action that the individual imposes on themselves to achieve a goal.	Behavioural self-regulation of behaviour	A behaviour process that modulates the frequency, rate or extent of behaviour, the specific actions or reactions of an organism in response to external or internal stimuli that is instigated by the organism itself.	Behaviour process
72	Self-efficacy	Belief about personal capabilities to perform task or engage in a behaviour.	Self-efficacy	A belief about one's capabilities to engage in a behaviour.	Belief
73	Self-esteem	The degree to which the qualities and characteristics contained in one's self-concept are perceived to be positive.	Self-esteem	A cognitive representation of how one evaluates the qualities and characteristics in one's self concept.	Cognitive representation
74	Self-image	One's own view or concept of oneself.	Self-concept	A cognitive representation of one's own qualities and characteristics.	Cognitive representation
75	Self-monitoring	A process involving self-observation and self-control with the aim of maintaining situation-appropriate behaviour.	Self-monitoring	A mental process in which one observes and evaluates one's own behaviour.	Mental process
76	Self-regulation and control	The process by which people regulate their behaviour; a process whereby intentions are enacted in the face of desires or impulses arising from other sources.	Self-regulation of behaviour	A bodily process that modulates the frequency, rate or extent of behaviour, the specific actions or reactions of an organism in response to external or internal stimuli and that is instigated by the organism itself.	Bodily process
77	Service availability	The extend one can access services that make the behaviour possible or facilitate it.	Healthcare service accessibility	A quality of a healthcare service regarding how easy it is for a person to approach and use it.	Quality
78	Stimulus	Any agent, event, or situation—internal or external—that elicits a behaviour from an individual.	Behavioural cue	A stimulus that serves to elicit or guide behaviour.	Process

No.	MoA group label	MoA group definition	MoA class label (If imported, URI)	MoA class definition	Parent class from existing ontology
79	Skill	Ability or proficiency acquired through training and practice required to engage in a behaviour.	Skill	A capability acquired through training and practice	Capability
80	Social embeddedness	The extent to which a person is linked to the social environment.	Social embeddedness	A mental disposition to view and experience oneself as attached to and involved in a social group.	Mental disposition
81	Social influence	The impact or influence others have on thoughts, feelings or behaviours.	Social influence process	An interpersonal process where one or more person exerts an influence on the behaviour of another.	Interpersonal process
82	Social interaction	A set of social encounters with important others that may facilitate or hinder the behaviour.	Social interaction process	An interpersonal process involving reciprocal communication between two or more people.	Interpersonal process
83	Social opportunity	The affordance of the social environment in which people live.	Social opportunity	A quality of the social environment that influences performance of a behaviour.	Quality
84	Socially shared norm	A standard or a set of standards that is consensual and is held by a social group.	Socially shared norm	A belief regarding standards for behaviour that one sees as mutually agreed by and shared by members of one's social group.	Belief
85	Support from social network	The response of acceptance, encouragement or approval from others for an individual's behaviour.	Interpersonal approval for behaviour	An interpersonal process in which one or more person indicates approval of another person performing a particular behaviour.	Interpersonal process
86	Temporal constraint	The availability of time to engage in a behaviour.	Temporal opportunity	A quality of a person's social and physical environment regarding whether the person has sufficient time to engage in a behaviour	Quality
87	Temporal orientation	The tendency to focus on short- or long-term outcomes.	Temporal orientation	A mental disposition to focus more on present or future outcomes.	Mental disposition
88	Value	A moral, social or aesthetic principle accepted by an individual or society as a guide to what is good, desirable or important.	Personal value	A mental disposition regarding what is fundamentally important in life and which informs standards for behaviour.	Mental disposition

Appendix 4-3. MoA groups that were dissolved and their reasons for being dissolved

No.	MoA group label	Definition	Reasons for group being dissolved
1	Act-related affect	A feeling about or arising from a behaviour.	Incompatible with structure of 'emotion' subclasses in the Emotion Ontology
2	Feeling towards stimulus	Any experience of affect about a perceived agent, event or situation.	Incompatible with structure of 'Emotion' subclasses in the Emotion Ontology
3	Drive	A generalised state of readiness precipitating or motivating an activity or course of action.	Partially overlapping with class 'Arousal'
4	Energy state	The state of internal resources that give strength and vitality to pursue and achieve an end state.	The group's instances did not share sufficient attributes
5	Expectation about social relatedness	A belief about whether the individual will achieve a certain connection with the social environment.	The group's instances did not share sufficient attributes
6	False belief about social groups	A mental proposition about beliefs and behaviours in social groups that is asserted but lacks a basis in reality.	The group's instances did not share sufficient attributes
7	Feedback	A process whereby behaviour sustains or modifies subsequent behaviour.	The group's instances did not share sufficient attributes
8	Future-oriented negative feeling	Negative affective state associated with anticipated events.	Incompatible with structure of 'Emotion' subclasses in the Emotion Ontology
9	Interpersonal dynamic	Set of ongoing interactions/exchanges among people that can be supportive or disruptive.	Partially overlapping with class 'Social interaction process'
10	Learning associated with presented pattern	The acquisition of novel information, emotions, behaviours, or abilities based on the exposure to stimuli that is presented in a particular pattern.	Incompatible with structure of 'Learning' subclasses in the Gene Ontology
11	Rule	Specific guideline or standard that determine how a person behaves in a specific situation.	Partially overlapping with class 'Desired standard for behaviour'
12	Positive feeling	A positive affective state.	Incompatible with structure of 'Emotion' subclasses in the Emotion Ontology
13	Reinforcement	A process in which the frequency or probability of a response is increased by a dependent relationship or contingency with a stimulus or circumstance.	Incompatible with structure of 'Learning' subclasses in the Gene Ontology
14	Repression of information	The process of restricting, restraining or subduing aspects of information that is presented.	The group's instances did not share sufficient attributes
15	Subjective decisional balance	The value the individual associates with engaging in a behaviour.	Partially overlapping with classes 'Belief about consequences' and 'Belief about the desirability of consequences of behaviour'
16	Urge	Impulse to engage in an action.	Partially overlapping with class 'Action script'

Appendix 4-4. The labels and definitions of MoA instances that qualified as subclasses of their respective classes, and the subclasses developed based on these instances

MoA class label (if imported, URI)	MoA instance label	Definition	Subclass label (if imported, URI)	Subclass definition
Affective process MFOEM:000195		Any process that has positive or negative valence.		
	Affective reaction	Emotional reaction to an event	Emotion process MFOEM:000001	An emotion process is a complex mental process that is a synchronized aggregate of constituent mental processes including an appraisal process as part, and which gives rise to an action tendency.
	Stress	Negative emotion state caused by events (e.g. divorce, bereavement)	Stress MFOEM:000029	A negative emotion in response to a stressful elicitor.
Evaluating multiple options		A cognitive process that gives rise to an evaluation and comparison of the nature and significance of two or more options.		
	Appraisal of means	An evaluation of the resources or methods (means) that are available to facilitate goal achievement	Evaluating multiple goal means	A cognitive process that gives rise to an evaluation and comparison of two or more resources or methods to facilitate goal achievement
	Desirability and feasibility of goals	An assessment of the relative appeal and practicability of a variety of goals	Evaluating multiple goal options	A cognitive process that gives rise to an evaluation and comparison of the appeal and feasibility or two or more goals.
Associative learning		Learning concerning the association between two or more stimuli or between a stimulus and a response.		
	Classical conditioning	The process by which a stimulus acquires motivational significance as a result of being paired with one that already has that significance	Classical conditioning	Associative learning that occurs when the pairing of a conditioned and unconditioned stimulus leads to the conditioned stimulus producing a response that would otherwise have only been produced by the unconditioned stimulus.

MoA class label (if imported, URI)	MoA instance label	Definition	Subclass label (if imported, URI)	Subclass definition
	Discrimination	The process by which people learn to distinguish between appropriate responses to similar but different cues depending on whether a generalised response is rewarded or not	Discrimination learning	Associative learning process in which people learn to distinguish between appropriate responses to similar but different stimuli depending on whether a generalised response is rewarded or not.
	Habituation	The process through which smoking becomes habitual, through the repeated pairing of smoking with social and physiological reinforcement	Operant conditioning	Associative learning in which the likelihood of a particular behavioural response is influenced by the past consequences associated with performing that behaviour.
Attending MF:0000018		A mental process whereby relevant aspects of our mental experience are focused on specific targets.		
	Attention to the self	The direction of thought towards self-oriented higher-level goals	Attending to a self-oriented goal	A mental process whereby relevant aspects of our mental experience are focused on a desired end state for oneself.
	Locus of attention	The focus of one's attention on one out of many goals that a person may have at any given moment	Attending to a goal	A mental process whereby relevant aspects of our mental experience are focused on a desired end state.
	Norm focus	The degree to which attention is attracted to or focused on a norm at any given moment	Attending to a norm	A mental process whereby relevant aspects of our mental experience are focused on what others do and think about a behaviour.
Appraisal of causal agency MFOEM:000075		An appraisal that represents an evaluation of who or what caused an event.		
	Ascription of responsibility	The belief that one's own actions have contributed to, or could alleviate, negative consequences to others	Appraisal as caused by self* MFOEM:000076	An appraisal that represents an evaluation that an event was caused by the self.
	External attribution	Attributing discrepancies (between the information about one's own behaviour gathered during the self- monitoring stage and one's standards for that behaviour) to an external cause	Appraisal as caused by factors external to the person	An appraisal that represents an evaluation that an event was caused by factors external to the person.
	Internal attribution	Attributing discrepancies (between the information about one's own behaviour gathered during the self- monitoring stage and one's standards for that behaviour) to an aspect of the individual	Appraisal as caused by self* MFOEM:000076	An appraisal that represents an evaluation that an event was caused by the self.

MoA class label (if imported, URI)	MoA instance label	Definition	Subclass label (if imported, URI)	Subclass definition
Awareness		A mental disposition to be conscious of events, objects or sensory patterns.		
	Awareness	One's consciousness of a persuasive message	Awareness of persuasive message	A mental disposition to be conscious of a verbal, written or recorded communication that aims to influence the recipient to think or act in a particular manner.
	Awareness of need	Awareness of the possible or actual deprivation of a necessary or wanted resource of another individual, group, or entity	Awareness of others' possible needs	A mental disposition to be conscious of the possible or actual deprivation of a necessary or wanted resources of another individual, group, or entity.
Belief MF:0000041		A disposition to mental processes that represent some proposition X to be true.		
	Anchor	General belief about technology and technology use	Belief about technology use	A disposition to mental processes that represent some proposition X regarding technology and technology use to be true.
Belief about barriers		A belief about the existence of factors that could restrict or impede the person from engaging in a behaviour.		
	Perceived cost	Belief about the costs of a behaviour or behaviour change	Belief about cost barriers*	A belief about the existence of monetary or other cost factors that could restrict or impede the person from engaging in a behaviour.
	Response cost	The perceived cost associated with the protective behaviour (e.g. the amount of work involved in implementing the recommendation)	Belief about cost barriers*	A belief about the existence of monetary or other cost factors that could restrict or impede the person from engaging in a behaviour.
Capability		A bodily disposition that is realised by the bearer engaging in a particular behaviour when appropriate circumstances occur.		
	Physical capability	Physical capacity to engage in the activity concerned	Physical capability	A bodily disposition that is realised by the organism using physical skills, strength or stamina to perform the behaviour.
	Public prevention act	The ability to carry out disease relevant protective behaviours that must be performed out in the open or not in completely private settings (e.g. purchasing condoms and undergoing HIV testing)	Coping capability	A bodily disposition which is realised in processes which enable the bearer to overcome barriers to perform a behaviour.

MoA class label (if imported, URI)	MoA instance label	Definition	Subclass label (if imported, URI)	Subclass definition
Mental categorising		A mental process in which objects, events, people, or experiences are grouped into cognitive representations of classes, on the basis of features shared by members of the same class and features distinguishing the members of one class from those of another.		
	Social categorisation	The process of using cognitive tools that serve to provide order and classification to the social environment	Mental categorising of the social environment	A mental process in which aspects of the immediate physical and social settings in which people live, including culture and the people and institutions with whom they interact, are grouped into cognitive representations of classes, on the basis of features shared by members of the same class and features distinguishing the members of one class from those of another.
Behavioural cue		A stimulus that serves to elicit or guide behaviour.		
	Cue	Stimulus that arises from the person's cognitions and/or goals and serves to guide behaviour by signalling likely consequences.	Internal behavioural cue	A stimulus that arises from mental processes and serves to elicit or guide behaviour.
Dissonance reduction process		A mental process through which a perceived inconsistency between two concurrently held cognitive representations is reduced.		
	Changing the standard	A strategy for reducing the discrepancy between one's current state and goal state, whereby one changes the goal state or the standard for goal achievement	Goal changing dissonance reduction process	A dissonance reduction process through which an inconsistency between the cognitive representation of one's current state and a cognitive representation of the end state to which one is striving is reduced by changing the cog rep of the end state to which one is striving.
	Rejecting the feedback	A strategy for reducing the discrepancy between one's current state and goal state, whereby one dismisses the feedback that indicates such a discrepancy exists (i.e. reduces the perceived, not actual, discrepancy)	Feedback rejecting dissonance reduction process	A dissonance reduction process through which an inconsistency between the cognitive representation of one's current state based on feedback received and a cognitive representation of the end state to which one is striving is reduced by dismissing the feedback.

MoA class label (if imported, URI)	MoA instance label	Definition	Subclass label (if imported, URI)	Subclass definition
Mentally comparing against a standard		A mental process in which current conditions are compared against a particular reference level.		
	Feedback mechanism	Process whereby current behaviour is compared against an emotional or behavioural standard in order to modify subsequent goal-directed behaviour	Mentally comparing behaviour against a standard*	A mental process in which current behaviour is compared against a particular reference level.
	Self-evaluation	The process of appraising behaviour gathered during the self-monitoring stage and comparing against the set standards for that behaviour	Mentally comparing behaviour against a standard*	A mental process in which current behaviour is compared against a particular reference level.
Goal		A cognitive representation of the end state to which one is striving.		
	Extrinsic goal	Goal that is related to obtaining contingent approval or external signs of worth (e.g. attaining wealth or fame)	Extrinsic goal	A goal related to obtaining external signs of worth.
	Gain goal	Goal relating to the improvement and protection of one's resources	Gain-related goal	A goal related to improving and protecting one's resources.
	Hedonic goal	A goal relating to instantly feeling better	Hedonic goal	A goal related to feeling better quickly.
	Intrinsic goal	Goal that is closely associated with basic need satisfaction (e.g., affiliation, personal growth)	Intrinsic goal	A goal related to obtaining satisfaction of basic needs.
	Normative goal	A goal to act in line with what is considered acceptable	Normative goal	A goal to act in line with what is considered acceptable.
	Proximal goal	A goal that is short term	Proximal goal	A goal concerning an end state to be achieved in the short term.
Goal pursuit process		A bodily process in which attempts are made to achieve a desired end state.		

MoA class label (if imported, URI)	MoA instance label	Definition	Subclass label (if imported, URI)	Subclass definition
	Eagerness means	A type of goal means that have good regulatory fit with a promotion focused orientation; involves looking for means of advancement that support progress from a current state to a better state	Promotion-focused goal pursuit process	A goal pursuit process focused on supporting progress from a current state to a better state.
	Vigilance means	A type of goal means that have good regulatory fit with a prevention focused orientation; involves being careful to maintain a current satisfactory state against a worse state	Prevention-focused goal pursuit process	A goal pursuit process focused on maintaining a current satisfactory state and avoiding a worse state.
Heuristic process		A mental process that uses simple rules and associations learnt from experience to make judgements.		
	Certainty effect	The tendency to overweight outcomes considered to be certain compared to outcomes that are presented as probabilistic	Certainty effect heuristic process	A heuristic process using a rule that overweighs outcomes considered to be certain compared to outcomes considered as probabilistic.
	Isolation effect	The tendency to ignore the shared characteristics of presented alternatives and focus on the differences between them in order to simplify choices.	Isolation effect heuristic process	A heuristic process using a rule that tends to ignore the shared characteristics of presented alternatives and focus on the differences between them in order to simplify choices.
Injunctive norm		A belief regarding whether a behaviour is appropriate and correct for people who belong to a particular social group.		
	Definition of legal codes	Favourable or unfavourable view on legal codes that is shared by members of a group (e.g. view on whether laws should be adhered to or violated).	Legal injunctive norm	A belief regarding whether following legal codes is appropriate and correct for people who belong to a particular social group.
	Standard of comfort, cleanliness and convenience	A set of socially constructed, culturally shared and relatively stable social standards regarding acceptable levels of hygiene, etc.	Cleanliness injunctive norm	A belief regarding whether a certain level of hygiene is appropriate and correct for people who belong to a particular social group.
Knowledge		A cognitive representation of the nature of the world, or a specific aspect of the world, that corresponds to the actual state of the world and is acquired through experience or learning.		

MoA class label (if imported, URI)	MoA instance label	Definition	Subclass label (if imported, URI)	Subclass definition
	Condition specific knowledge	Factual and condition-specific information, including one's perceptions regarding a specific condition or health behaviour	Knowledge regarding behaviour linked to health*	Knowledge regarding how a particular set of actions may affect physical or mental wellbeing.
	Knowledge	Factual and condition-specific information	Knowledge regarding behaviour linked to health*	Knowledge regarding how a particular set of actions may affect physical or mental wellbeing.
	Health-related knowledge	Base of information relating to the causes of health threats and ways to avoid these threats	Knowledge regarding a health threat	Knowledge regarding a potential harm to physical or mental wellbeing.
	Information	Knowledge of highly active antiretroviral therapy (HAART) including knowledge about the regimen, correct HAART utilisation, side effects, drug interactions	Knowledge regarding treatment	Knowledge regarding a therapy or medication for a health problem.
	Information	Knowledge about the threat (e.g. means of transmission and prevention)	Knowledge regarding a threat	Knowledge regarding a potential harm.
	Information about means of prevention	Specific knowledge about the processes by which a threat is prevented	Knowledge regarding threat prevention	Knowledge regarding methods to avert a potential harm.
	Information about means of transmission	Specific knowledge about the processes by which a threat is transmitted	Knowledge regarding threat transmission	Knowledge regarding how a potential harm may spread.
	Knowledge	Awareness and understanding of an innovation/behaviour	Knowledge regarding an innovation	Knowledge regarding a novel invention or way of doing something.
	Knowledge	Factual information about the effects of risk behaviours and health threats.	Knowledge regarding a behaviour*	Knowledge regarding a particular set of actions.

MoA class label (if imported, URI)	MoA instance label	Definition	Subclass label (if imported, URI)	Subclass definition
	Knowledge	Information about, and understanding of, smoking behaviour; usually acquired by experience or by learning	Knowledge regarding a behaviour*	Knowledge regarding a particular set of actions.
	Knowledge	Knowledge and awareness of the environmental problem and its causes, and ways in which one can act to lower one's impact on the problem	Knowledge regarding environmental threat prevention	Knowledge regarding a potential harm to the circumstances, objects, or conditions by which one is surrounded.
	Knowledge	Knowledge of the behavioural risk factors associated with the disease or health risk	Knowledge regarding behaviour linked to health*	Knowledge regarding how a particular set of actions may affect physical or mental wellbeing.
	Knowledge	Knowledge about the causes and effects of ecological degradation	Knowledge regarding an environmental threat	Knowledge regarding methods to prevent a potential harm to the circumstances, objects, or conditions by which one is surrounded.
	Knowledge	Information and understanding of topics relevant to the behaviour	Knowledge regarding a behaviour*	Knowledge regarding a particular set of actions.
	Knowledge (preparation)	Information and understanding of the behaviour, usually acquired by experience or by learning	Knowledge regarding a behaviour*	Knowledge regarding a particular set of actions.
Learning GO:0007612		Any process in an organism in which a relatively long-lasting adaptive behavioural change occurs as the result of experience.		
	Generalisation	The process by which the effects of learning in one situation are transferred to another	Generalisation (learning)	Process in which the effects of conditioning on behaviour spread to stimuli that differ in certain aspects from the stimulus present during the original conditioning.
Memory GO:0007613		The activities involved in the mental information processing system that receives (registers), modifies, stores, and retrieves informational stimuli.		

MoA class label (if imported, URI)	MoA instance label	Definition	Subclass label (if imported, URI)	Subclass definition
	Associative memory	Any experienced association linked to a remembered object or event	Associative memory*	The activities involved in the mental information processing system that receives (registers), modifies, stores, and retrieves informational stimuli regarding the set of entities associated with a particular object or event.
	Episodic memory	A memory for specific, personally experienced events that happened at a particular time or place	Episodic memory	The activities involved in the mental information processing system that receives (registers), modifies, stores, and retrieves informational stimuli that were contained in a message.
	Memory	The retention of message content such that it can be reproduced or recalled	Message memory	The activities involved in the mental information processing system that receives (registers), modifies, stores, and retrieves informational stimuli regarding a personally experienced event at a particular time or place.
	Semantic memory	The set of associations generated by an object or idea, which in total constitute its meaning (implies more than consciously synthesised meaning)	Associative memory*	The activities involved in the mental information processing system that receives (registers), modifies, stores, and retrieves informational stimuli regarding the set of entities associated with a particular object or event.
Motivation		A mental process that energises and directs behaviour.		
	Automatic motivation	An aspect of motivation that does not require reflective thought (involving emotions and impulses that arise from associative learning and/or innate dispositions)	Automatic motivation	A mental process that energises and directs behaviour via emotions and impulses that arise from associative learning or innate dispositions.
	Danger control process	The motivation to control the threat; initiated when one perceives that there is a high level of threat and that one is capable of taking effective action to avert that threat	Threat reduction motivation*	Motivation in order to avert a perceived threat.
	Extrinsic motivation	Motivation arising from consequences that are separate from the behaviour itself	Extrinsic motivation	Motivation in order to attain some external goal or externally imposed constraint.
	Intrinsic motivation	Motivation to engage in an activity arising from the behaviour itself being interesting and enjoyable	Intrinsic motivation	Motivation due to the behaviour itself being interesting or enjoyable.
	Protection motivation	The motivation to avert a threat to oneself	Threat reduction motivation*	Motivation in order to avert a perceived threat.

MoA class label (if imported, URI)	MoA instance label	Definition	Subclass label (if imported, URI)	Subclass definition
Motivational orientation		A mental disposition for motivation to be guided by a focus on the presence or absence of outcomes of a certain valence.		
	Prevention focus	A motivational orientation that is concerned with the presence or absence of negative outcomes	Prevention focused motivational orientation	A mental disposition for motivation to be guided by a focus on the presence or absence of negative outcomes.
	Promotion focus	A motivational orientation that is concerned with the presence or absence of positive outcomes	Promotion focused motivational orientation	A mental disposition for motivation to be guided by a focus on the presence or absence of positive outcomes.
Need		A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining a particular state.		
	Context	A behaviour-related need; the need one feels for a behaviour to take place in a context that is enjoyable	Enjoyable context need	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining opportunities for behaviour to take place in an enjoyable context.
	Coping	A behaviour-related need; the need one feels to have available effective coping strategies, especially when one gives up a coping strategy for a health-related reason	Coping strategy need	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining effective coping strategies.
	Need for accessibility	Need related to the pattern, quantity, quality, variety and proximity of activities present, as well as the connectivity between the uses (e.g. actual or perceived barriers to walking, number of destinations available to walk)	Need for location access	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining access to suitable locations to perform the behaviour.
	Need for autonomy	The necessity of experiencing self-determination and volition rather than feeling governed by other forces	Autonomy need*	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining a sense of personal agency and initiative.
	Need for beauty	Need for the ability to experience and enjoy beautiful things inside and around the home	Aesthetic need	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining the experience of aesthetically pleasing things.

MoA class label (if imported, URI)	MoA instance label	Definition	Subclass label (if imported, URI)	Subclass definition
	Need for comfort	Needed level of ease, convenience, and contentment	Need for comfortable daily life*	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining an easy and comfortable everyday life.
	Need for comfort	The need for everyday life to be easy and comfortable	Need for comfortable daily life*	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining an easy and comfortable everyday life.
	Need for competence	The importance of experiencing oneself as able and effective in dealing with the environment	Need to feel competent	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining the experience of oneself as able and effective.
	Need for competence	A behaviour-related need; the need one feels to be capable of engaging with and carrying out a behaviour well and with relative ease	Need to feel behaviourally competent	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining the experience of oneself as capable of performing a behaviour well.
	Need for development and education	The need for an opportunity to receive a good education and to develop general knowledge	Need for education	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining a good education and developing general knowledge.
	Need for freedom and control	Need for the course of one to be able to control their life, and make individual decisions (e.g. about what one wants to do)	Autonomy need*	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining a sense of personal agency and initiative.
	Need for health**	Need for good health and adequate, accessible healthcare	Need for health	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining good health.
			Need for healthcare	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining access to appropriate healthcare.
	Need for labour	Need to have a good job that is enjoyable, and the ability to perform that job well	Need for good work situation*	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining a satisfying and enjoyable job.
	Need for leisure time	Need for one to have sufficient time for leisure	Need for leisure time	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining time when one is not working or occupied.

MoA class label (if imported, URI)	MoA instance label	Definition	Subclass label (if imported, URI)	Subclass definition
	Need for nature and environment	Need for the environment to provide clean air, water and soil, and healthy animals and plants	Need for healthy natural environment	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining an environment with clean water, air and soil and healthy animals and plants.
	Need for pleasure and arousal	Need for everyday life to provide experiences that are enjoyable and exciting	Need for enjoyable everyday life	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining pleasurable and exciting experiences in everyday life.
	Need for privacy	Need for one to be oneself, do things for oneself and have one's own place	Autonomy need*	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining a sense of personal agency and initiative.
	Need for relatedness	The importance of caring for, being cared for by, and feeling connected to other people	Need for social relatedness*	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining a sense of connectedness to others.
	Need for safety	Need for personal safety and protection from crime and accidents both at home and outside	Need for safety from accidents	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining protection from accidents.
	Need for safety	The need to feel safe from the threat of crime	Need for safety from crime	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining freedom from the threat of crime.
	Need for self-esteem	The requirement for a positive self-concept that influences behaviour	Need for self-esteem*	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining a positive evaluation of oneself and one's qualities and characteristics.
	Need for social relation	Need for good relationships with family, friends and peers and the opportunity to improve these relationships	Need for social relatedness*	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining caring relationships with other people.
	Need for status	The need to receive the appreciation of others due to personal skills, achievements or possessions	Need for social recognition	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining appreciation from others due to one's skills, achievements or possessions.

MoA class label (if imported, URI)	MoA instance label	Definition	Subclass label (if imported, URI)	Subclass definition
	Need for work	The extent to which one has a good job that is enjoyable	Need for good work situation*	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining a satisfying and enjoyable job.
	Ownership	A self-need; the need one feels to engage in a new behaviour for personal reasons, as opposed to reasons dictated by another	Behavioural autonomy need	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining a sense of personal agency and initiative when changing one's behaviour.
	Preference	A behaviour-related need; the need for one's behaviours to be congruent with one's tastes and preferences	Need for consistency between beliefs and behaviour	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining consistency between one's opinions or attitudes and behaviours.
	Security	A self-need; the need one feels to establish a sense of security when faced with a personal health threat	Need for sense of security	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining a feeling of being safe from threats.
	Self-determination	A self-need; the need one feels to possess a sense of personal agency and initiative in relation to adopting a new behaviour	Autonomy need*	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining a sense of personal agency and initiative.
	Self-esteem	The need to view oneself as valuable; serves as a buffer against anxiety	Need for self-esteem*	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining a positive evaluation of oneself and one's qualities and characteristics.
	Support	A self-need; the need one feels for family, friends or caregivers to give support to meet self-related and behaviour-related needs in a manner associated with the integration of a new behaviour with one's values and sense of self	Need for social relatedness*	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining a sense of connectedness to others.
Belief about likelihood of consequences of behaviour		A belief about the likelihood a particular behaviour will result in particular outcomes.		

MoA class label (if imported, URI)	MoA instance label	Definition	Subclass label (if imported, URI)	Subclass definition
	Belief about the efficacy of change	Perception of whether change will lead to the desired health outcome	Belief about likelihood of health consequences of behaviour*	A belief about the likelihood of a behaviour resulting in a change in a threat to health and wellbeing.
	Perceived benefit	Belief about the relative effectiveness of known options for reducing a health threat, distinct from objective facts	Belief about likelihood of health consequences of behaviour*	A belief about the likelihood of a behaviour resulting in a change in a threat to health and wellbeing.
	Response efficacy	Perception of the likelihood that taking a particular action would be effective in averting a threat	Belief about likelihood of health consequences of behaviour*	A belief about the likelihood of a behaviour resulting in a change in a threat to health and wellbeing.
	Response efficacy	Belief about how effective a coping response will be in averting the threat	Belief about likelihood of health consequences of behaviour*	A belief about the likelihood of a behaviour resulting in a change in a threat to health and wellbeing.
	Response efficacy	Perception of whether reducing risky behaviours and increasing low-risk behaviours will be effective in reducing one's risk of the disease or health risk	Belief about likelihood of health consequences of behaviour*	A belief about the likelihood of a behaviour resulting in a change in a threat to health and wellbeing.
Belief about the availability of behavioural options		A belief about having the option of performing different behaviours.		

MoA class label (if imported, URI)	MoA instance label	Definition	Subclass label (if imported, URI)	Subclass definition
	Perceived availability of alternative, self-enhancing deviant behaviour pattern	Perception of the availability of alternative behaviour patterns that enhance one's evaluations of oneself but that deviate significantly from what is considered appropriate or typical for a social group	Belief about the availability of self-enhancing deviant behavioural options	A belief about having the option of performing different behaviours that would enhance one's self-evaluation but not be considered appropriate or typical for a social group.
	Perceived availability of alternative, self-enhancing normative behaviour patterns	Perception of the availability of alternative behaviour patterns that enhance one's evaluations of oneself and are in line with the standards of typical behaviour for other individuals, groups or society	Belief about the availability of self-enhancing normative behavioural options	A belief about having the option of performing different behaviours that would enhance one's self-evaluation and be considered appropriate or typical for a social group.
Belief about one's environment		A belief about the nature of the immediate physical and social settings in which people live, including culture and the people and institutions with whom they interact.		
	Perceived autonomy support	The extent to which there is perceived to be environmental support in relation to independence and self-determination in an individual	Belief about autonomy support in one's environment	A belief about whether the immediate physical and social settings in which people live, including culture and the people and institutions with whom they interact, support self-determination in a person.
	Perception of external control	A belief about whether external resources are available to support the behaviour	Belief about availability of resources to support behaviour in one's environment	A belief about whether there are resources available in a person's immediate physical and social settings that will facilitate performance of a behaviour.

MoA class label (if imported, URI)	MoA instance label	Definition	Subclass label (if imported, URI)	Subclass definition
	Pleasurability	The level of appeal that a setting provides with respect to the experience of the behaviour	Belief about pleasurability of a behaviour in one's environment	A belief about whether the immediate physical and social settings in which people live, including culture and the people and institutions with whom they interact, will result in the behaviour being pleasurable.
Importance of goal attainment		A cognitive representation of the significance of successfully meeting a goal.		
	Perceived importance of problem	Belief about the importance of behaviour change with respect to other ongoing problems	Importance of goal attainment relative to other goals*	A cognitive representation of the significance of successfully meeting a goal compared to the significance of meeting other goals.
	Priority	The relative importance of engaging in a particular goal, when compared with other life goals; can be overall and/or at any particular point in time	Importance of goal attainment relative to other goals*	A cognitive representation of the significance of successfully meeting a goal compared to the significance of meeting other goals.
Belief about social influence processes		A belief about whether or how others will attempt to use social influence processes to affect the person's behaviour.		
	Parent-friends influence	Perceived influence of one's friends and parents on the behaviour	Belief about social influence processes involving parents and friends	A belief about whether or how parents and friends will attempt to use social influence processes to affect the person's behaviour.
Belief about threat		A belief about the nature of a potential harm.		
	Awareness of consequences	The belief that environmental conditions pose threats to other people, other species and the biosphere	Belief about environmental threat	A belief about the nature of a potential harm to the circumstances, objects, or conditions by which one is surrounded.
Planning MF:0000027		A mental process that involves mentally manipulating representations of steps in an imagined process which has some objective.		

MoA class label (if imported, URI)	MoA instance label	Definition	Subclass label (if imported, URI)	Subclass definition
	Problem solving	Strategy that provide guides for action in different circumstances	Problem solving planning	Planning involving forming at least two plans in order to guide action in different circumstances.
Psychological capability		A mental disposition that is realised in mental processes relating to ability to perform a behaviour.		
	Ability to use controls and defences	The ability to defend oneself against, or to cope with, experiences that are self-devaluing	Self-worth regulation capability	A psychological capability to cope with experiences that reduce one's sense of self-worth.
	Forethought capability	The ability to regulate behaviour on the basis of the future	Future-focused self-regulatory capability	A self-regulatory capability to module behaviour based on thoughts about the future.
	Generative capability	A form of knowledge that allows one to envisage alternative goals and create novel action strategies	Goal generating capability	A self-regulatory capability to envisage alternative goals and create new strategies for action.
	Management of Emotions	The ability to appropriately managing one's emotions (coping)	Emotion regulation capability	A psychological capability to modulate one's emotions in order to facilitate goal attainment.
	Self-control	Executive capacity to inhibit action tendencies	Self-control capability	A self-regulatory capability to inhibit activated action scripts or action tendencies.
	Self-reflective capability	The ability to analyse one's own experiences, thoughts and knowledge	Self-reflective capability	A psychological capability to analyse one's own experiences and thoughts.
	Self-regulatory ability	The ability or capacity to control one's own behaviour	Self-regulatory capability*	A psychological capability that involves processes that modulate the frequency, rate or extent of behaviour, the specific actions or reactions of a person in response to external or internal stimuli and that are instigated by the person themselves.
	Self-regulatory capability	The ability to motivate or regulate one's own behaviour on the basis of personal standards and evaluations of the behaviour	Self-regulatory capability*	A psychological capability that involves processes that modulate the frequency, rate or extent of behaviour, the specific actions or reactions of a person in response to external or internal stimuli and that are instigated by the person themselves.

MoA class label (if imported, URI)	MoA instance label	Definition	Subclass label (if imported, URI)	Subclass definition
	Self-regulatory capacity	Any state- or trait-like factor that influences one's ability to make efforts to regulate their behaviour (e.g. energy levels, executive functioning)	Self-regulatory capability*	A psychological capability that involves processes that modulate the frequency, rate or extent of behaviour, the specific actions or reactions of a person in response to external or internal stimuli and that are instigated by the person themselves.
	Symbolising capability	The capacity to use symbols	Symbol use capability	A psychological capability to use marks or characters to represent objects, functions or processes.
	Vicarious capability	The ability to learn through observation	Vicarious learning capability	A psychological capability to acquire knowledge or skill from observation.
Desired standard		A cognitive representation of a desired state that serves as a reference level.		
	Reference value	The standard against which one's current behaviour is compared (e.g. a desired behaviour or state)	Desired standard for behaviour	A cognitive representation of one's desired level of behaviour.
	Self-standard	Level of quality against which one judges one's efforts towards goal attainment	Desired standard for effort	A cognitive representation of one's desired level of effort towards a goal.
	System concept	The reference value at the highest level of the hierarchical system that represents the desired self-image	Desired standard for self-image	A cognitive representation of how one wishes to perceive oneself.
Judging as potential peer		Judging whether an individual or individuals should be considered as a person of the same status or rank.		
	Selection of peers	The choice of people you consider yourself equal/very similar to in terms of status/ability	Judging as peer of similar status or ability*	Judging whether an individual or individuals should be considered as a person of the same status or rank in terms of ability.
	Selection of peers	The choice of people you consider yourself equal/very similar to in terms of status/ability	Judging as peer of similar status or ability*	Judging whether an individual or individuals should be considered as a person of the same status or rank in terms of ability.
	Selection of significant others	The selection of individuals who have substantial influence on one's behaviour or self-opinion	Judging as peer influential to one's behaviour or self-evaluation	Judging whether an individual or individuals should be considered as a person of the same status or rank who influences one's behaviour or self-evaluation.

MoA class label (if imported, URI)	MoA instance label	Definition	Subclass label (if imported, URI)	Subclass definition
Behavioural self-regulation of behaviour		A behaviour undertaken to modulate the frequency, rate or extent of a different behaviour, the specific actions or reactions of an organism in response to external or internal stimuli, and that is instigated by the organism itself.		
	Avoidance	The practice or instance of increasing the distance between oneself and the environment or removal of the aspect of the environment altogether	Avoidant behavioural self-regulation	A behaviour to increase the distance between oneself and an aspect of one's environment or to completely remove an aspect of the environment, in order to modulate the frequency, rate or extent of a different behaviour.
	Restructuring personal environments	Actions to change the rules and/or structure of one's own personal environment, including the other actors who are part of it	Environment restructuring self-regulation*	A behaviour that alters the rules or structure of one's environment in order to modulate the frequency, rate or extent of a different behaviour.
	Stimulus Control	The process through which the environment is restructured (e.g. by the individual) such that cues for problem behaviours are reduced and cues for healthier behaviours increased	Environment restructuring self-regulation*	A behaviour that alters the rules or structure of one's environment in order to modulate the frequency, rate or extent of a different behaviour.
	Self-Reinforcement	Process by which one self-administers a reward (either tangible or internal) for attaining a goal	Self-reinforcing self-regulation	Self-regulation
Self-efficacy		A belief about one's capabilities to engage in a behaviour.		
	Recovery self-efficacy	Belief about one's ability to address experiences of failure in a behaviour change attempt and to resume a behaviour following such a setback	Recovery self-efficacy	A belief about one's capabilities to resume a behaviour change attempt after a setback.
	Self-efficacy	Belief about one's ability to cope with high risk situations	Situational self-efficacy*	A belief about one's capabilities to engage in a behaviour in a particular situation.
	Situational self-efficacy	The moment to moment, subjective perception of one's capability for performance in a given setting or ability to attain desired results in a particular situation	Situational self-efficacy*	A belief about one's capabilities to engage in a behaviour in a particular situation.
	Situational self-efficacy	The confidence to engage in a behaviour when in certain situations or locations	Situational self-efficacy*	A belief about one's capabilities to engage in a behaviour in a particular situation.

MoA class label (if imported, URI)	MoA instance label	Definition	Subclass label (if imported, URI)	Subclass definition
	Social self-efficacy	The confidence to engage in a behaviour when there are social influences opposing that behaviour (e.g. when with friends)	Situational self-efficacy*	A belief about one's capabilities to engage in a behaviour in a particular situation.
	Stress self-efficacy	The confidence to engage in a behaviour when confronted with emotional and stressful situations	Situational self-efficacy*	A belief about one's capabilities to engage in a behaviour in a particular situation.
Self-regulation of behaviour		A bodily process that modulates the frequency, rate or extent of behaviour, the specific actions or reactions of an organism in response to external or internal stimuli and that is instigated by the organism itself.		
	Integrated self-regulation	The self-management of behaviour driven by the congruency between the behaviour and one's values and sense of self	Value-congruent self-regulation	Self-regulation undertaken to achieve congruence between one's values and the behaviour performed.
Perception MF:0000019		A mental process which is a) produced by a causal process (for example involving light rays or air vibrations) involving a part of the environment of the organism, and b) is experienced by the organism as being so caused, and c) in which the relevant part of the environment is thereby represented to the organism.		
	Discomfort	Unpleasant sensation arising from senses, images or thoughts	Perception of discomfort	A mental process which is a) produced by a causal process (for example involving light rays or air vibrations) involving a part of the environment of the organism, and b) is experienced by the organism as being so caused and as unpleasant, and c) in which the relevant part of the environment is thereby represented to the organism.
	Physiological reaction to smoking	The physical sensation experienced as a result of smoking	Perception of physiological effects of smoking*	A mental process which is a) produced by the person smoking tobacco, and b) is experienced by the person as being so caused, and c) in which the effect of smoking tobacco on the body is thereby represented to the person.
	Perceived physiological effect	Perceived sensation in the body resulting from smoking	Perception of physiological	A mental process which is a) produced by the person smoking tobacco, and b) is experienced by the person as

MoA class label (if imported, URI)	MoA instance label	Definition	Subclass label (if imported, URI)	Subclass definition
			effects of smoking*	being so caused, and c) in which the effect of smoking tobacco on the body is thereby represented to the person.
Social embeddedness		A mental disposition to view and experience oneself as attached to and involved in a social group.		
	Attachment	The extent to which one is attached to conventional society	Social embeddedness in conventional society	A mental disposition to view and experience oneself as attached to and involved in a large social group whose members follow prevailing norms for thoughts and behaviour
Social influence process		An interpersonal process where one or more person exerts an influence on the behaviour of another.		
	Family influence	The influence of one's family on one's smoking behaviour	Family social influence process*	An interpersonal process where one or more family member exerts an influence on the behaviour of another.
	Family influence	Influence of one's family on the development of smoking behaviour	Family social influence process*	An interpersonal process where one or more family member exerts an influence on the behaviour of another.
	Family reaction	Response from family members that occur as a consequence of performing the behaviour	Family social influence process*	An interpersonal process where one or more family member exerts an influence on the behaviour of another.
	Friends control	Personal and social controls instigated by friends relating to the problem behaviour	Friend social influence process	An interpersonal process where one or more friend exerts an influence on the behaviour of another.
	Peer influence	The influence of people of the same status or rank on one's smoking behaviour	Peer social influence*	An interpersonal process where one or more person of the same status or rank exerts an influence on the behaviour of another.
	Peer influence	Influence of one's peers on the development of smoking behaviour (e.g. peer pressure)	Peer social influence*	An interpersonal process where one or more person of the same status or rank exerts an influence on the behaviour of another.
	Peer influence	The influence of one's peers on behaviour	Peer social influence*	An interpersonal process where one or more person of the same status or rank exerts an influence on the behaviour of another.

MoA class label (if imported, URI)	MoA instance label	Definition	Subclass label (if imported, URI)	Subclass definition
	Peer influence	The influence of one's peers on the behaviour	Peer social influence*	An interpersonal process where one or more person of the same status or rank exerts an influence on the behaviour of another.
Social interaction process		An interpersonal process involving reciprocal communication between two or more people.		
	Interpersonal situation	Social interaction that will either facilitate or make behaviour change difficult (e.g. peer interaction, communication with parents or teachers and drug-avoiding socialising)	Behaviour-influencing social interaction process*	An interpersonal process in which one person's reciprocal communication with one or more others may facilitate or hinder the person's behaviour.
	Social bonding	Process through which one establishes an affective relation between individuals	Bonding social interaction process	An interpersonal process involving reciprocal communication between two or more people leading to the establishment of an affective relationship between those individuals.
	Social interaction	Social encounters with important others that may facilitate or hinder the behaviour	Behaviour-influencing social interaction process*	An interpersonal process in which one person's reciprocal communication with one or more others may facilitate or hinder the person's behaviour.
Observational learning GO:0098597		Learning that occurs through observing the behavior of others.		
	Copying	Form of imitation that occurs when an observer seeks to optimize the accuracy of his/her behaviour to that of a model, whereby one brings one's behaviour to approximate that of a model and where one knows that this act is an acceptable replication of the model act; includes contingent rewards based on sameness and differences cues which are based on the closeness of the match between a model's and an observer's behaviour	Imitative learning* GO:0098596	Learning in which new behaviours are acquired through imitation.
	Imitation	The process of copying the behaviour of another person, group, or object, intentionally or unintentionally	Imitative learning* GO:0098596	Learning in which new behaviours are acquired through imitation.

MoA class label (if imported, URI)	MoA instance label	Definition	Subclass label (if imported, URI)	Subclass definition
	Modelling	The process by which one or more individuals or other entities serve as examples that others will emulate	Imitative learning* GO:0098596	Learning in which new behaviours are acquired through imitation.
	Role-modelling	The process of emulating a behaviour displayed by another individual whom one identifies with or admires	Imitative learning from valued others*	Learning in which new behaviours are acquired through imitation of another person one admires or has a close bond with.
	Social learning	Process through which one's health-related behaviours can be shaped by observing and imitating the attitudes and behaviours of others to whom one is closely bonded	Imitative learning from valued others*	Learning in which new behaviours are acquired through imitation of another person one admires or has a close bond with.
	Vicarious experience of mastery	Observation of others successfully performing the behaviour or engaging in threatening activities without the expected adverse consequences	Vicarious mastery observational learning	Learning that occurs through observing others successfully perform a behaviour.
Social opportunity		A quality of the social environment that influences performance of a behaviour.		
	Need for social justice	The extent to which the environment provides equal opportunities and the right to own and do things	Social opportunity for equality	The extent to which the social environment provides equal opportunities to act and own property to all people.
	Opportunity for involvement	The extent to which one has the opportunity for social involvement which influences the behaviour	Social involvement opportunity	The extent to which the social environment provides opportunities for a person to actively engage in social groups.
Interpersonal approval for behaviour		An interpersonal process in which one or more person indicates approval of another person performing a particular behaviour.		
	Friends approval of problem behaviour	The extent to which one's friends believe that the problem behaviour is good or acceptable	Interpersonal approval for behaviour by friends*	An interpersonal process in which one or more person indicates approval of their friend performing a particular behaviour.
	Friends support	Support or approval shown by friends for the problem behaviour	Interpersonal approval for behaviour by friends*	An interpersonal process in which one or more person indicates approval of their friend performing a particular behaviour.

MoA class label (if imported, URI)	MoA instance label	Definition	Subclass label (if imported, URI)	Subclass definition
	Parent approval of problem behaviour	The extent to which one's parents believe that the problem behaviour is good or acceptable	Interpersonal approval for behaviour by parent*	An interpersonal process in which one or more parent indicates approval of their child performing a particular behaviour.
	Parental support	Support or approval shown by parents for the problem behaviour	Interpersonal approval for behaviour by parent*	An interpersonal process in which one or more parent indicates approval of their child performing a particular behaviour.
	Social reinforcement	Positive interpersonal stimulus such as verbal praise, a smile, touch or other sign of approval that increases the frequency of the behaviour that immediately precedes it	Interpersonal approval subsequent to behaviour	An interpersonal process in which one or more person indicates approval subsequent to another person performing a particular behaviour.
Temporal orientation		A mental disposition to focus more on present or future outcomes.		
	Future-oriented	An attitude characterised by a focus on long-term goals and outcomes	Temporal orientation to the future	A mental disposition to focus more on future than present outcomes.
	Myopia	Near-sightedness such that one is more present-focused than future-oriented	Temporal orientation to the present*	A mental disposition to focus more on present than future outcomes.
	Present-oriented	An attitude characterised by a focus on short-term benefits and outcomes	Temporal orientation to the present*	A mental disposition to focus more on present than future outcomes.
Personal value		A mental disposition regarding what is fundamentally important in life and which informs standards for behaviour.		
	Altruistic value	Moral, social or aesthetic principle that stems from an apparently unselfish concern for others	Altruistic personal value	A personal value that stems from an apparently unselfish concern for others.
	Egoistic value	Moral, social or aesthetic principle that stems from self-interest/self-enhancement motives	Egoistic personal value	A personal value that stems from self-interest or self-enhancement motives.

MoA class label (if imported, URI)	MoA instance label	Definition	Subclass label (if imported, URI)	Subclass definition
	Health related value	Moral, social or aesthetic principle that concern one's health	Health related personal value	A personal value that concerns one's health.
	Traditional value	Moral, social or aesthetic principle that stems from a set of social customs or other ethnic or family practices handed down from generation to generation (e.g. duty, family loyalty)	Tradition related personal value	A personal value that stems from a set of social customs or other ethnic or family practices handed down from generation to generation.

Notes. * Classes that were added to the MoA Ontology to represent more than one MoA instance

** Two classes were developed from the 'Need for health' MoA instance

Appendix 4-5. MoA instances that qualified as examples of their respective MoA classes

MoA class label	MoA instance label	Definition
Action script		A cognitive representation that guides a sequence of behaviours.
	Action script	A scripted behaviour chain in which one behaviour within a sequence reinforces the previous action and guides the next.
	Action script	Cognitive structure that directs the implementation of a goal or other chosen action.
Addiction		A chronic acquired mental disorder involving repeated abnormally powerful motivation to engage in a behaviour despite risk or experience of harm.
	Addiction	A chronic condition involving a repeated powerful motivation to engage in a rewarding behaviour, acquired as a result of engaging in that behaviour, that has significant potential for unintended harm.
	Substance use/Addiction	A chronic condition involving a repeated powerful motivation to engage in a rewarding behaviour, acquired as a result of engaging in that behaviour, that has significant potential for unintended harm.
	Addiction	A process in which the current consumption of a product increases its future consumption.
	Adjacent complementarity	The process of becoming addicted to a substance that results from past consumption of the substance raising the marginal utility of current consumption, and the current consumption raising the marginal utility of future consumption (i.e. similar to the idea of classic reinforcement).
Affective process		Any process that has positive or negative valence.
	Affect	An internal feeling state that can be positive (occurs when a goal has been attained, a source of threat has been avoided or the individual is satisfied with the current state of affairs) or negative (occurs when processes are under strain or otherwise out of balance).
	Affect towards means	Feeling toward the available resources and methods (means) for goal achievement.
	Context-related affect	Emotional response to the environment in which the behaviour occurs.
Evaluating multiple options		A cognitive process that gives rise to an evaluation and comparison of the nature and significance of two or more options.
	Coding	The process through which outcomes are sorted into gains or losses.
	Cognitive evaluation	Evaluation of risky alternatives at a cognitive level (based largely on the probability and desirability of associated consequences).
	Decisional balance	The process through which the pros and cons of behaviour change are evaluated.
	Editing phase	Stage at which a preliminary analysis of available prospects is conducted, and options are organised and reformulated.
Arousal		Physiological and psychological state of being awake or reactive to stimuli.
	Alertness	A state relating to the degree to which one is attending to information and ready for action.

MoA class label	MoA instance label	Definition
	Arousal	A generalised level of energy imparted to the motivational system.
	Arousal	The process by which systems are activated in preparation for either increased processing or action, or the level of such activation.
	Arousal	A state of alertness and readiness for action.
	Arousal	A state of alertness and readiness for action.
	Emotion arousal	A state of excitement or energy expenditure linked to an emotion; elicited by stressful or demanding situations.
	Motive	Physiological or psychological arousal that directs energy and attention towards a goal.
Associative learning		Learning concerning the association between two or more stimuli or between a stimulus and a response.
	Associative learning	A process whereby patterns of brain activity representing perceptions, emotions or response organisation become linked so that, when a particular pattern occurs, another is made more likely to occur.
	Conditioning	The process by which certain kinds of experience make operationally generated actions more or less likely.
Attending		A mental process whereby relevant aspects of our mental experience are focused on specific targets.
	Attention/Attend	The act of directing attention to a person, location, object or event which is presumed to increase processing of the attended information and make it more prominent in conscious awareness.
	Attention	The process by which executive processes become engaged with stimuli.
	Attention	The extent to which people attend to the information being presented.
Attitude towards behaviour		A cognitive representation which represents an overall evaluation of the impact of the possible outcomes of a behaviour to the organism.
	Attitude	A general evaluation of pro-environmental behaviour on a scale ranging from negative to positive.
	Attitude	General evaluation of health-related behaviour ranging on a scale from negative to positive.
	Attitude	The perceived cognitive and emotional advantage and/or disadvantage of the behaviour.
	Attitude (preparation)	The general evaluation of the behaviour on a scale ranging from negative to positive, developed during preparation stage.
	Attitude towards the behaviour	A general evaluation of the behaviour on a scale ranging from negative to positive; a function of beliefs and evaluations of outcome.
	Attitude	A subjective belief and/or evaluation associated with the behaviour.
	Attitude	Belief and/or feeling of favourableness or unfavourableness in relation to a behaviour.
	Attitude	The overall feeling of favourableness or unfavourableness towards performing the behaviour.

MoA class label	MoA instance label	Definition
	Attitude	The general evaluation of performing the behaviour on a scale ranging from negative to positive.
	Attitude	The general evaluation of the behaviour on a scale ranging from negative to positive.
	Attitude	Belief about how favourable or unfavourable the behaviour is.
	Attitude	Favourable or unfavourable evaluation or appraisal of the behaviour.
	Attitude	Belief about/evaluation of a behaviour.
	Belief (preparation)	Association of some characteristic or attribute, usually evaluative in nature, in relation to the behaviour.
Appraisal of causal agency		An appraisal that represents an evaluation of who or what caused an event.
	Attributional process	Process relating to assigning causality for events, which may include internal/external attribution.
	Locus of Control	The extent to which one attributes valued outcomes or reinforcement to either internal or external circumstances.
	Locus of control	The extent to which one attributes valued outcomes or reinforcement to either internal or external circumstances.
Awareness		A mental disposition to be conscious of events, objects or sensory patterns.
	Awareness	A consciousness of internal or external events or experiences.
Behavioural intention formation		A cognitive process that brings into being a behavioural intention.
	Intention formation	The process by which a conscious decision is made to perform the behaviour.
	Intention formation process	The process by which a self-conscious plan to engage or not engage in a given health behaviour is formed.
	Planning	The action or process of forming or arranging an intention to do something.
Attending disrupted by behavioural alternatives		A mental process whereby relevant asepcts of our mental experience become focused on a behaviour other than the currently planned or engaged in course of action.
	Competing demand	An alternative behaviour that intrudes into a person's thoughts one has no control over (e.g. childcare responsibilities).
	Competing preference	An alternative behaviour that interludes consciousness over which one has control, but that has highly reinforcing properties.
Belief		A disposition to mental processes that represent some proposition X to be true.
	Belief	One's perception regarding a specific condition or health behaviour.
	Belief	A propositional cognitive representation (i.e. that can be expressed through language).
	Belief	Propositional type of mental representation to which is attached a sense of adherence.
	Belief	Propositional type of mental representation to which is attached a sense of adherence.
Belief about barriers		A belief about the existence of factors that could restrict or impede the person from engaging in a behaviour.

MoA class label	MoA instance label	Definition
	Control belief	Belief about the presence or absence of factors that can facilitate or impede performance of the behaviour; assumed to determine perceived behavioural control.
	Perceived barrier	Belief about the negative aspects of taking health-protective action (e.g. inconvenience, expense, discomfort).
	Perceived barrier to action	Belief about barriers (e.g. lack of resources) to engaging in a behaviour, and personal cost associated with engaging in the behaviour.
Capability		A bodily disposition that is realised by the bearer engaging in a particular behaviour when appropriate circumstances occur.
	Ability factor	Factor relating to one's capability of undertaking a given behaviour.
	Capability to change	The ability or capacity to make a change in the behaviour.
Mental categorising		A mental process in which objects, events, people, or experiences are grouped into cognitive representations of classes, on the basis of features shared by members of the same class and features distinguishing the members of one class from those of another.
	Propositional categorisation	Categorisation through which semantic concepts emerge from the impulsive system.
Judging		A mental process during which a decision is made and the outcome of which is a belief or opinion. Judging is the evaluation of evidence to make a decision or form a belief.
	Choice	The process whereby alternative course of action is imagined and one of them selected through a process of reflective analysis.
	Choice	The selection of one prospect over another or others.
	Decision making	The cognitive process of choosing between two or more alternatives.
Commitment making		A mental process by which one decides to pursue a goal and develops a sense of being obligated or emotionally impelled to act upon that goal.
	Commitment	Executive strategy that imposes rules, whereby one feels more obligated or emotionally impelled to engage in a behaviour.
	Commitment (to a goal and to the means for goal attainment)	The 'binding' of someone to a decision to try to achieve a goal and to use certain means to do so.
	Commitment to change	The decision-making process to reach a firm decision to reduce high risk behaviour and increase low risk behaviour.
Communication		An interpersonal process that involves as participant at least two linguistically capable organisms, one of whom produces an utterance that is well-formed in a given language and the other of whom perceives and understands that utterance by virtue of their recognition of the meaning of the utterance through their knowledge of the language.
	Communication with others	The transmission of information between oneself and another, or multiple others.
	Communication	The transmission of information from one person or source to another, which may be by verbal (oral or written) or nonverbal means.
Comprehension		A cognitive process that creates a representation of the meaning and significance of a communication, object, event or situation.

MoA class label	MoA instance label	Definition
	Comprehension	Learning process through which the educational content (e.g. of a communication) is understood.
	Comprehension	The process of understanding communications, objects, events, or situations with respect to meaning, significance, relationships, or general principles.
Behavioural cue		A stimulus that serves to elicit or guide behaviour.
	Cue	Stimulus that serves to guide behaviour, determines when/where a person will respond, and which response he/she will make.
Descriptive norm		A belief regarding the prevalence of performance of a given behaviour by people within a group.
	Descriptive norm	What is perceived as typically done; what is perceived as 'normal' within a culture.
	Descriptive norm	Socially determined consensual standards relating to the prevalence of the behaviour (i.e. perceptions of what most people actually do).
	Descriptive norm	Individual belief about the prevalence of a behaviour.
	Norm	A standard or range of values that represents the typical performance of a group against which comparisons can be made.
	Provincial norm	A sub-type of norm about what is perceived as typically done or 'normal' in a specific environment.
	Smart norm	Standard representing the typical performance of a group or a person and that are abstract, as opposed to concrete.
Wanting		A mental process that involves thinking about a level of performance of a behaviour that does not currently obtain together with a desire for that level of performance of a behaviour to obtain.
	Desire	A feeling of want or need.
	Desire	Feeling of wanting or needing to engage in the behaviour.
	Want	Attraction to things on the basis of feelings of anticipated pleasure of satisfaction attached to them.
Dissonance reduction process		A mental process through which a perceived inconsistency between the two concurrently held cognitive representations is reduced.
	Dissonance reduction	The process by which a person reduces the uncomfortable psychological state that results from inconsistency among elements of a cognitive system.
Belief about the desirability of consequences of behaviour		A belief about the desirability or worth of the possible outcomes of a behaviour.
	Behavioural belief and its evaluative aspect	Belief about and evaluation of the possible outcomes of the behaviour.
	Evaluation	Belief about the worth or desirability of the outcomes of HAART adherence (or non-adherence).
	Incentive	The anticipated satisfaction of desired accomplishments and the negative appraisal of insufficient performance.
	Marginal Utility	The perceived gain from an increase, or loss from a decrease, in the consumption of a good or service.
	Perceived emotional cost and benefit	Expectation regarding all possible emotional and well-being-related outcomes of a behaviour, positive or negative.

MoA class label	MoA instance label	Definition
	Pros & Con s (Advantage/Disadvantage)	The positive or negative consequence that a person associates as outcomes from his behaviour.
Evaluation of goal achievement		A mental process which evaluates the appropriateness of current goal attainment strategies given one's progress towards goal achievement.
	Evaluation in respect to goals	The view of one's behaviour with respect to short-term and/or long-term desired end states.
	Guidance and control process	The evaluation of barriers to goal achievement, failures to make progress towards a goal and perceived external factors that may prevent goal achievement.
	Reflection and evaluation	Process by which executive processes provide feedback in relation to goal achievement or the appropriateness of goals or strategies.
Mentally comparing against a standard		A mental process in which current conditions are compared against a particular reference level.
	Comparator	The mechanism through which perceived current conditions are compared against a particular standard.
Financial opportunity		A quality of a person's social and physical environment regarding whether the person has sufficient financial resources to engage in a behaviour.
	Economic constraint	Financial restriction limiting human capacity to act.
	Economic availability	The extent to which it is financially viable to access alcohol (i.e. the retail price of alcohol in relation to disposable income).
	Financial ability	The financial element required for engaging in behaviour (e.g. income, credit, loans).
	Need for money	Need for financial means to buy and do things that are necessary and enjoyable.
Goal		A cognitive representation of the end state to which one is striving.
	Behavioural intention	Goals or goal states that are formulated after some deliberation or reasoning.
	Goal	The object or aim of action(s), for example, to attain a specific standard of proficiency, usually within a specified time limit.
	Goal	A desired end state towards which one is striving.
	Standard	The goal one is aiming to achieve; desired end states.
	Goal	The end state toward which one is striving; the purpose of an activity or endeavour, can be extrinsic or intrinsic.
	Goal	Conceptually identified target; can be specific behavioural or outcome-based (which cannot be pursued directly, e.g. I want to be happy).
	Goal	The end state toward which one is striving; the desired outcome of an activity or endeavour, which can be either extrinsic or intrinsic.
	Higher order goal	An abstract goal relating to what one wants in life, generally associated with self-concept, and positioned at the higher end of a hierarchy of such goals.
	Lower order goal	A concrete goal relating to the things one wants in life; generated as a result of more abstract goals relating to self concept, has a higher level of specificity, tends to relate to daily activities, and is at the lower end of a hierarchy of such goals.

MoA class label	MoA instance label	Definition
Goal pursuit process		A bodily process in which attempts are made to achieve a desired end state.
	Instrumental act	The process by which attempts are made to perform the means chosen to achieve a goal; consist of planning, monitoring and guidance and control processes.
	Persistence	The state of maintaining a course of action or keeping at a task and finishing it despite the obstacles or effort involved.
	Trying	A sub-type of action involving cognitive, affective and physical processes that join sequentially, interactively or in parallel to cause the bodily movements making up goal-directed behaviours.
Habitual behaviour		A behaviour that is well-learned and can be in automatic sequence with other behaviours, and has become reflexive over time.
	Habit	A routine that allows specific behaviours to be performed automatically with minimal conscious effort.
	Habit	A well-learned behaviour or automatic sequence of behaviours that is relatively situation specific and over time has become motorically reflexive and independent of motivational or cognitive influence.
Heuristic process		A mental process that uses simple rules and associations learnt from experience to make judgements.
	Adherence-related heuristic	Strategy for problem solving/decision-making that provide an efficient means for making somewhat automatic decisions regarding the behaviour.
	Social reaction path	A heuristically-based decision making path that is image-based and involves more heuristic processing.
Image		A cognitive representation that resembles the experience of perceiving some object or event but occurs when the relevant object or event is not actually present to the senses.
	Image	A visual representation of objects or events.
	Image	Iconic cognitive representation (i.e. one that represents images and other sensory experiences).
Inference		A mental process that involves applying rules to a set of premises to reach a conclusion.
	Inference	Mental process by which beliefs are created using deduction and induction.
	Syllogistic rule	Applying a rule that describes the transfer of truth from a premise to a conclusion.
Injunctive norm		A belief regarding whether a behaviour is appropriate and correct for people who belong to a particular social group.
	Injunctive norm	Socially determined consensual standard that describe one's attitudes, beliefs and morals in relation to a given situation (i.e. what most people think is 'right' to do).
	Injunctive norm	What is perceived as typically approved or disapproved of within a culture; the perceived moral rules of a group.
	Norm	Belief that certain behaviours are correct, appropriate or desirable and other behaviours are incorrect, inappropriate, immoral or undesirable.
	Role	Set of behaviours that is considered appropriate for persons holding particular positions in a group.

MoA class label	MoA instance label	Definition
	Social norm	The social expectation relating to what is deemed to be acceptable behaviour in a group or society.
	Social norm	A norm relating to what is deemed to be acceptable behaviour in a group or society.
Intention		A cognitive representation of one's plan to engage or not engage in a particular behaviour.
	General behavioural intention	Non-specific self-conscious plan to engage or not engage in a given behaviour.
	Intention	A self-conscious plan to engage or not engage in a given behaviour.
	Health intention	A self-conscious plan to engage or not engage in a given health behaviour.
	Intention	Mental representation of actions or action sequences, together with at least some degree of commitment to them and some form of cognitive representation of the starting conditions.
	Intention	Self-conscious plan to engage or not engage in a given behaviour; determined by beliefs about the extent to which significant others would approve of behavioural performance and valence of attitude toward the behaviour.
	Intention	The expressed motivation to perform the behaviour.
	Intention	Plan to engage in a behaviour, predicted by social normative beliefs, attitudes and personality.
	Intention	The cognitive representation of one's readiness to perform the behaviour; considered to be the immediate antecedent of behaviour.
	Intention	A conscious decision to perform a behaviour.
	Behavioural Intention	A conscious decision to perform a behaviour.
	Intention	Conscious decision relating to the performance of a behaviour.
	Intention	A person's conscious plan or decision to perform a particular behavior.
	Intention	Conscious decision relating to the performance of a behaviour.
	Intention	Conscious decision relating to the performance of a behaviour.
	Intention	A conscious decision to perform a behaviour.
	Intention	A conscious decision to engage in the behaviour that occurs when the necessary levels of motivation and behavioural control are present.
	Intention	A conscious decision to pursue the behaviour change.
	Intention to change	A conscious decision to change a behaviour.
	Motivation	One's intention to carry out a particular type of behaviour; determined by attitudes, social influences and self-efficacy.
	Social motive	Intention to engage in a behaviour that is based on a striving for status, achievement, power, or connection with others and the maintenance of relationships.
	Specific behavioural intention	Clearly defined or identified intention that corresponds directly to particular acts.
Interdependent action script		A disposition to an interpersonal process in which a sequence of behaviour in one individual elicits a sequence of behaviour in at least one other individual with whom the first is in a close relationship.

MoA class label	MoA instance label	Definition
	Interlinked script	A set of scripted behaviour (i.e. action) chains that have become connected; occurs among people in close social relationships.
	Social interdependence	A state in which action scripts are interlinked, meaning that someone in a close social relationship has the potential to influence another's action sequences.
Appraisal of obligation to respond		An appraisal that represents an evaluation of how much one is personally obliged to respond to an event or person in need.
	Accountability	The feeling that there is a responsibility to respond because one is made liable for the outcomes of the person in need.
	Activation of norms	The point at which there is a heightened sense of obligation to respond to need based on previously established norms.
	Arousal of some sense of responsibility to respond	The elicitation of a feeling of a sense of obligation to help a person in need, may occur in response to various conditions.
	Causal responsibility	The feeling that there is a responsibility to respond when one is at fault for causing another person's need.
	Personal moral norm	The perception that one is personally obligated to act.
Knowledge		A cognitive representation of the nature of the world, or a specific aspect of the world, that corresponds to the actual state of the world and is acquired through experience or learning.
	Associative cluster	Cluster of elements that represents knowledge; can be arranged hierarchically and represents either concrete or abstract concepts or schemata.
	Declarative knowledge schema	Set of knowledge that represents facts and beliefs about the world and about oneself.
	Information	Knowledge about facts or ideas gained through investigation, experience, or practice; the reduction in uncertainty provided by a message.
	Knowledge	Information and understanding of a specific topic or of the world in general, usually acquired by experience or by learning.
	Noetic state of awareness	Knowledge that something is or is not the case.
	Propositional knowledge	The abstract representation of knowledge, words or images.
Learning		Any process in an organism in which a relatively long-lasting adaptive behavioural change occurs as the result of experience.
	Learning	Feature of the experimentation phase in which one learns how to handle the cigarette, how to inhale correctly, and what the different effects are under different conditions.
	Learning	The process of acquiring new and relatively enduring information, behaviour patterns, or abilities, characterised by modification of behaviour as a result of practice, study or experience.
Perceived self-determination of behaviour		A cognitive representation of the degree to which one's behaviour is controlled by one's internal convictions rather than external demands.
	Locus of causality	The relative degree of independence [of the behaviour] perceived by the individual.
	Perceived locus of causality	Mental representation of the degree to which one's behaviour is regulated by one's true self.

MoA class label	MoA instance label	Definition
	Perception of control	The extent to which one believes that one's behaviour is under one's own control.
	Self determination	A sense of control of one's behaviours by internal convictions and decisions rather than by external demands.
Memory		The activities involved in the mental information processing system that receives (registers), modifies, stores, and retrieves informational stimuli.
	Memory	The process of storing and regenerating images and thoughts.
	Retention	The extent to which new information or knowledge is retained as a result of receiving a message.
Motivation		A mental process that energises and directs behaviour.
	Motivation	The impetus that gives purpose or direction to initiate and maintain behaviours.
	Motivation	The impetus or 'trigger' that gives purpose or direction to initiate and maintain behaviours; comprises both personal motivation and social motivation to adhere to HAART.
	Motivation	One's motivation (the impetus that gives purpose or direction to behaviour) to carry out the behaviour.
	Protection motivation	A motivational state that activates, sustains and/or directs behaviour.
	Personal motivation	The extent to which one is personally motivated towards adherence; arises from attitudes towards adherence.
Motivation to comply		A mental disposition to consider the likely approval of referent others for a course of action during decision making.
	Motivation to comply	Willingness to agree with referent others' opinions.
	Motivation to comply	The extent to which one cares about the approval or disapproval of referent individuals or groups.
	Motivation to comply	A felt need to comply with the expectations of others.
	Motivation to comply	The extent to which a person feels pressure to act in accordance with those norms.
	Motivation to comply	Willingness to exert physical or mental effort in order to act in accordance with others; can be exhibited either as conformity or rebellion/nonconformity.
	Motivation to comply	Willingness to exert physical or mental effort in order to act in accordance with others' normative beliefs.
Need		A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining a particular state.
	Need	Imbalance, typically deficit of something required for survival, well-being or personal fulfilment.
	Need	Attraction to things on the basis of feelings of anticipated relief from actual or possible mental or physical discomfort.
Normative belief		A belief about whether important others think one should perform a behaviour.
	Injunctive norm	Perception of what important others expect one to do or approve of.
	Normative belief	Perception of referent others' beliefs regarding whether or not one should perform a behaviour.
	Normative belief	Perception of social pressures or other's beliefs that one should or should not perform a behaviour.

MoA class label	MoA instance label	Definition
	Subjective Norm	One's perception of important others' beliefs about whether or not one should perform the behaviour.
	Social outcome expectancy	Perception one has regarding whether important others believe that one should or should not perform a behaviour.
	Norm	The perceived expectation of important others in relation to a behaviour.
	Normative Belief	Belief about the likelihood that important referent individuals or groups approve or disapprove of performing the behaviour; assumed to determine subjective norm.
	Social norm	The perception of what others want one to do.
	Subjective norm	Perceived social pressure to engage in a behaviour from significant others.
Belief about consequences of behaviour		A belief about the outcomes resulting from a behaviour.
	Cognitive/Rational pros & cons	One's cognition and belief about the positive and negative consequences that may result from carrying out the behaviour.
	Value of the consequences	A person's positive or negative feeling about the consequences of a behaviour.
	Behavioural Belief	Belief about the likely outcomes or other attributes (e.g. cost) of the behaviour; assumed to determine attitude.
	Belief in a new ecological paradigm	The view that human actions can have significant effects upon the environment and biosphere.
	Expectation about consequences	Belief about the health / financial consequences of a health-related behaviour.
	Generalized outcome expectancy	General expectation about the outcomes of a behaviour.
	Outcome expectancy	Belief about the likely consequences of a behaviour.
	Outcome expectancy	Belief about the consequences of a behaviour.
	Belief	A propositional mental representation about possible outcomes of a behaviour.
	Expectancy	Belief about the probable consequences of behaviour.
	Outcome Expectancy	Relatively stable belief about the likely consequences of a behaviour (i.e. perception about what will be achieved and/or lost by undertaking a behaviour).
	Perceived consequence	A person's subjective perception of the consequences that are likely to arise from the adoption of a behaviour.
	Outcome expectation	Type of normative mechanism relating to expectations about the consequences of an action (includes benefits to oneself, benefits to others and anticipatory socialisation).
Belief about likelihood of consequences of behaviour		A belief about the likelihood a particular behaviour will result in particular outcomes.
	Benefit to others	Belief about whether others engaging in the behaviour would benefit from doing so.
	Connectedness belief	Belief about the extent to which the behaviour is related to later outcomes, or perception of the likelihood of expected outcomes of the behaviour.

Page 592

MoA class label	MoA instance label	Definition
	Outcome expectancy	Belief about whether or not a recommended action will lead to valued outcomes.
	Outcome expectancy	The belief that carrying out the behaviour will lead to the desired results.
	Outcome Expectancy	Belief about whether a certain behaviour will lead to desired outcomes.
	Outcome Expectation	A belief about whether behaviour change will lead to the desired outcome.
	Perceived usefulness	Belief about whether or not using the technology will enhance one's performance.
	Positive expectancy	Belief that engaging in the health risk behaviour will produce positive effects.
Belief about one's environment		A belief about the nature of the immediate physical and social settings in which people live, including culture and the people and institutions with whom they interact.
	Perceived environment	Perception of the environment in which one exists.
	Perception of environmental factors	Belief about the variables in one's environment such as those that describe the health care system or the work environment.
Belief about own health		A belief regarding the state of one's health.
	Health belief	Perception of one's health, specifically relating to susceptibility/vulnerability; arises from perception of health status.
	Subjective health	Individual perceptions relating to one's health.
	Perception of Health Status	Belief regarding the current state of one's health.
Importance of goal attainment		A cognitive representation of the significance of successfully meeting a goal.
	Importance	The level to which goal attainment has import or significance; is carried with great or serious consequences; is weighty, momentous, grave, significant.
Belief about severity		A belief about how serious the harm associated with an outcome could be.
	Belief about importance	Perception of how important the health condition to be avoided is.
	Belief about the undesirability of AIDS	A perception about the extent to which AIDS is undesirable.
	Perceived severity	Perception of the seriousness of the disease both in terms of the emotional arousal elicited by thoughts of the disease and the anticipated difficulties that could be created by the disease.
	Perceived severity	Perception about the severity of the consequences and/or experience of the disease.
	Perceived severity	Belief about the degree of harm associated with an outcome.
	Perceived severity	Perception of the degree of harm associated with an outcome.
	Perceived severity	The appraisal of the seriousness of the threat.
	Severity	The appraised seriousness of the threat.
	Perceived severity/ severity of the problem	A perception of how serious a health-risk is.

MoA class label	MoA instance label	Definition
	Relevance of behaviour for threat of creatureliness	The perceived importance of the health behaviour for reminders of threats associated with the creatureliness (a reminder of physicality) of the body.
Belief about social influence processes		A belief about whether or how others will attempt to use social influence processes to affect the person's behaviour.
	Perceived social support	Perception of support from others for engaging in the behaviour.
	Perception of social influence	Belief regarding the influence of others on one's behaviour.
	Social influence	Expectation regarding how one's social environment might respond to the adoption of a new behaviour.
	Social norm	Perception of whether important others are supportive of one's behaviour/behaviour change.
Belief about susceptibility		A belief about how vulnerable one is to a threat.
	Perceived susceptibility	A subjective estimate of the likelihood of personally contracting the disease.
	Perceived susceptibility	The extent to which one believes one is at risk of contracting a particular disease or developing a particular health problem.
	Perceived Susceptibility/ Personal Susceptibility	Perception relating to the likelihood that one could experience the health threat.
	Belief about personal risk	Perception of one's personal risk of experiencing the health condition.
	Perceived susceptibility	Perception of the likelihood that one is vulnerable to a threat.
	Vulnerability	One's perceived susceptibility to the threat.
	Perceived susceptibility to HIV	Perception of one's personal risk of HIV.
	Perceived vulnerability	Belief relating to one's susceptibility to an outcome.
	Perceived vulnerability	Perception of one's susceptibility to an outcome
	Perception of vulnerability	Belief about the extent to which one is at risk from the risky behaviour.
Belief about threat		A belief about the nature of a potential harm.
	Personal relevance	The extent to which a health threat is perceived to be relevant to an individual; determined by perceptions about the severity of the threat and personal susceptibility to it.
	Risk perception	One's subjective assessment about the threat posed by a health risk; based on an interplay between perceptions of risk and severity.
	Threat perception	Belief about the threat posed by a health risk; based on an interplay between perceptions of risk and severity.
	Risk perception	Perception of the threat posed by a health risk; based on an interplay between perceptions of risk and severity.
	Perceived threat	A perception of the threat posed by a disease or health problem, based on one's perceived susceptibility to, and the perceived severity of, a disease or health problem.
Perception		A mental process which is a) produced by a causal process (for example involving light rays or air vibrations) involving a part of the environment of the organism, and b) is experienced by the

MoA class label	MoA instance label	Definition
		organism as being so caused, and c) in which the relevant part of the environment is thereby represented to the organism.
	Perception	The process through which one makes perceptions about the current situation.
	Perception	The process or result of becoming consciously aware of something by means of the senses.
	Perception	Detection of a relevant stimulus linked directly to behaviour.
	Perception	Sensation together with their interpretation
Physical opportunity		A quality of the physical environment that influences performance of a behaviour.
	Physical constraint	Physical restriction limiting human capacity to act.
	Physical availability	The extent to which alcohol is physically available (e.g. proximity to stores selling alcohol).
	Physical opportunity	Opportunity afforded by the physical environment.
Planning		A mental process that involves mentally manipulating representations of steps in an imagined process which has some objective, e.g. to bring about a desired state of affairs. The outcome of this mental process is a plan which has the potential to be followed to bring about the desired outcome.
	Action plan	The specific plan of a person to translate an intention into behaviour, including preparation plan, coping plan and plan enactment.
	Action plan	Detailed specification of how to perform an intended behaviour.
	Action planning	The process by which detailed specifications of how to perform an intended behaviour are formed.
	Action schemata	Operationally controlled sub-components of scripts, which serve to guide action.
	Implementation intention	A commitment to act that includes particular memory processes and specific execution rules; Has two forms: a contingent one focusing on a specific event happening and a forthcoming response (e.g., I will do X, if event Y occurs), and a planning one (i.e. one decides where, when, and how to act so as to achieve a goal).
	Planning	The formulation of a cognitive representation of an intended action, such as an utterance or a complex movement, that is presumed to guide the individual in carrying out that action.
	Process dimension	Process by which action scripts are created or modified (i.e. by which one can transition to a new action state, thus changing behaviour).
Sadness		A negative emotion felt when an event is appraised as unpleasant, obstructive to one's goals and concerns, and one feels unable to cope with it or modify it.
	Depression	Negative emotion, feeling low in oneself.
	Sadness	Negative emotion, feeling miserable or low.
Psychological capability		A mental disposition that is realised in mental processes relating to ability to perform a behaviour.
	Psychological capability	The capacity to engage in the necessary thought processes for the behaviour.
Desired standard		A cognitive representation of a desired state that serves as a reference level.

MoA class label	MoA instance label	Definition
	Principle control	The reference value at the second highest level of the hierarchical system that serves as a guiding principle to describe how people self-regulate with respect to system concepts.
Reflective thinking		Thinking that involves generation of inferences based on syllogistic reasoning or decision making based on the evaluation of anticipated consequences or the construction of propositional representations.
	Analysis	Mental process by which beliefs are created from other beliefs according to a set of principles or rules (e.g. mental arithmetic).
	Analysis and inference	The division of any entity into its component parts for the purpose of investigation (analysis) and a conclusion deduced from an earlier premise (inference).
	Controlled processing	A mode of cognitive processing requiring focused attention and continuous decision making among alternate responses.
	Evaluation phase	A second stage of prospect evaluation where edited prospects are assessed and the prospect with the greatest value is chosen.
	Reflective change process	Change process that involves reflective thought.
	Reflective thinking	Type of thinking in which decisions are made (e.g. about complex problems) slowly and deliberately (i.e. not impulsively).
Contentment		A pleasant emotion, which can be defined as a milder form of joy.
	Satisfaction	A sensation of contentment or fulfilment.
	Satisfaction	The state or fact of being contented, pleased, gratified.
	Utility	The total satisfaction received from consuming a good or service.
Cognitive schema		An aggregate of cognitive representations about a concept or entity that serves to guide to perceiving or responding to a complex situation or set of stimuli.
	Propositional representation	Representation that connects one or more elements through the instantiation of relational schemata to which a truth value is attached.
	Relational schemata	A mental representation that connects knowledge in the reflective system.
Self-efficacy		
	Action self-efficacy	Belief about one's ability to adopt a new behaviour.
	Computer self-efficacy	One's perception of whether one is capable of performing a task using the technology.
	Efficacy Belief	Perception relating to one's possession of the necessary skills and abilities to perform the behaviour, even in the face of specific barriers or obstacles.
	Efficacy Belief	Belief about whether one has the skills and abilities to perform the behaviour, even in the face of barriers.
	Maintenance self-efficacy	Belief regarding one's ability to maintain a newly adopted behaviour and to deal with any barriers to performing that behaviour that arise during long-term maintenance of the behaviour change.

MoA class label	MoA instance label	Definition
	Perceived behavioural control	Belief about one's ability to carry out a behaviour, and the possible outcomes of that behaviour.
	Perceived competence	The degree to which one is perceived to be capable of carrying out or adopting a behaviour.
	Perceived control	The extent to which one feels one has control over maintaining abstinence or complying with other rules governing the target behaviour.
	Perceived self-efficacy	Perception of one's ability to take a recommended protective action.
	Perceived self-efficacy	Perceived judgement of one's ability to cope effectively in different circumstances.
	Recognition of own ability to provide relief	The recognition that one is capable of performing the actions necessary to provide relief; may be influenced by one's overall sense of personal competence.
	Routine self-efficacy	The confidence to engage in a behaviour when carrying out routine activities.
	Self-efficacy	The degree to which one is confident one can perform the behaviour.
	Self-efficacy	Belief about whether one is capable of carrying out a behaviour or making a behaviour change.
	Self-efficacy	Self-belief in one's ability to use one's skills effectively in order to carry out the behaviours.
	Self-efficacy	One's beliefs about one's ability to carry out a behaviour in any given situation.
	Self-efficacy	The belief that one can perform the behaviour, even under a number of difficult circumstances.
	Self-efficacy	The sense that one has the skills and will to take charge of their health.
	Self-efficacy	A belief in one's capability to enact a behaviour or achieve a particular outcome.
	Self-efficacy	The belief in personal ability to successfully perform a task or engage in a behaviour.
	Self-efficacy	Related to the need for competence; the confidence that one has the capacity to act effectively to bring about desired results.
	Self-efficacy	The confidence in one's ability to successfully carry out the behaviour even under conditions of stress.
	Self-efficacy	The belief in personal ability to successfully perform a task or engage in a behaviour.
	Self-efficacy	Belief that one is capable of carrying out a specific behaviour that will lead to desired outcomes.
	Self-efficacy	A person's belief about whether they are capable or incapable of performing the coping response.
	Self-efficacy	Perception of one's ability to carry out health-protective behaviours.
	Perceived capacity (relatively stable)	The extent to which one perceives oneself to be capable of engaging in a behaviour.
	Self-efficacy	Belief about one's ability to successfully carry out a behaviour.
	Self-efficacy	Belief about whether or not one is capable of taking a health-protective action.
	Perceived self-efficacy	Belief about one's ability to successfully carry out a behaviour.
	Perceived self-efficacy	Belief about one's ability to carry out specific behaviours.
	Self-efficacy	Belief about one's ability to perform certain behaviours.
	Self-efficacy	The belief one has that one can accomplish a specified task.

MoA class label	MoA instance label	Definition
	Perceived competence	Perceptions of one's ability to carry out a behaviour.
	Self-efficacy	Belief about whether or not one is capable of performing a recommended behaviour.
	Perceived behavioural control	The perceived ability to perform the behaviour.
	Perceived behavioural control	One's belief about one's ability to carry out a behaviour.
	Self-efficacy	Feeling that one possesses or can acquire control over the behaviour.
	Self-efficacy	The feeling of possession of (or ability to acquire) control over the behaviour.
	Self-efficacy	Belief about whether one is capable of attaining a goal or a particular performance outcome.
	Self-efficacy belief	Perception of one's ability and confidence to carry out the behaviour.
	Self-efficacy with respect to means	Belief about one's confidence that one can use the resources or perform the methods (means) needed to achieve a goal.
Self-esteem		A belief about one's capabilities to engage in a behaviour.
	Self-esteem	The degree to which the qualities and characteristics contained in one's self-concept are perceived to be positive.
	Global self-esteem	The degree to which the qualities and characteristics contained within one's self-concept are perceived to be positive.
	Self-esteem	The degree to which the qualities and characteristics contained in one's self-concept are perceived to be positive.
	Self-esteem	The degree to which the qualities and characteristics contained in one's self-concept are perceived to be positive.
	Self-esteem	The degree to which the qualities and characteristics contained in one's self-concept are perceived to be positive.
	Self-referent value	Value relating to the sense of worth, usefulness or importance primarily involving and referring to one's personal self.
Self-concept		A cognitive representation of one's own qualities and characteristics.
	Perception of self	Belief relating to self-concept, self-image, value orientation and/or personality traits.
	Self-attribute	Belief about one's characteristics (adjectives that apply to oneself).
	Self-concept	The traits and behaviours one attributes to oneself.
	Self-feeling	Feeling about oneself.
	Self-image	The view or concept one holds of oneself.
	Self-image	One's own view or concept of oneself.
	Self-image	Image about oneself.
	Self-label	Belief about the categories one belongs to (e.g. I am a vegetarian).
	Self-schemata	The idea and/or belief one has about themselves.
	Self-thought	Belief about oneself.
Self-monitoring		A mental process in which one observes and evaluates one's own behaviour.
	Self-monitoring	A process involving self-observation and self-control with the aim of maintaining situation-appropriate behaviour.

Page 598

MoA class label	MoA instance label	Definition
	Self-monitoring	A self-observational process of assessing current behaviour.
Self-regulation of behaviour		A bodily process that modulates the frequency, rate or extent of behaviour, the specific actions or reactions of an organism in response to external or internal stimuli and that is instigated by the organism itself.
	Inhibition	Blockade of action schemas.
	Self-control	A process whereby intentions are enacted in the face of desires or impulses arising from other sources.
	Self-regulation	An activity of the executive system that is designed to constrain or change the patterns of behaviour, particularly where this requires action in opposition to Operationally generated action tendencies.
	Self-regulation	The process by which people regulate or control their behaviour.
Perception		A mental process which is a) produced by a causal process (for example involving light rays or air vibrations) involving a part of the environment of the organism, and b) is experienced by the organism as being so caused, and c) in which the relevant part of the environment is thereby represented to the organism.
	Sensation	Unit of experience referring to the aspects of sensory inputs that is reacted to by Operational processes (c/f perception where there is conscious awareness).
	Sensation	A feeling arising from senses or imagined experiences, without interpretation.
Healthcare service accessibility		A quality of a healthcare service regarding how easy it is for a person to approach and use it.
	Access to medical care	The extent to which one can obtain health-related services.
	Availability and accessibility of necessary service	The extent to which relevant service (e.g. family planning service) is easily available/accessible.
Skill		A capability acquired through training and practice.
	Skill for Involvement	The extent to which one has the ability or proficiency (acquired through training and practice) to engage in the behaviour.
	Skill	Health-related ability or proficiency acquired through training and practice (i.e. in relation to performing health-related behaviours).
	Skill	Ability or proficiency acquired through training and practice.
	Skill	Abilities or proficiencies acquired through training and practice.
	Skill	Ability or proficiency (acquired through training and practice) that is required to modify behaviour.
Social embeddedness		A mental disposition to view and experience oneself as attached to and involved in a social group.
	Affective component of social identity	A sense of attachment and involvement in the group.
	Intensity	The intensity of one's association with criminal or non-criminal groups (e.g. group prestige, emotions associated with specific groups).
	Social integration	The degree to which one is embedded in, or part of, a social network (e.g. connectedness, bonding).

MoA class label	MoA instance label	Definition
Social identity		A cognitive representation relating to how one perceives oneself as belonging to a social group.
	Cognitive component of social identity	Self-awareness in categorising oneself as a member of the group.
	Social identity	Sense of identification with, and membership of, the virtual community.
	Social identity	An aspect of an individual's self-image that derives from the social categories to which he/she perceives him/herself as belonging; given by social groups to their members, based upon comparisons against members of other groups.
Social influence process		An interpersonal process where one or more person exerts an influence on the behaviour of another.
	Personal socialization process	Behaviour change process that involves family and social dynamics which serve to teach individuals their role within the family and within broader social contexts.
	Social influence	The influence of others on behaviour (e.g. peer pressure/behaviour and parental modelling)
	Social pressure	The exertion of influence on a person or group by another person or group (e.g. being with others who are performing the behaviour)
Social interaction process		An interpersonal process involving reciprocal communication between two or more people.
	Social interaction process	Process that involves reciprocal stimulation or response between two or more individuals.
Observational learning		Learning that occurs through observing the behavior of others.
	Modelling	Vicarious learning through observation of others' behaviour.
	Observational learning	The acquisition of information, skills or behaviour through watching the performance of others.
Social opportunity		A quality of the social environment that influences performance of a behaviour.
	Social constraint	A restriction relating to society that limits human capacity to act.
	Social control	Characteristic of the social environment that serve to reduce proneness to problem behaviour.
	Social opportunity	Opportunity afforded by the social environment.
Socially shared norm		A belief regarding standards for behaviour that one sees as mutually agreed by and shared by members of one's social group.
	Consensual belief	A shared agreement of certain beliefs within one's social network.
	Mutual agreement	Mutual understanding among group members to engage in the behaviour.
	Norm	Shared rule and expectation that govern everyday life.
	Social belief	Socially shared body of tenets held by a group.
Interpersonal approval for behaviour		An interpersonal process in which one or more person indicates approval of another person performing a particular behaviour.
	Social approval	Positive appraisal and acceptance by one's social group for the behaviour from important referents.

MoA class label	MoA instance label	Definition
Temporal opportunity		A quality of a person's social and physical environment regarding whether the person has sufficient time to engage in a behaviour.
	Temporal ability	The availability of time in which to engage in behaviour.
	Time constraint	Time restriction limiting human capacity to act.
Temporal orientation		A mental disposition to focus more on present or future outcomes.
	Time preference	The extent to which one's attitude is present or future-oriented.
Personal value		A mental disposition regarding what is fundamentally important in life and which informs standards for behaviour.
	Value (preparation)	Moral, social or aesthetic principle accepted by an individual or society as a guide to what is good, desirable or important
	Value	Moral, social, or aesthetic principle accepted by an individual or society as a guide to what is good, desirable or important
	Value	Moral, social, or aesthetic principle accepted by an individual or society as a guide to what is good, desirable or important

Appendix 4-6. The labels and definitions of ungrouped MoAs that qualified as classes, and the classes imported from other ontologies based on these ungrouped MoAs

Ungrouped MoA label	Ungrouped MoA definition	Ungrouped during?	Imported class label	Imported class definition	Parent class
Anxiety	A mood state characterised by apprehension and somatic symptoms of tension in which an individual anticipates impending danger, catastrophe or misfortune.	Study 3	Anxiety* MFOEM:0000 28	A negative, aversive emotion provoked by the prospect of future threat.	Emotion process
Anxiety	Negative emotion, feeling agitated by anticipated negative events.	Study 3	Anxiety* MFOEM:0000 28	A negative, aversive emotion provoked by the prospect of future threat.	Emotion process
Anxiety	A mood state characterised by apprehension and somatic symptoms of tension in which one anticipates impending danger, catastrophe or misfortune.	Study 3	Anxiety* MFOEM:000 028	A negative, aversive emotion provoked by the prospect of future threat.	Emotion process
Attitude	Psychological tendency that captures one's appraisal of a product or service judged to be instrumental in goal attainment.	Study 3	Appraisal* MFOEM:0000 05	An appraisal is a cognitive representation which represents an evaluation of the relevance of some triggering object or event to the organism.	Cognitive representation
Attitude	A general evaluation of an object, person, group, issue or concept on a scale ranging from negative to positive.	Study 3	Appraisal* MFOEM:0000 05	An appraisal is a cognitive representation which represents an evaluation of the relevance of some triggering object or event to the organism.	Cognitive representation
Attitude	A general evaluation of an object, person, group, issue or concept on a scale ranging from negative to positive.	Study 3	Appraisal* MFOEM:0000 05	An appraisal is a cognitive representation which represents an evaluation of the relevance of some triggering object or event to the organism.	Cognitive representation
Belief	Association of some characteristic or attribute, evaluative in nature, towards the possible outcomes of engagement in the behaviour.	Study 3	Appraisal* MFOEM:0000 05	An appraisal is a cognitive representation which represents an evaluation of the relevance of some triggering object or event to the organism.	Cognitive representation
Evaluation	The positive or negative appraisal held by the individual.	Study 3	Appraisal* MFOEM:0000 05	An appraisal is a cognitive representation which represents an evaluation of the relevance of some triggering object or event to the organism.	Cognitive representation

Ungrouped MoA label	Ungrouped MoA definition	Ungrouped during?	Imported class label	Imported class definition	Parent class
Individual attitude	The positive or negative evaluation/appraisal held by the individual.	Study 3	Appraisal* MFOEM:0000 05	An appraisal is a cognitive representation which represents an evaluation of the relevance of some triggering object or event to the organism.	Cognitive representation
Individual belief	An evaluation of attitude objects held by the individual.	Study 3	Appraisal* MFOEM:0000 05	An appraisal is a cognitive representation which represents an evaluation of the relevance of some triggering object or event to the organism.	Cognitive representation
Proposition	The smallest unit of meaningful thought; Network of interconnected propositions for propositional knowledge.	Study 3	Cognitive representatio n* MF:0000031	A representation which specifically depends on an anatomical structure in the cognitive system of an organism.	Specifically dependent continuant
Cognitive representatio n	Image (not necessarily visual) and propositions representing states of the internal and external environment.	Study 3	Cognitive representatio n* MF:0000031	A representation which specifically depends on an anatomical structure in the cognitive system of an organism.	Specifically dependent continuant
Fear	A negatively valanced emotion that is accompanied by a high level of arousal and elicited by a threat that is perceived to be significant and personally relevant.	Study 3	Fear* MFOEM:0000 26	An activated, aversive emotion that motivates attempts to cope with events that provide threats to the survival or well-being of organisms.	Emotion process
Fear arousal	The elicitation of fear caused by the detection of an imminent threat	Study 3	Fear* MFOEM:0000 26	An activated, aversive emotion that motivates attempts to cope with events that provide threats to the survival or well-being of organisms.	Emotion process
Habituation	Reduced responsiveness as a result of repeated or continuing exposure to a stimulus.	Study 3	Habituation GO:0046959	A decrease in a behavioural response to a repeated stimulus.	Non-associative learning
Happiness	Positive emotion, feeling of wellbeing.	Study 3	Happiness MFOEM:0000 42	A positive emotion which is experienced in reaction to a positive experience or event.	Emotion process
Cognitive ability	The cognitive capability to engage in the behaviour.	Study 3	Intelligence MF:0000025	A mental disposition realised in processes involving understanding complex ideas, adapting effectively to the environment, learning from experience, engaging in	Mental disposition

Ungrouped MoA label	Ungrouped MoA definition	Ungrouped during?	Imported class label	Imported class definition	Parent class
				various forms of reasoning, and overcome obstacles through the outcome of thinking processes.	
Disliking	Feeling negative about something.	Study 3	Negative emotion MFOEM:000212	A negative emotion is an emotion that has a negative valence.	Emotion process
Pain	Aversive sensation arising from pain receptors.	Study 3	Pain MFOEM:000203	A bodily process in an organism S, involving two integrated levels: (a) activation of the nociceptive system and associated emotion generating brain components of S, and (b) a simultaneous aversive sensory and emotional experience on the part of S, where (b) is phenomenologically similar to the sort of aversive experience involved in pain with concordant tissue damage.	Bodily feeling
Pleasantness	A conscious, hedonic state, typically deemed highly desirable, that is experienced when an event is congruent with one's goals or is associated with pleasure.	Study 3	Pleasure* MFOEM:000035	A positively experienced emotion which is sought out (approached) and is associated with happiness, enjoyment, and satisfaction.	Emotion process
Pleasure	Sensation of enjoyment.	Study 3	Pleasure* MFOEM:000035	A positively experienced emotion which is sought out (approached) and is associated with happiness, enjoyment, and satisfaction.	Emotion process
Liking	Feeling positive about something.	Study 3	Positive emotion MFOEM:000211	A positive emotion is an emotion that has a positive valence.	Emotion process
Sensitisation	An increase in magnitude of a response as a result of continued or repeated exposure to the stimulus.	Study 3	Sensitization GO:0046960	An increase in a behavioural response to a repeated stimulus.	Non-associative learning
Sexual pleasure	Positive feeling associated with sexual activities.	Study 3	Sexual pleasure	A positively experienced emotion which is sought out (approached) and is associated with happiness, enjoyment, and satisfaction as a result of sexual activities.	Pleasure

Ungrouped MoA label	Ungrouped MoA definition	Ungrouped during?	Imported class label	Imported class definition	Parent class
			MFOEM:0000 40		
Terror	A mood state characterised by intense and overwhelming fear.	Study 3	Terror MFOEM:0000 27	Fear that is intense.	Fear
Value	An experience of the attraction toward or repulsion from something whose intensity is a function of the strength of hedonic pleasure or pain and the strength of engagement.	Study 3	Subjective emotional feeling* MFOEM:0000 06	The subjective emotional feeling is that (fiat) part of the emotion process by which the organism experiences its own emotion.	Affective process
Generalised emotion	Emotion not focused on a particular object but just experienced.	Study 2	Subjective emotional feeling* MFOEM:0000 06	The subjective emotional feeling is that (fiat) part of the emotion process by which the organism experiences its own emotion.	Affective process
Vigilance	The action or state of the executive directing attention to ensure that appropriate actions are undertaken when required.	Study 2	Vigilance MF:0000060	The ability to maintain attention and alertness over prolonged periods of time.	Attending

Notes. *The same class was imported for ungrouped MoAs that shared the same differentiating attribute

Appendix 4-7. The labels and definitions ungrouped MoAs that qualified as classes and the novel classes developed based on these ungrouped MoAs

Ungrouped MoA label	Ungrouped MoA definition	Ungrouped during?	Class label	Class definition	Parent class
Alienation	The sense of meaninglessness in everyday roles and isolation from others.	Study 2	Alienation	A mental disposition to view and experience oneself as isolated from and not meaningfully involved in social groups.	Mental disposition
Coping appraisal	The cognitive evaluation of factors that influence a person's ability to cope with a threat.	Study 2	Appraisal of coping capability	An appraisal that represents an evaluation of the factors that influence one's ability to cope with a threat.	Appraisal
Anticipated outcome	Predicted outcome, including anticipatory emotion, of each risky response alternative.	Study 3	Appraisal of potential outcomes of a future choice*	An appraisal that represents an evaluation of the possible states and events that might follow from a choice made in the future.	Appraisal
Prospective evaluation	The appraisal of the outcome of a future choice.	Study 2	Appraisal of potential outcomes of a future choice*	An appraisal that represents an evaluation of the possible states and events that might follow from a choice made in the future.	Appraisal
Exposure	The action of noticing the information in a message.	Study 2	Attending to a message	A mental process whereby relevant aspects of our mental experience become focused on a verbal, written or recorded communication.	Attending
Perception that need can be relieved by action	The recognition that action can be taken in response to the need.	Study 2	Belief about behaviour meeting needs	A belief about the behaviour resulting in one's needs being met.	Belief about consequences of behaviour
Psychological cost	Perceived cost and/or benefit associated with a line of action that are guided by the consequences of a course of action to one's self-concept (e.g. loss of self-esteem or a sense of achievement).	Study 3	Belief about consequences of behaviour for self-concept	A belief about the impact of performing the behaviour on one's cognitive representation of one's own qualities and characteristics.	Belief about consequences of behaviour
Purposive value	Value derived from achieving an instrumental or informational goal.	Study 2	Belief about consequences of goal attainment	A belief about the outcomes resulting from achieving a goal.	Belief

Ungrouped MoA label	Ungrouped MoA definition	Ungrouped during?	Class label	Class definition	Parent class
Self-efficacy	The degree to which one believes that one can control one's future.	Study 2	Belief about control over one's future	A belief about the extent to which one can direct what happens in one's future.	Belief
Misperception	The perception of the discrepancy between perceived norms and actual norms.	Study 2	Belief about discrepancy between perceived and actual norms	A belief about existence of a discrepancy between what one thought was typical for people who belong to a particular social group and what is actually typical for people who belong to that social group.	Belief
Anticipated emotion	Expectation of emotional consequences of achieving and not achieving a goal.	Study 3	Belief about emotional consequences of goal attainment	A belief about the feelings and emotions that are associated with achieving a goal.	Belief about consequences of goal attainment***
Gain	Perceived positive increase from the reference point.	Study 2	Belief about gain	A belief about the existence of an increase from an initial reference point.	Belief
Parasocial interaction	The degree to which an audience or individual develops a perceived interpersonal relationship with a media character.	Study 2	Belief about having an interpersonal relationship	A belief about the existence and intensity of a social relationship between a person and another person, social group or character.	Belief
Perceived enjoyment	The extent to which engaging in a behaviour is perceived as enjoyable in its own right, regardless of external consequences.	Study 3	Belief about intrinsic enjoyment of behaviour	A belief about extent to which engaging in a behaviour is seen as enjoyable in its own right, regardless of the consequences of the behaviour.	Belief
Expectation for academic achievement	A high or low expectation one holds in relation to academic recognition.	Study 3	Belief about likelihood of academic recognition	A belief about the probability of being acknowledged for one's educational achievements.	Belief
Expectation for affection	A high or low expectation one holds in relation to experiencing feelings of tenderness and attachment.	Study 3	Belief about likelihood of experiencing affection	A belief about the probability of experiencing feelings of tenderness and attachment.	Belief

Ungrouped MoA label	Ungrouped MoA definition	Ungrouped during?	Class label	Class definition	Parent class
Instrumental belief	Judgement about the extent to which available means of goal achievement are likely to lead to actual goal achievement.	Study 3	Belief about likelihood of goal achievement with available means	A belief about the probability of attaining a desired standard given the available resources or methods to facilitate doing so.	Belief
Expectation for independence	A high or low expectation one holds in relation to personal autonomy and unconventionality.	Study 3	Belief about likelihood of personal autonomy	A belief about the probability of being able to exercise autonomy or act unconventionally.	Belief
Subjective probability	One's opinion of how likely the anticipated outcomes is to occur.	Study 3	Belief about likelihood of potential outcomes	A belief regarding the probability that a given event or state will occur in the future.	Belief
Loss	Perceived negative decrease from the reference point.	Study 2	Belief about loss	A belief about the existence of a decrease from an initial reference point.	Belief
Perception of message relevance	The perception of a message as relevant or not relevant.	Study 3	Belief about message relevance	A belief regarding whether the content of a verbal, written or recorded communication is relevant to oneself.	Belief
Moral imperative	An action that is necessary because is the 'right thing' to do in a moral sense.	Study 2	Belief about moral imperative for behaviour	A belief about whether a behaviour is necessary because it is morally the right thing to do.	Belief
Denial of responsibility to respond	The refusal to believe that there is a responsibility to respond.	Study 2	Belief about responsibility to act	A belief about whether one is personally obliged to take a certain course of action.	Belief
Similarity	The extent to which one perceives oneself to be similar to referent others.	Study 3	Belief about similarity to referent others	A belief about the extent to which one is similar to members of a social group whose behaviour or opinions one wishes to emulate.	Belief
Identification	A belief that performing a behaviour increases one's social status in a group because important others in the group believe that the behaviour should be performed.	Study 2	Belief about social consequences of behaviour*	A belief about the outcomes of a behaviour in terms of one's social status or social approval.	Belief about consequences of behaviour

Ungrouped MoA label	Ungrouped MoA definition	Ungrouped during?	Class label	Class definition	Parent class
Social cost	A social cost and benefit associated with a line of action that is guided by social norms and includes anticipations of praise, blame, promotion and prosecution from those in one's social network.	Study 3	Belief about social consequences of behaviour*	A belief about the outcomes of a behaviour in terms of one's social status or social approval.	Belief about consequences of behaviour
Social enhancement	The value one derives from gaining acceptance and approval of others, and the enhancement of one's social status within the community on account of one's contributions to it.	Study 3	Belief about social consequences of behaviour*	A belief about the outcomes of a behaviour in terms of one's social status or social approval.	Belief about consequences of behaviour
Perceived social support	One's perception of the provision of assistance or comfort from others to help them cope with a variety of biological, psychological and social stressors; can be practical, informational or emotional.	Study 3	Belief about social support*	A belief about whether others will provide assistance or comfort to help the person cope with a variety of stressors.	Belief
Social support	Perceived emotional encouragement and practical support from others for a behaviour.	Study 3	Belief about social support*	A belief about whether others will provide assistance or comfort to help the person cope with a variety of stressors.	Belief
Perceived ease of use	Belief about the level of effort required to use the technology.	Study 3	Belief about task difficulty*	A belief about how much work or skill a task involves.	Belief
Task difficulty (perceived)	Perception of how much work or skill the task involves.	Study 2	Belief about task difficulty*	A belief about how much work or skill a task involves.	Belief
Relative advantage	The perceived added benefit of a new innovation/behaviour over the innovation/behaviour that it follows.	Study 2	Belief about the desirability of the consequences of a new behaviour vs prior behaviour	A belief about the potential benefits of adopting a new behaviour relative to the benefits of the previous behaviour.	Belief about the desirability of consequences of behaviour

Ungrouped MoA label	Ungrouped MoA definition	Ungrouped during?	Class label	Class definition	Parent class
Enjoyment value	Belief about whether health-protective behaviours (e.g. condom use) are more or less enjoyable than high-risk behaviours (e.g. unprotected sex).	Study 3	Belief about the relative desirability of the consequences of behaviour	A belief about the desirability of consequences of one behaviour relative to the desirability of consequences of a different behaviour.	Belief about the desirability of consequences of behaviour
Ambient Temporal Contingency	The cost and benefit of a specific behaviour, and their level of immediacy, in the social or physical environment.	Study 2	Belief about the timing of the consequences of behaviour*	A belief regarding how long after the performance of behaviour particular consequences will occur.	Belief
Perceived temporal proximity	The extent to which the outcome is believed to be immediate or non-immediate, whereby the greater the proximity, the higher the valuation.	Study 2	Belief about the timing of the consequences of behaviour*	A belief regarding how long after the performance of behaviour particular consequences will occur.	Belief
Value on affection	Degree of positive or negative value placed on feelings of tenderness and attachment.	Study 3	Belief about value of affection	A belief about the value of experiencing feelings of tenderness and attachment.	Belief
Value on independence	Degree of positive or negative value placed on personal autonomy and unconventionality.	Study 3	Belief about value of personal autonomy	A belief about the value of personal self-determination.	Belief
Voluntariness	The extent to which one perceives the behaviour to be mandatory.	Study 2	Belief about voluntariness of behaviour	A belief regarding the extent that one is free to choose whether to perform the behaviour.	Belief
Self-acceptance of sexuality	The ability to acknowledge that one is sexually active and thus should consider AIDS prevention.	Study 3	Capability to acknowledge behavioural risk status	Psychological capability to recognise and accept that one's behaviour places one at a certain likelihood of future harm.	Psychological capability
Emotional commitment	The level of certainty that one's decision to try to use certain means to achieve a goal is correct.	Study 2	Certainty about a decision	A cognitive representation of how sure one feels that one's decision is correct.	Cognitive representation

Ungrouped MoA label	Ungrouped MoA definition	Ungrouped during?	Class label	Class definition	Parent class
Cognitive dissonance	The experience of feeling conflict and guilt due to simultaneous contradictory beliefs, values, or ideas.	Study 3	Cognitive dissonance	An unpleasant subjective emotional feeling experienced due to perceived inconsistency between two concurrently held cognitive representations.	Subjective emotional feeling***
Computer anxiety	The level of apprehension or fear felt when faced with the possibility of using technology.	Study 3	Computer anxiety	A negative, aversive emotion provoked by the prospect of using computer technology.	Anxiety*
Interpersonal conflict	On-going or recent conflict in an interpersonal relationship such as a marriage or friendship.	Study 3	Conflict social interaction process	A social interaction process in which participants actions convey openness, trust and empathy, and offer support with regard to other participants' problems.	Social interaction process
Conscious death thought activation	The arousal of death-related cognitions that are within one's conscious awareness.	Study 2	Conscious death thought activation	Mental process in which cognitive representations regarding death are made salient for further mental processing and the person is conscious of these thoughts.	Thought activation with awareness***
Combination	A process of simplifying prospects by combining the probabilities of identical outcomes, and evaluating them in this combined form.	Study 3	Decision simplification by combining probabilities of identical outcomes	A mental process that simplifies decision making by combining the probabilities of alternative options with identical outcomes.	Decision simplification
Cancellation	A process of information editing that disregards shared components of alternative prospects in order to simplify decision-making.	Study 3	Decision simplification by disregarding shared components	A mental process that simplifies decision making by identifying and disregarding shared components of alternative options.	Decision simplification
Detection of dominance	A process of editing information to assess for any superior prospects and disregarding those that are inferior.	Study 3	Decision simplification by identifying clearly better or worse options	A mental process that simplifies decision making by editing information to identify any clearly superior or inferior options.	Decision simplification

Ungrouped MoA label	Ungrouped MoA definition	Ungrouped during?	Class label	Class definition	Parent class
Mental Segregation	A process by which the riskless component is separated from the risky component.	Study 2	Decision simplification by separating risky and riskless components	A mental process that simplifies decision making by separating elements of alternative options that involve risk from those that do not involve risk.	Decision simplification
Simplification	A process of simplifying prospects by rounding probabilities and or outcomes, or by disregarding extremely unlikely outcomes.	Study 3	Decision simplification through rounding	A mental process that simplifies decision making by rounding probabilities or outcomes associated with alternative options, or by disregarding options with extremely unlikely outcomes.	Decision simplification
Depletion of cognitive resources	The reduction in cognitive resources that occurs as a result of directing attention to higher-level, self-oriented goals.	Study 3	Depletion of self-regulatory capability	A process by which a person's self-regulatory capability is diminished by their having already recently used it.	Bodily process
Normative mechanism	Process through which the influence of descriptive norms on behaviours is heightened.	Study 2	Descriptive norm activation	A mental process in which beliefs regarding the prevalence of performance of a given behaviour by people within a group are made salient for further mental processes.	Norm activation***
Desire	A mental representation of different entities and the degree of attraction attached to them.	Study 3	Desirability representation	A cognitive representation of a possible state of affairs together with the degree of wishing for that state of affairs to obtain.	Cognitive representation
Personal norm	Belief and/or value regarding what is appropriate and morally correct behaviour for oneself, involving personal expectations of self-criticism or self-approval following pro- or anti-norm actions.	Study 3	Desired standard for behaviour based on personal values	A cognitive representation of one's desired level of behaviour.	Desired standard for behaviour
Identification	The process through which one begins to see oneself in the role of another person and empathises with the circumstances of that person.	Study 2	Empathising process	A mental process that brings into being, sustains or modifies a cognitive representation of how another person may experience the world.	Mental process

Ungrouped MoA label	Ungrouped MoA definition	Ungrouped during?	Class label	Class definition	Parent class
Aspiration	Hope or ambition to emulate referent others.	Study 2	Emulation goal	A goal to imitate referent others.	Goal
Extinction	The decrease in the tendency for a response to be performed when it repeatedly goes without reward.	Study 3	Extinction in classical conditioning	Process in which presenting the conditioned stimulus in the absence of the unconditioned stimulus makes the conditioned response less likely to occur.	Classical conditioning
Operant extinction	The process in which reinforcement for an operation behaviour has stopped and the frequency of that behaviour decreases.	Study 3	Extinction in operant conditioning	Process in which when reinforcement for an operant behaviour has stopped, the behaviour becomes less likely to occur.	Operant conditioning***
False consensus	The tendency to incorrectly assume that one's behaviours and thoughts are more widely shared by the majority of other members of the group than is actually the case.	Study 3	False consensus	A mental disposition to assume other members of the group share one's behaviours and thoughts more than is actually the case.	Belief
False uniqueness	The tendency to incorrectly believe that one's thoughts or behaviours are more unique than those of one's peers.	Study 3	False uniqueness	A mental disposition to assume that one's thoughts or behaviours are more unique than those of one's peers.	Belief
Defensive motivation	The process by which one becomes motivated to cope with feelings of fear.	Study 2	Fear reduction motivation	Motivation in order to lessen feelings of fear.	Threat reduction motivation
Feedback	Process by which personal experiences provide information for, and influence, future behaviours.	Study 3	Feedback from past personal experience	A process by which personal experiences provide information for and influence subsequent behaviour.	Bodily process
Urge	A subjective feeling of impulse to engage in an action that arises when the impulse is not immediately acted upon.	Study 3	Feeling an urge*	A subjective emotional feeling of desire to engage in a behaviour that arises when an action script is activated but not immediately acted upon.	Subjective emotional feeling***
Urge/Impulse to Act	Subjective feeling of impulse to engage in an action that arises when the impulse is not immediately acted upon.	Study 3	Feeling an urge*	A subjective emotional feeling of desire to engage in a behaviour that arises when an action script is activated but not immediately acted upon.	Subjective emotional feeling***

Ungrouped MoA label	Ungrouped MoA definition	Ungrouped during?	Class label	Class definition	Parent class
Achievability	The extent to which an identified goal is perceived to be achievable by the individual.	Study 2	Goal achievability*	A cognitive representation of how easy it will be to reach the end state to which one is striving.	Cognitive representation
Background goal	Goal that is not activated at a given moment.	Study 3	Goal activation process*	A mental process that brings a goal into attention.	Mental process
Goal frame	A goal that is activated at a given moment in time.	Study 3	Goal activation process*	A mental process that brings a goal into attention.	Mental process
Goal setting	A process that establishes specific, time-based behaviour targets that are measurable, achievable and realistic.	Study 3	Goal setting	A mental process that establishes a cognitive representation of the end state to which one is striving.	Mental process
Helping relationship	Relationship characterised by openness, trust and empathy, which is supportive with regard to the problem behaviour and health behaviour change.	Study 3	Helping relationship social interaction process	A social interaction process in which participants interactions have involved disagreeing or disapproving with at least one other participant.	Social interaction process
Identity	Mental representations of the self as one is or aspires to be and feelings associated with these.	Study 2	Identity	A cognitive representation relating to how one perceives oneself.	Cognitive representation
Anticipatory socialization	The process by which one takes on the values of the group to which one aspires but does not belong.	Study 2	Imitating values of aspirational social group	A mental process by which one takes on the values of a social group to which one aspires to belong.	Mental process
Value on academic achievement	Degree of positive or negative value placed on achieving educational goals.	Study 3	Importance of academic goal attainment	A cognitive representation of the significance of successfully meeting an educational goal.	Importance of goal attainment
Relevance of behaviour for meaning and self-esteem	The perceived importance of the health behaviour for maintaining meaning and value of the self.	Study 3	Importance of behaviour for self esteem	A cognitive representation of the significance of performing a behaviour to one's sense of one's worth, usefulness or importance.	Cognitive process

Ungrouped MoA label	Ungrouped MoA definition	Ungrouped during?	Class label	Class definition	Parent class
Identified regulation	The drive to perform a behaviour because of the importance one ascribes to the behaviour.	Study 3	Importance-based motivation	Motivation due to the behaviour being seen as personally important.	Motivation
Acquisition of behaviourally relevant information	The ability to obtain accurate information about methods of preventing the threat.	Study 3	Information acquisition capability	A bodily disposition that is realised by the bearer being able to engage in processes to obtain information relevant to a behaviour.	Capability
Internal incentive	An internal reward that reinforces anticipating positive consequences.	Study 2	Internal reward for a response*	A process by which the person experiences an internally-generated positive physical or psychological state subsequent to a response.	Bodily process
Intrinsic reward	Positive physical and/or psychological reinforcer for the maladaptive response (e.g. bodily pleasure, satisfaction).	Study 2	Internal reward for a response*	A process by which the person experiences an internally-generated positive physical or psychological state subsequent to a response.	Bodily process
General community reaction	Response from the community in which one lives or works as a consequence of performing the behaviour.	Study 3	Interpersonal approval for behaviour by community	An interpersonal process in which a set of people with whom one lives or works indicate approval of one performing a behaviour.	Interpersonal approval for behaviour
Introjected self-regulation	The self-management of behaviour driven by a sense of guilt, obligation, anxiety, or a need to prove something, often experienced as being conflicted or controlled.	Study 2	Introjected self-regulation	Self-regulation undertaken to manage a sense of guilt, anxiety or obligation.	Self-regulation of behaviour
Work attitude	A general evaluation of work (i.e. job satisfaction).	Study 3	Job satisfaction	A cognitive representation of the extent to which one's job fulfils one's expectations and needs.	Cognitive representation
Environmental reevaluation	The process of cognitively and affectively assessing the ways in which a personal behaviour might have an impact on the social environment.	Study 2	Judging consequences of behaviour*	A mental process during which a decision is made and the outcome of which is a belief about the consequences of a particular behaviour.	Judging

Ungrouped MoA label	Ungrouped MoA definition	Ungrouped during?	Class label	Class definition	Parent class
Evaluation of consequences	Careful examination or appraisal of the health, financial and social consequences of health-related behaviour.	Study 3	Judging consequences of behaviour*	A mental process during which a decision is made and the outcome of which is a belief about the consequences of a particular behaviour.	Judging
Self-reevaluation	The process of cognitively and affectively assessing one's self-image in relation to the problem behaviour.	Study 3	Judging self-concept in relation to behaviour	A mental process during which one evaluates how one's performance of a behaviour affects one's cognitive representation of one's own qualities and characteristics.	Judging
Conditioned reflex	A learned stimulus-response association.	Study 3	Learned stimulus-response association	A cognitive representation of the relationship between an event in a person's environment and a bodily or behaviour reaction, acquired through an associative learning process.	Cognitive representation
Task-learning process	Feedback process (i.e. the perception of a discrepancy between one's current outcome and one's desired end state and one's efforts to reduce that discrepancy) relating to the specific details of a focal task, positioned at the lower end of a hierarchy of negative feedback loops.	Study 2	Mentally comparing current effort and outcome against a standard	A mental process in which current outcome and efforts to attain that outcome are compared against a desired end.	Mentally comparing against a standard
Mutual accommodation	Inclination to mutually accommodate participants' schedules, preferences and commitments with others' in order to be able to engage in group action.	Study 3	Mutually accommodating social interaction process	A social interaction process in which participants interactions have involved attempting to take account of other participants' preferences, schedules and needs in order to engage in group action.	Social interaction process
Non-conscious death thought activation	The arousal of death-related cognitions that are outside of one's conscious awareness.	Study 2	Non-conscious death thought activation	Mental process in which cognitive representations regarding death are made salient for further mental processing and the person is not conscious of these thoughts	Thought activation without awareness***
Perceived norm	Perception of what most other people within a social group believe and do.	Study 3	Norm*	Belief regarding what is typical for people who belong to a particular social group.	Belief

Ungrouped MoA label	Ungrouped MoA definition	Ungrouped during?	Class label	Class definition	Parent class
Perceived norm	Perceived opinion of the 'normal' behaviour of others, including both perceptions of what others think one should do and perceptions of what others are doing.	Study 3	Norm*	A cognitive representation of whether one's own behaviour is similar to that of referent others.	Belief
Social norm	Belief about what others do and what others think one should do.	Study 3	Norm*	Belief regarding what is typical for people who belong to a particular social group.	Belief
Social norm	A socially determined consensual standards that indicates (a) what behaviours are considered typical in a given context and (b) what behaviours are considered proper in the context.	Study 3	Norm*	Belief regarding what is typical for people who belong to a particular social group.	Belief
Specific norm	Activated norm that relate to different possible courses of action.	Study 2	Norm activation	A mental process in which norms are made salient for further mental processing.	Mental process
Introjected regulation	The drive to perform a behaviour out of a sense of guilt or obligation or a need to prove something.	Study 3	Obligation-based motivation	A mental process that energises and directs behaviour to meet a perceived obligation.	Motivation
Affordance	The environmental property that allows the behaviour to occur.	Study 3	Opportunity*	A quality of a person's social and physical environment that makes behaviour possible or facilitates it.	Quality
Opportunity	A relevant, i.e., facilitating or impeding, contextual condition influencing how easy or difficult it is to perform the behaviour. (e.g., for people to recycle, it matters whether recycling bins are in place).	Study 2	Opportunity*	A quality of a person's social and physical environment that makes behaviour possible or facilitates it.	Quality
Perceived norm	A perception of whether the behaviour is in line with that of referent others.	Study 2	Perceived conformity to behavioural norms	Belief regarding what is typical for people who belong to a particular social group.	Cognitive representation

Ungrouped MoA label	Ungrouped MoA definition	Ungrouped during?	Class label	Class definition	Parent class
Regulatory fit	An experiential phenomenon whereby the manner of one's engagement in an activity sustains one's goal orientation or interests regarding that activity.	Study 3	Perceived regulatory fit process	A process by which the manner in which one attempts to achieve a goal creates an experiential sense of rightness associated with pursuing the goal, which in turn increases task engagement.	Bodily process
Personal goal	A goal that one has set for oneself.	Study 3	Personally set goal	A goal that one has decided upon for oneself.	Goal
Behavioural decision	A decision made based on a feasibility assessment of the behaviour and the desirability of its possible outcomes.	Study 3	Decision based on behaviour characteristics	A decision based on the perceived feasibility of a behaviour and the desirability of its possible outcomes.	Decision***
Choice among means	A decision to use a specific method or resource for goal achievement that has optimum or at least satisfactory levels of instrumentality, self-efficacy and affect.	Study 3	Decision with respect to means*	A decision about how to achieve a goal based on an appraisal of the relevant and available resources or means for goal achievement.	Decision***
Decision with respect to means	Decision about how best to achieve a goal that are based on an appraisal of the relevant resources or methods (means) for goal achievement that are available.	Study 3	Decision with respect to means*	A decision about how to achieve a goal based on an appraisal of the relevant and available resources or means for goal achievement.	Decision***
Optional innovation-decision	Choice to adopt or reject an innovation/behaviour that are made by an individual, independent of the decisions made by other members within the social system.	Study 3	Independent decision	A decision made independently of decisions made by other members of a social group.	Decision***
Decision	The choice of whether to adopt or reject an innovation/behaviour.	Study 3	Decision	A cognitive representation of the choice of one proposition from a set of at least two alternative propositions.	Cognitive representation

Ungrouped MoA label	Ungrouped MoA definition	Ungrouped during?	Class label	Class definition	Parent class
Cognitive control schema	A type of procedural mental representation that influences behavioural choices by increasing temptation avoidance-related self-efficacy.	Study 2	Plan*	A cognitive representation of a series of steps to be taken to achieve a goal.	Cognitive representation
Contractual Arrangement	A specific plan made between individuals.	Study 2	Plan*	A cognitive representation of a series of steps to be taken to achieve a goal.	Cognitive representation
Strategy	Programme of action designed to achieve a goal or accomplish a task.	Study 2	Plan*	A cognitive representation of a series of steps to be taken to achieve a goal.	Cognitive representation
Plan enactment	The process of putting plans into action.	Study 2	Plan enactment	A process by which a person attempts to follow the steps in a plan.	Bodily process
Quality of life	The extent to which one obtains satisfaction from life; influenced by emotional, material, and physical well-being, engagement in interpersonal relations; opportunities for personal development, exercising rights and making self-determining lifestyle choices and participation in society.	Study 3	Quality of life	A cognitive representation which represents an overall evaluation of how much one obtains satisfaction from one's life.	Cognitive representation
Religiosity	The level of one's involvement with religion, whereby a low level of involvement suggests an absence of internalisation of the moral perspective of the main conventional institution in society.	Study 2	Religion-related personal value	A personal value that stems from having a set of beliefs concerning the cause, nature, and purpose of the universe, especially when considered as the creation of a superhuman agency or agencies.	Personal value
Risk prototype	Image or cognitive representation of the 'type' of person that engages in risk behaviours.	Study 2	Risk prototype	A cognitive representation of the typical characteristics and qualities of a person who engages in a behaviour that poses a risk to their wellbeing.	Cognitive representation
Information-seeking	The process of gathering ideas and others' opinions about ways to change risky health behaviours.	Study 2	Searching for information about	A process in which people seek information and others opinions about how to alter their behaviour.	Bodily process

Ungrouped MoA label	Ungrouped MoA definition	Ungrouped during?	Class label	Class definition	Parent class
			how to change behaviour		
Help-seeking	The process of searching for solutions to problems associated with risky health behaviours.	Study 2	Searching for solutions to health risks	A process in which people seek methods to reduce the problems associated with behaviours that put health at risk.	Bodily process
Sense of value within the cultural drama	Maintaining a sense of worth, usefulness or importance within one's cultural worldview.	Study 2	Self-esteem maintenance process	A cognitive process that serves to maintain one's sense of worth, usefulness or importance.	Cognitive process
Self-esteem motive	The desire to maintain or increase positive emotions that arise from self-evaluation, and to reduce negative emotions of the same type.	Study 2	Self-esteem motivation	Motivation to maintain or increase positive self evaluations and to reduce negative self evaluations.	Motivation
Self- and partner-reinforcement**	The ability to reinforce oneself or one's sexual partner's safe sex practices.	Study 3	Self-reinforcement capability	A bodily disposition that is realised by the bearer being able to reward themselves for performing an intended behaviour.	Capability
			Close other reinforcement capability	A bodily disposition that is realised by the bearer being able to reward a friend or partner for performing an intended behaviour.	Capability
Assertiveness and social skill	The assertiveness and/or communication skill necessary to engage in discourse regarding matters such as condom use and sexual history with a potential sexual partner.	Study 3	Social capability*	A bodily disposition that is realised by the bearer engaging in interpersonal processes that influence ability to perform a behaviour, when appropriate circumstances occur.	Capability
Communication skill	The adequacy of one's verbal communication skill to assert desires for safe sex with an uncooperative partner.	Study 3	Social capability*	A bodily disposition that is realised by the bearer engaging in interpersonal processes that influence ability to perform a behaviour, when appropriate circumstances occur.	Capability

Ungrouped MoA label	Ungrouped MoA definition	Ungrouped during?	Class label	Class definition	Parent class
Social competence	The extent of one's skill in interpersonal relationships, especially the ability to handle a wide variety of social situations effectively.	Study 3	Social capability*	A bodily disposition that is realised by the bearer engaging in interpersonal processes that influence ability to perform a behaviour, when appropriate circumstances occur.	Capability
Social competence	The level of skill in interpersonal relations, especially the ability to handle a variety of social situations effectively.	Study 3	Social capability*	A bodily disposition that is realised by the bearer engaging in interpersonal processes that influence ability to perform a behaviour, when appropriate circumstances occur.	Capability
Intergroup comparison	Process in which evaluation of one's own group is determined with reference to specific other groups through social comparisons in terms of value-laden attributes and characteristics.	Study 2	Social comparison process*	Evaluating oneself or one's social group in relation to the qualities or characteristics of another person or social group.	Judging
Intergroup differentiation	Process in which pressures to evaluate one's own group positively through in-group/out-group comparisons lead social groups to attempt to differentiate themselves from each other.	Study 2	Social comparison process*	Evaluating oneself or one's social group in relation to the qualities or characteristics of another person or social group.	Judging
Evaluative component of social identity	An appraisal of self-worth based on membership of the group.	Study 3	Social identity-related self-esteem*	A cognitive representation of how one evaluates one's self concept based on perceived membership of a social group.	Self esteem
Group-referent value	Value relating to the sense of worth, usefulness or importance attached to the self in relation to other group members.	Study 2	Social identity-related self-esteem*	A cognitive representation of how one evaluates one's self concept based on perceived membership of a social group.	Self esteem
Somatic marker process	Non-conscious preference bias arising from previous emotional experiences associated with relevant behaviours.	Study 2	Somatic marker heuristic process	A heuristic process that uses previous emotional experiences of the relevant behaviours to make judgments.	Heuristic process
Stereotype	A set of cognitive generalisations about the qualities and characteristics of the	Study 3	Stereotype	A cognitive representation of the generalised qualities and characteristics of the members of a particular social group or social category.	Cognitive representation

Ungrouped MoA label	Ungrouped MoA definition	Ungrouped during?	Class label	Class definition	Parent class
	members of a particular group or social category.				
Result demonstrability (technology acceptance model)	The extent to which the results of using the technology are tangible, allowing for the attribution of improved job performance to technology use.	Study 2	System result tangibility	A quality of a technological system regarding the extent to which the results of its usage are concrete or discernible.	Quality
Objective usability	The actual amount of effort needed to perform a task using a system.	Study 2	System usability	A quality of a technological system regarding the amount of effort required to successfully use the system.	Quality
Spreading activation	Process through which the impulsive system activates behavioural schemata.	Study 2	Thought activation	Mental process in which cognitive representations regarding a topic are made salient for further mental processing.	Cognitive process
Attitudinal tolerance of deviance	A belief that transgressions are not deemed to be wrong.	Study 3	Tolerance of transgressions	A mental disposition to tolerate one or more others acting in a manner that goes against a moral code of conduct.	Mental disposition
Rationality	The extent to which one seeks to maximise utility continuously over time.	Study 2	Utility maximising goal pursuit process	A goal pursuit process focused on maximising one's satisfaction with the outcomes of one's choices.	Goal pursuit process***
Cultural worldview and drama	A mental framework within which one can imbue the universe with order, predictability, meaning and permanence.	Study 3	Worldview schema	An aggregate of cognitive representations that enable one to perceive and respond to the universe as having order, predictability, meaning and permanence.	Cognitive schema

Notes. * Classes that were added to the MoA Ontology to represent more than one MoA instance

** Two classes were developed from the 'Self- and partner- reinforcement' MoA instance

*** The parent classes were identified as classes developed from ungrouped MoAs

Appendix 4-8. The labels and definitions of ungrouped MoAs judged to qualify as the examples of MoA Ontology classes, and the relevant classes

Ungrouped MoA label	Ungrouped MoA definition	Ungrouped during?	Class the ungrouped MoA is an example of
Personal project	A large clusters of action scripts that relate to the achievement of a superordinate goal (e.g. achieving social standing, acquiring financial wealth).	Study 2	Action script
Procedural schema	Set of knowledge that represents the skills and routines for performing tasks.	Study 3	Action script
Action tendency	Urge that, if not inhibited, results in some form of behaviour (expressive or instrumental); required to allow for interruption and thus modification of the pathway between the ways inputs are processed and outputs.	Study 3	Action script
Impulse	Organised action schemas that are the immediate precursors to responses.	Study 3	Action script
Personal attribution	An inference in which one blames oneself as being the cause of the relapse.	Study 3	Appraisal as caused by self
Perceived cause of negative self-attitudes	Perception of the causes of any negative emotions one feels as a result of self-evaluation.	Study 2	Appraisal of causal agency
Decisional balance	The moment to moment (i.e. situational) assessment of the value of a goal, whereby the long-term net effects are considered against the immediate value.	Study 3	Appraisal of goal importance
Drive	Generalised state of readiness precipitating or motivating courses of action.	Study 3	Arousal
Drive	Generalised state of readiness precipitating or motivating courses of action.	Study 3	Arousal
Drive	The motivation or desire to act or respond, a covert stimulus that triggers action.	Study 3	Arousal
Social liberation	The process of noticing social, policy or environmental changes that facilitate health behaviour change.	Study 3	Attending
Immediate competing demand and preference	Alternative behavioural option that intrudes into one's thoughts immediately prior to engaging in a behaviour.	Study 2	Attending disrupted by behavioural alternatives
Pros and cons of behaviour change	Decisional balance constructed by individuals relating to the relative advantages and disadvantages of alternative behaviours.	Study 2	Attitudes towards a behaviour
Innate drive	Motivation to act or respond that exists in an organism from birth and form the primary basis for the greater proportion of motivation (e.g. pain, hunger, thirst).	Study 3	Automatic motivation
System norm	Established behaviour pattern for people within a social system.	Study 3	Behaviour
Behavioural willingness	Openness to engaging in the risky behaviour.	Study 2	Behavioural intention
We-intention	Commitment to engage in joint action with others.	Study 3	Behavioural intention
Intention	Self-conscious plan to engage or not engage in a given behaviour, consisting of a cognitive representation of the behaviour associated with a feeling of imperative to engage in the behaviour.	Study 3	Behavioural intention

Ungrouped MoA label	Ungrouped MoA definition	Ungrouped during?	Class the ungrouped MoA is an example of
Goal intention	A consciously made decision to pursue a desired end state.	Study 3	Behavioural intention
Commitment	The extent of one's dedication to abstinence.	Study 3	Behavioural intention
Peer and social reaction	Response of individuals or social groups that occurs as a consequence of the behaviour and reinforces subsequent behaviours.	Study 3	Behaviour-influencing social interaction process
Expectation	Belief about future states of the world with associated subjective probabilities of their occurrence.	Study 3	Belief
Hassle	Inconvenience relating to the desired behaviour.	Study 2	Belief about barriers
Evaluation	The expected consequence of an action or object.	Study 2	Belief about consequences
Perceived situational influence	Perception of the environment in which a behaviour takes place, specifically how compatible or incompatible one feels one is with that environment.	Study 3	Belief about one's environment
Distinctive suitability	The feeling that there is a unique ability to respond due to specific skills, knowledge or availability; may elicit a responsibility to respond.	Study 3	Belief about responsibility to act
Job relevance	The perception of how applicable a technology is to one's job.	Study 2	Belief about technology use
Output quality (Technology Acceptance Model)	The perception of how well a technology performs job-relevant tasks.	Study 2	Belief about technology use
Behavioural option	Perceived alternative to the behaviour in question.	Study 2	Belief about the availability of behavioural options
Physical cost	Perceived physical cost and/or benefit associated with a line of action that includes effort expenditure, time loss, excitement and exhilaration.	Study 3	Belief about the consequences of behaviour
Perceived benefit of action	Belief about the positive or reinforcing outcomes of engaging in a behaviour.	Study 3	Belief about the consequences of behaviour
Benefit to oneself	Belief about whether engaging in the behaviour will be beneficial to oneself.	Study 3	Belief about the desirability of consequences of behaviour
Perceived benefit	Belief about the benefits of a behaviour or behaviour change.	Study 3	Belief about the desirability of consequences of behaviour
Behavioural belief	Evaluation of the possible outcomes of the behaviour (e.g. belief that the behaviour will lead to positive outcomes and prevent negative ones).	Study 3	Belief about the desirability of consequences of behaviour
Evaluation of outcomes	Positive or negative belief about the consequences of engaging in the behaviour.	Study 3	Belief about the desirability of consequences of behaviour
Evaluative aspect	Appraisal about how desirable or undesirable the outcomes of a behaviour will be.	Study 3	Belief about the desirability of consequences of behaviour

Ungrouped MoA label	Ungrouped MoA definition	Ungrouped during?	Class the ungrouped MoA is an example of
Incentive	The extent to which perceived consequences of behaviour change are personally valued.	Study 3	Belief about the desirability of consequences of behaviour
Problem perception (Labelling)	The stage at which one labels one's behaviours as problematic or risky.	Study 3	Beliefs about consequences
Perceived health cost and benefit	Expectation regarding all possible health outcomes of a behaviour (i.e. positive or negative).	Study 3	Beliefs about likely health consequences of behaviour
Image	The degree to which use of an innovation is perceived to enhance one's status among one's social group and influences.	Study 3	Beliefs about social consequences of behaviour
Adherence behaviour	The ability to conform to a treatment regimen, especially one involving drug treatment as outlined by a health care provider.	Study 3	Capability
Objective ability	Ability to perform a behaviour based on observable phenomena.	Study 3	Capability
Behavioural skill	The ability that is necessary in order to execute the new behaviour effectively.	Study 3	Capability
Skill	An ability or proficiency that facilitates performance of the behaviour.	Study 3	Capability
Technique	Practical skill and ability related to the performance of a behaviour; way of performing a behaviour, varying complexity from very simple to very complicated.	Study 3	Capability
Implicit theory	Complex set of beliefs that require cognitive effort to apply to the behaviour.	Study 2	Cognitive schema
Frame	The assumption (implicit or explicit) as to what is relevant to the topic.	Study 2	Cognitive schema
Behavioural Schemata	A mental representation of incoming physiological or psychological stimuli that gives rise to a behaviour.	Study 2	Cognitive schema
Goal structure	Cluster of action scripts directed toward some greater goal.	Study 3	Cognitive schema
Knowledge	A change in one's understanding as a result of receiving a message.	Study 3	Comprehension
Understanding of a message	The act of knowing and understanding the educational content (e.g. of a communication).	Study 3	Comprehension
Available behavioural alternative	Possession of the necessary coping skills to resist or cope with barriers.	Study 3	Coping capability
Available behavioural alternative	Possession of the necessary coping skills to resist or cope with barriers.	Study 3	Coping capability
Collective innovation-decision	Choice to adopt or reject an innovation/behaviour that is made by consensus amongst the members of a social system.	Study 2	Decision
Noetic Decision	Decision made in the reflective system that draws upon syllogistic rules and evaluations of utility.	Study 3	Decision
Contingent innovation-decision	A choice to adopt or reject an innovation/behaviour that can only be made after a prior decision to adopt or reject.	Study 3	Decision
Intention to perform means	A conscious decision to use a certain method to achieve a goal.	Study 3	Decision with respect to means

Ungrouped MoA label	Ungrouped MoA definition	Ungrouped during?	Class the ungrouped MoA is an example of
Perceived norm	Perception of the standard or range of values that represents the typical performance of a group or individual concerning a given behaviour.	Study 3	Descriptive norm
Subjective norm	Perception of what others are doing in relation to the behaviour.	Study 3	Descriptive norm
Hypothesis (Feedback Intervention Theory)	New standard for the components of a task that is generated and tested for success in improving performance on that task.	Study 2	Desired standard
Personal rule	Imperative about what we do and not do.	Study 3	Desired standard for behaviour
Rule of behaviour	A guideline or standard that determines how a person behaves in specific social situations.	Study 3	Desired standard for behaviour
Rule	A self-imposed standard, guideline and/or restriction on executive-driven behaviour.	Study 3	Desired standard for behaviour
Standard	The personal rule by which one judges one's own behaviour.	Study 3	Desired standard for behaviour
External regulation	The drive to perform a behaviour to gain some reward or avoid some negative contingency, arising from either environmental circumstances or from another person.	Study 3	Extrinsic motivation
External regulation	The drive to perform a behaviour to gain some reward or avoid some negative contingency.	Study 3	Extrinsic motivation
Parental control	Personal and social control instigated by parents relating to the problem behaviour.	Study 3	Family social influence process
Shared goal	A goal that is shared by others in a social relationship.	Study 3	Goal
Computer playfulness	The level of cognitive spontaneity in interactions with technology; represents the intrinsic motivation associated with using any new system.	Study 2	Intrinsic motivation
Resolving feedback-self discrepancies	Process by which one aims to resolve apparent discrepancies between current outcomes and the goal towards which one is striving.	Study 2	Goal pursuit process
Intrinsic motivation	The drive to perform a behaviour because the behaviour is consistent with other goals and values.	Study 3	Intrinsic motivation
Innate reward	Events producing a reduction in drive (e.g. lessened hunger).	Study 2	Intrinsic reward for a response
Cognitive appraisal of efficacy information	The cognitive evaluation of information relating to the belief that one is capable of carrying out a specific behaviour that will lead to desired outcomes.	Study 2	Judging
Persuasion	The formation of a positive or negative opinion about an innovation/behaviour.	Study 2	Judging
Retrospective evaluation	The appraisal of the outcome of a previous choice.	Study 3	Judging
Opinion	Change in perception/belief as a result of a receiving a message.	Study 3	Judging
Anticipatory response	The process through which responses that are temporally more proximal to a reward will, wherever possible, become earlier in the sequence than they were originally.	Study 2	Learning

Ungrouped MoA label	Ungrouped MoA definition	Ungrouped during?	Class the ungrouped MoA is an example of
Cognitive representation	Mental depiction of oneself trying to perform a behaviour.	Study 2	Mental image
Self-directive goal	Behavioural intention embedded in personal projects; guides people into activities and environments that affect their responses to behaviour change inducements.	Study 3	Behavioural intention
Desirability	The extent to which action is evaluated as being worth pursuing (i.e. the extent to which one is motivated to act).	Study 2	Motivation
Social motivation	Motivation to engage in the behaviour arising from perceived social support from important others and willingness to comply with such others.	Study 3	Motivation
Consistency	The level of consistency in one's behaviour, opinions and attitudes, the need for which can motivate changes in feelings, beliefs or behaviour.	Study 2	Need for consistency between beliefs and behaviour
Subjective norm	The perceived social pressure to perform or not to perform the behaviour.	Study 3	Norm
Felt Social Pressure	Perception of the expectations of others.	Study 2	Normative belief
Social norm	Perception of others' beliefs about threat prevention.	Study 2	Normative belief
Social normative belief	A perception relating to social norms, influences and pressures.	Study 3	Normative belief
Social normative belief	Perception related to social norms, influences and pressures.	Study 3	Normative belief
Physiological reinforcement for smoking	The process by which the sensations experienced as a result of smoking reinforce the behaviour (i.e. increase the frequency or probability of smoking).	Study 3	Operant conditioning
Operant conditioning	A type of learning in which behaviour change occurs as a function of the consequences of behaviour.	Study 3	Operant conditioning
Operant conditioning	The process by which a response becomes more or less likely as a result of stimuli that follow it.	Study 3	Operant conditioning
Spatial (ability)	The availability of space in which to store goods and the distance between the home and shops and services.	Study 2	Physical opportunity
Program control	The reference value at the third highest level of the hierarchical system that specifies a course of action required, and that is particularly important for self-regulation.	Study 3	Plan
Coping planning	The anticipation of potential barriers to action and the generation of behavioural options to overcome these barriers.	Study 3	Problem solving planning
Self-evaluation	One's conception and evaluation of oneself, including psychological and physical characteristics, qualities and skills.	Study 3	Self esteem
Action control	A self-regulatory process involved in the maintenance of a newly adopted behaviour (change), includes self-monitoring of behaviour.	Study 3	Self-regulation of behaviour
Action control	A self-regulatory process involved in the maintenance of a newly adopted behaviour (change), includes self-monitoring of behaviour.	Study 3	Self-regulation of behaviour

Ungrouped MoA label	Ungrouped MoA definition	Ungrouped during?	Class the ungrouped MoA is an example of
Self-Monitoring	A strategy in which individuals keep a personal behaviour record, typically in connection with efforts to change or regulate the self.	Study 3	Self-regulation of behaviour
Mental energy/ego depletion	Mental energy needed for the exercise of self-control.	Study 3	Self-regulatory capability
Conjoint competence	The ability of people in a social relationship to collaborate in problem solving.	Study 2	Social capability
Commitment	The extent to which one is dedicated to conventional society.	Study 2	Social embeddedness in conventional society
Belief	One's belief in conventional society.	Study 2	Social embeddedness in conventional society
Social reinforcement	Positive interpersonal stimulus such as verbal praise, a smile, touch or other sign of approval that is received as a result of behaviour and increases the frequency of the behaviour that immediately precedes it.	Study 3	Interpersonal approval subsequent to behaviour

Appendix 4-9. The labels and definitions of ungrouped MoAs that were not included in this version of the MoA Ontology, and the reason for their exclusion

Ungrouped MoA label	Ungrouped MoA definition	Ungrouped during?	Reason for not being included in this version of the ontology
Self-liberation	The process through which one comes to believe in one's ability to change a particular behaviour and one's commitment to act on that belief.	Study 2	The definition included a process of committing to something and actual commitment
Personal norm	Norm related to one's self-concept.	Study 2	Underspecified definition
Approach	A basic preconsciously generated reaction to a stimulus as potentially desirable.	Study 2	Underspecified definition
Faith in the cultural drama	Maintaining loyalty, belief and trust in the reality, significance and permanence of cultural drama.	Study 2	The definition included maintenance of three entities and focuses on three aspects of cultural drama
Self-discovery	Value involving personal understanding gained through interacting with others.	Study 2	Underspecified definition
Approach	The practice or instance of decreasing the distance between oneself and an aspect of the environment.	Study 2	Underspecified definition
Introjection	The process whereby an external regulation is "partially" internalised such that it essentially retains its original form, and thus is not accepted as one's own (e.g. contingent self-esteem and ego-involvement).	Study 2	The definition included two processes
Complexity	The perceived difficulty of understanding, using or performing an innovation/behaviour.	Study 2	The definition included two different beliefs - self-efficacy and belief about technology use
Unfreezing	Overcoming inner resistance to change such that one is ready to change, 'breaking the habit'.	Study 2	The definition included readiness to change and habit breaking
Goal	The outcome of a combination or sequence of a number of acts.	Study 2	Underspecified definition for goal
Acceptance/ yielding	The extent to which the content of a message is accepted and retained.	Study 2	The definition included both acceptance and memory process
Behavioural proneness	A dynamic state that specifies the likelihood of occurrence of the problem behaviour from within the behavioural system; consists of higher involvement in other problem behaviours than the one being predicted or explained, and lower involvement in conventional behaviour.	Study 2	The definition included various types of 'involvement' with different behaviours
Task-motivation process	Negative feedback process (i.e. the perception of a discrepancy between one's current behaviour and one's desired end state and one's efforts to reduce that discrepancy) that relates to a focal task.	Study 2	The definition included the perceived discrepancy and efforts to reduce that discrepancy
Counter conditioning	The process of adopting healthier behaviours as substitutes for problem behaviours.	Study 2	Underspecified definition and unclear whether the entities is a MoA or part of the intervention
Monitoring activity	The assessment of how successful the methods of goal achievement a person has chosen will be, and consideration of whether additional contingencies, barriers or facilitators should be factored into decision-making.	Study 2	The definition included monitoring and decision-making

Intending	Process that monitors the impulsive system for information, enabling the behavioural implementation of the decision.	Study 2	Underspecified definition
Performance accomplishment	The extent to which prior experiences of performing the behaviour have been successful.	Study 2	Not a MoA, as the entity is defined as past experience with the behaviour
Conventional behaviour structure	Interconnected set of conventional behaviours.	Study 2	Underspecified definition
Comprehension (and memory)	The extent to which the message is understood and remembered.	Study 2	The definition included two entities - comprehension and memory outcome
Action-outcome feedback loop	A representation in which self-regulation is a condition of a self-sustaining, dynamic equilibrium between self-protective activities and their experienced biologic, emotional, and social consequences.	Study 2	The definition included representation of multiple interconnected processes
Self-Interest	Behaviour or a state of mind that does not take the interests of others into account.	Study 2	The definition included behaviour and a mental disposition
Identification	The process of identifying with the importance of a behaviour and accepting responsibility for regulating the behaviour.	Study 2	The definition included two processes - acceptance of the importance of a behaviour and accepting the behaviour as a personal responsibility to regulate the behaviour
Discursive and practical consciousness	The awareness with which individuals think and talk and act; a body of knowledge that both enables individuals to act (practical) and is an ongoing development of ideas and possibilities, anchored in knowledge, values and experiences (discursive).	Study 2	The definition included both awareness and body of knowledge
Reference point	One's current level of assets.	Study 2	Underspecified definition
Dramatic relief	The process of experiencing and releasing feelings about the problem and the solution.	Study 2	Underspecified definition - unclear what is meant with realising feelings
Internalisation	The process through which one acquires a belief, value, or behavioural regulation and progressively transforms and organizes it into a personal value or goal.	Study 2	The definition included multiple processes
Temptation	A desire, or stimulus that creates a desire, to carry out the problem behaviour(s).	Study 2	The definition included desire and stimulus to create that desire
Valued Quality or Success	The extent to which one possesses the attributes that they value and has achieved the successes that they value.	Study 2	The definition included the possession of attributes one values and the achieved success that one values
Group norm	A set of goals, values, beliefs and conventions of the group's members.	Study 2	The definition included goals, values, beliefs and conventions
Commitment	An agreement or pledge to achieve a goal in the future, or the state or instance of being obligated or emotionally impelled to achieve a goal.	Study 2	The definition included 'commitment making' and the disposition of being committed to an end state
Weight	A process of attributing a degree of importance to attitudes and social normative beliefs.	Study 2	Underspecified definition

'Weight'	Weight assigned to beliefs based on the value attributed to a relevant object or to the anticipated consequences of a relevant action.	Study 2	Underspecified definition
Coping response	Response that allows an individual to cope with high risk situations (e.g. assertiveness in coping with social pressure).	Study 2	Underspecified definition - unclear if referring to behaviours, mental processes, or both.
Denial of the state of need	The refusal to believe that a need exists.	Study 2	Underspecified definition
Group standard	The value, belief, norm and/or behaviour shared by a group.	Study 2	The definition included norm, belief and behaviour
Social criticism	The rejection of societal norms, values, and practices.	Study 2	The definition included rejection of societal norms, values and practices, and the definition was underspecified in terms of whether this entity was a process or disposition
Cost & benefit	The advantage and/or disadvantage of pursuing a line of action that can be social, physical, psychological or moral.	Study 2	Underspecified definition - unclear whether the costs and benefits of behaviour are subjective or objective.
Social consensus	The general agreement or understanding of knowledge, beliefs, social meanings and social norms that exist within social environments.	Study 2	The definition included various different entities, such as agreement of knowledge and beliefs
Internalisation	Incorporation of important others' beliefs about the behaviour into one's own belief system.	Study 2	Underspecified definition
Avoid	A basic preconsciously generated reaction to a stimulus as potentially threatening.	Study 2	Underspecified definition
Assessment, Evaluation & Reassessment	Stage of the norm activation process that contains two sub-stages: assessment and evaluation of responses, and reassessment and redefinition of the situation.	Study 2	The definition included sub-stages with different processes
Script	Sequence of behaviours that is expected in a given situation.	Study 2	Underspecified definition
Social Identity process	Method of processing information based on the awareness of one's place in a group, emotional attachment to the group, and the value placed on being a member of that group.	Study 2	Underspecified definition
Denial of suitability of norms	The refusal to believe that norms apply; may occur through consideration of additional alternative actions that could modify the outcome of one's cost-benefit analysis.	Study 2	Underspecified definition
Emotional involvement	The extent to which we have an affective relationship with the natural world.	Study 2	Underspecified definition
Decision weight	The impact of the probability on the total value of a prospect assigned.	Study 2	Not a MoA, as the entity is defined as a mathematical relationship between the probability and total value of a prospect
Economic condition	Status of a financial position within a specific period of time.	Study 2	Underspecified definition
Parent-friends compatibility	Perceived compatibility between parents' and friends' expectations.	Study 2	Underspecified definition

Reassessment & redefinition of the situation	Process of evaluation that occurs when the moral costs of not responding to the need, and the balance of the costs of response actions, are both high.	Study 2	Underspecified definition
Moral Cost	A specific type of psychological costs and benefits that relate to one's self-perception of how one responds to the welfare of others (e.g. perception of personal kindness and responsibility).	Study 2	Underspecified definition
Value	The weight placed upon the attributes of an object.	Study 2	Underspecified definition
Fear-control process	The process initiated when one has high perceptions of threat but low perceptions of one's ability to take action that would effectively avert that threat; involves a motivation to cope with fear.	Study 2	Underspecified definition
Maladaptive change	Dysfunctional strategy used to reduce fear in relation to a threat (e.g. denial, defensive avoidance).	Study 2	The definition included behavioural and cognitive strategies
Confirmation	Seeking reinforcement for a decision to adopt or reject an innovation/behaviour.	Study 2	Underspecified definition
Personal goal structure	A set of specific goals relating to what one feels is important in life, arranged hierarchically from the more concrete at the lower end to the more abstract at the higher end.	Study 2	The definition included a set of different goals
Compatibility	The extent to which a new innovation/behaviour can co-exist with the existing needs and values of a potential adopter of that innovation/behaviour.	Study 2	Underspecified definition - unclear if the definition refers to the technology or behaviour
Task Knowledge	A set of facts, skills and/or information about how to accurately perform the behaviour.	Study 2	The definition included facts/information and skills
Authority innovation-decision	A choice to adopt or reject an innovation/behaviour that are made by relatively few individuals within a social system who possess power, status or technical expertise. Other individuals within the system have no choice over adoption and simply implement the decision.	Study 2	The definition included the decision made by authority and the inability of others to implement any other decisions
Rationalisation	Justification of the behaviour with excuses and explanations.	Study 2	Underspecified definition - unclear if the definition refers to a mental or a cognitive representation
Social meaning	An image and/or interpretation that social groups attach to behaviour.	Study 2	The definition included a mental image and the interpretation of this image
Friends modelling problem behaviour	The extent to which one's friends serve as examples for exhibiting the problem behaviour.	Study 3	Specifically related to friends' behaviour
Association with non-delinquent peers	The act of associating with peer groups who do not violate social rules or conventions.	Study 3	Underspecified definition
Differential association	The balance of one's association with, or isolation from, criminal or non-criminal groups.	Study 3	Underspecified definition

Actual norm	The real attitude held and behaviours exhibited by the majority of other people within a social group.	Study 3	The definition included the attitudes and behaviours of others
External regulation	The regulation of behaviour by external factors (e.g., rewards and punishments).	Study 3	Not a MoA - the regulation is not instigated by the organism itself
Bringing up and negotiating AIDS prevention with partner	The ability to discuss and agree upon AIDS-preventative actions with a sexual partner, and to remove oneself from situations in which safe sex cannot be agreed upon.	Study 3	The definition included two types of capability
Self-attitude	Positive and negative emotional experiences that result from perceptions and evaluations of one's own attributes and behaviour.	Study 3	The definition included emotional experiences and the evaluations of one's own attributes and behaviour
Fatigue	A usually transient state of discomfort and loss of efficiency as a normal reaction to emotional strain, physical exertion, boredom or lack of rest.	Study 3	Underspecified definition - unclear if the definition refers to the symptom of fatigue or a subjective emotional feeling
Motivational orientation	The specific concerns and interests of an individual that have motivated them to pursue the goal.	Study 3	Underspecified definition
Pluralistic ignorance	The state of affairs in which the majority of members of a group believe that the majority of their peers think or act differently to themselves (i.e. the majority falsely believe themselves to be in the minority).	Study 3	Population attribute as a result of other mental dispositions (e.g., 'false uniqueness')
Belief about incentives and barriers for health behaviour	Perception about what will enhance or serve as a motive for, as well as what will restrict or impede, the behaviour (e.g. availability of programs).	Study 3	The definition included different types of beliefs (e.g., about what will enhance and serve as motive for behaviour)
Outcome expectation	Belief about the impact of current behaviour on health, and beliefs about whether behaviour change would be personally beneficial to one's health.	Study 3	The definition included different types of beliefs
Temporal valuation	The value attached to certain outcomes, incorporating the temporal distribution of outcomes.	Study 3	Underspecified definition
Attitude	Change in one's positive/negative evaluation (e.g. about smoking) as a result of receiving a message.	Study 3	Underspecified definition - unclear what kind of change the definition refers to
Subjective value	The extent to which one perceives an outcome as valuable; may be strictly positive, strictly negative or neither.	Study 3	Underspecified definition
Ego preoccupation	The extent to which one perceives an intention or decision to be personally important, and the level of commitment to that intention or decision.	Study 3	The definition included personal importance of an intention and commitment to that intention
Entertainment value	The value derived from fun and relaxation through playing or otherwise interacting with others.	Study 3	Underspecified definition
Maintaining interpersonal interconnectivity	The value one gets from establishing and maintaining contact with other people such as social support, friendship, and intimacy.	Study 3	Underspecified definition

Value	The sense of worth, usefulness or importance attached to an outcome.	Study 3	Underspecified definition - unclear what the 'outcome' is referring to
Value	Evaluation of broadly defined attributes of abstract concepts (e.g. justice).	Study 3	Underspecified definition
Experiential state of awareness	Experience of a feeling with a distinct phenomenal quality without necessarily knowing it's origin e.g. a feeling of knowing.	Study 3	Underspecified definition
Group identity	A type of normative mechanism relating to one's social network that is construed in terms of aspirations to emulate referent others and the extent to which one perceives similarity between oneself and those referents.	Study 3	The definition included perception of similarity and desire to emulate others
Imitation	A process by which thoughts, feelings and motivational states observed in others are internalised and replicated without the need for conscious awareness.	Study 3	The definition included processes to internalise thoughts, feelings and motivational states
Goal congruence	The resolution of confusion and anxiety arising from any competing demands associated with one's health goals.	Study 3	Underspecified definition
Prevention of learning by existing values	A process by which existing values prevent or reduce the acquisition of new information.	Study 3	Underspecified definition
Threat-avoidance outcome	Reaction aimed at minimising attention to the health danger or suppressing the threatening cognitions with which the health threat is associated.	Study 3	The definition included reactions aimed at minimising attention and repressing thoughts
Commitment to plan of action	The state or quality of being dedicated to carrying out a particular behaviour in a particular context despite any competing desires; includes the formation of strategies for successfully performing the behaviour.	Study 3	The definition included commitment and mental processes
Compliance	The performance of a particular behaviour in order to achieve a goal or avoid a punishment.	Study 3	Not a MoA - the definition suggested that the entity is an outcome behaviour
Directive function	The process by which goals direct attention and effort towards goal-relevant activities and away from goal-irrelevant activities.	Study 3	The definition included the process by which goals change attention and effort
Effort	The intensity and duration of thought, planning and activity expended in attempting to achieve a goal.	Study 3	The definition included thoughts, planning and activity processes
Energising function	An increase in effort invested in a task resulting from perceived difficulty of that task.	Study 3	Not a MoA - the definition focused on an interaction between two MoAs
Strength of engagement	The extent to which people are absorbed or involved in their goal pursuit or decision making process.	Study 3	The definition included attributes of the goal pursuit or decision-making process
Social norm belief	Perception of the norms that people have with respect to behaviours.	Study 3	Underspecified definition
Social modelling belief	Observation of others carrying out the behaviour.	Study 3	Underspecified definition
Activity-related affect	The feeling or emotion experienced before, during or after a behaviour.	Study 3	Not included to avoid contradicting the structure of the Emotion Ontology

Act-related affect	Emotional response to the behaviour itself.	Study 3	Not included to avoid contradicting the structure of the Emotion Ontology
Affect	The positive or negative emotion felt by the person at the idea of performing the act.	Study 3	Not included to avoid contradicting the structure of the Emotion Ontology
Aversive emotional state	Distress and other negative emotional state associated with behaviours that are perceived to be problematic.	Study 3	Not included to avoid contradicting the structure of the Emotion Ontology
Emotional pros & cons	One's positive and negative feelings about the positive and negative consequences that may result from carrying out the behaviour.	Study 3	Not included to avoid contradicting the structure of the Emotion Ontology
Affective Process	An emotional reaction that is triggered by the presentation of feedback on one's performance on a task.	Study 3	Not included to avoid contradicting the structure of the Emotion Ontology
Feedback intervention-induced affect	An emotional reaction that is triggered by the presentation of feedback on one's performance on a task.	Study 3	Not included to avoid contradicting the structure of the Emotion Ontology
Self-related affect	Emotional response to oneself engaging in the behaviour.	Study 3	Not included to avoid contradicting the structure of the Emotion Ontology
Behavioural intention	The thought process which is the direct behavioural antecedents of the act.	Study 3	Underspecified definition
Self-image	A set of ideas about who one perceives oneself to be; includes self-esteem and ideas about the behaviours that are correct, appropriate or enjoyable.	Study 3	The definition included self-concept and self-esteem
Sense of self	Conception and evaluation of oneself.	Study 3	The definition included self-concept and self-esteem
Reinforcement for involvement	A contingency whereby interaction or involvement is rewarded to increase the frequency or probability of further involvement.	Study 3	The definition under specific, but seems to imply someone providing a reward to increase the target person's social involvement (i.e., part of the intervention)
Covert antecedent	Event, circumstance or stimulus that precedes a relapse, that is not directly observable.	Study 3	Underspecified definition
Acquired drive	An elaboration of innate drives, serves as a façade behind which the functions of the underlying innate drives are hidden (e.g. fear, appetite).	Study 3	Underspecified definition
Need for feasibility	Most basic need within the hierarchy, relates to one's personal ability or limits in relation to the behaviour.	Study 3	Underspecified definition
Social pressure and support belief	The extent to which one feels pressure or support from others to execute the behaviour.	Study 3	The definition included social pressure and social support
Edited prospect	The prospect left to choose from after the editing phase.	Study 2	Underspecified definition
Self-need	A set of motivational variables related to one's sense of self that influences the internalisation process.	Study 2	Underspecified definition

Value from fit	Degree of positive or negative value attaching to good regulatory fit.	Study 3	Underspecified definition
Self-reference	The process by which social groups provide their members with an identification of themselves in social terms.	Study 3	Underspecified definition
Acceptance	The process of accepting the information.	Study 2	Underspecified definition
Self re-orientation	Process by which an attempt is made to modify the value placed on a particular behaviour by operational processes.	Study 2	Underspecified definition

Appendix 4-10. The labels and definitions of classes imported or developed to hierarchically structure classes in the MoA Ontology

Class label (If imported, URI)	Definition of class	Example of subclass
Specifically dependent continuant BFO:0000020	b is a specifically dependent continuant = Def. b is a continuant & there is some independent continuant c which is not a spatial region and which is such that b s-depends_on c at every time t during the course of b's existence	Disposition
Disposition BFO:0000016	b is a disposition means: b is a realizable entity & b's bearer is some material entity & b is such that if it ceases to exist, then its bearer is physically changed, & b's realization occurs when and because this bearer is in some special physical circumstances, & this realization occurs in virtue of the bearer's physical make-up.	Bodily disposition
Quality PATO:0000001	A dependent entity that inheres in a bearer by virtue of how the bearer is related to other entities.	Opportunity
Bodily disposition MF:0000032	A disposition that inheres in some extended organism.	Mental disposition
Mental disposition MF:0000033	A bodily disposition that is realized in a mental process.	Awareness
Process BFO:0000015	An occurrent that has temporal proper parts and for some time t, p s-depends_on some material entity at t.	Bodily process
Representation MF:0000030	A dependent continuant which is about a portion of reality.	Cognitive representation
Bodily process OGMS:0000060	A process in which at least one bodily component of an organism participates.	Behaviour
Behaviour GO:0007610	The specific actions or reactions of an organism in response to external or internal stimuli.	Habitual behaviour
Interpersonal process MF:0000021	A process in which at least two human beings are agents.	Communication
Mental disorder MFOMD:0000004	Clinically significant behavioural and/or cognitive pathology.	Addiction
Mental process MF:0000020	A mental process is a bodily process that is of a type such that it can of itself be conscious. Examples include thinking, feeling pain, remembering and emotion as occurrent experiences. Comment: A bodily process which brings into being, sustains or modifies a cognitive representation or a behaviour inducing state.	Affective process
Bodily feeling MFOEM:000202	No definition provided	Pain
Subjective emotional feeling MFOEM:000006	The subjective emotional feeling is that (fiat) part of the emotion process by which the organism experiences its own emotion.	Feeling an urge
Non-associative learning GO:0046958	A simple form of learning whereby the repeated presence of a stimulus leads to a change in the probability or strength of the response to that stimulus. There is no association of one type of stimulus with another, rather it is a generalized response to the environment.	Sensitization
Cognitive process MF:0000008	A mental process that creates, modifies or has as participant some cognitive representation.	Comprehension
Thinking MF:0000013	A mental process that involves the manipulation of mental language and/or mental images.	Reflective thinking
Aggregate of cognitive representations	An aggregate of cognitive representations about a concept or entity.	Cognitive schema

Class label (If imported, URI)	Definition of class	Example of subclass
Decision simplification	A mental process that simplifies decision making.	Decision simplification through rounding
Judging as potential peer	Judging whether an individual or individuals should be considered as a person of the same status or rank.	Judging as peer of similar status or ability
Thought activation	Mental process in which cognitive representations regarding a topic are made salient for further mental processing.	Norm activation
Thought activation with awareness	Mental process in which cognitive representations regarding a topic are made salient for further mental processing and the person is conscious of these thoughts.	Conscious death thought activation

Appendix 4-11. The labels and definitions of additional classes imported from other ontologies to help structure the MoA Ontology

Class label (URI)	Class definition	Parent class
Emotional action tendency MFOEM:000007	An emotional action tendency is a disposition to behaviour that inheres in an organism by virtue of the physical changes brought about by an emotion process.	Disposition
Appraisal as being disliked MFOEM:000191	An appraisal that represents a judgement that one is being disliked.	Appraisal
Appraisal as being liked MFOEM:000192	An appraisal that represents a judgement that one is being liked.	Appraisal
Appraisal of avoidability of consequences MFOEM:000091	An appraisal which represents a judgement about how avoidable the expected consequences of an event will be.	Appraisal
Appraisal of causal intent MFOEM:000082	An appraisal that represents an evaluation of the causal intent of the person who is evaluated to have caused an event.	Appraisal
Appraisal of congruence with ideals MFOEM:000094	An appraisal which represents a judgement about whether an event is consistent with the person's standards or ideals.	Appraisal
Appraisal of dangerousness MFOEM:000103	An appraisal which represents an evaluation of the dangerousness of an object or situation.	Appraisal
Appraisal of desirability of consequences MFOEM:000085	An appraisal that represents an evaluation of the desirability of the expected consequences of an event.	Appraisal
Appraisal of expectedness MFOEM:000060	An appraisal that represents an evaluation of whether an event was expected to occur.	Appraisal
Appraisal of familiarity MFOEM:000058	An appraisal that represents an evaluation of how familiar an object or event is.	Appraisal
Appraisal of goal importance MFOEM:000072	An appraisal that represents an evaluation of whether an event or object is important to the person's goals or needs.	Appraisal
Appraisal of justice of treatment MFOEM:000100	Appraisal which represents an evaluation of whether the person was treated justly or unjustly by another person.	Appraisal
Appraisal of loss MFOEM:000106	An appraisal that represents a belief that something or someone that is important to the person has been lost to the person.	Appraisal
Appraisal of pleasantness MFOEM:000061	An appraisal that represents an evaluation of the pleasantness of an object or event.	Appraisal
Appraisal of predictability MFOEM:000059	An appraisal that represents an evaluation of how predictable an event was.	Appraisal
Appraisal of social attention MFOEM:000097	An appraisal which represents a judgement about the direction and nature of the social attention surrounding an event.	Appraisal
Appraisal of suddenness MFOEM:000057	An appraisal which represents an evaluation of how suddenly an event occurred.	Appraisal
Appraisal of urgency of response MFOEM:000088	An appraisal that represents an evaluation of the urgency of responding to an event.	Appraisal
Emotional behavioural process MFOEM:000004	An emotional behavioural process is the behaviour of the organism in response to the appraisal, which includes the characteristic facial expressions for particular emotion types.	Behaviour

Class label (URI)	Class definition	Parent class
Physiological response to emotion process MFOEM:000003	A physiological response to emotion process is a bodily process which encompasses all the neurophysiological changes caused by the appraisal, which take place in the central nervous system (CNS), neuro-endocrine system (NES) and autonomous nervous system (ANS).	Bodily process
Amusement* MFOEM:000169	A positive emotion that is experienced when a person finds something funny and entertaining.	Emotion process
Anger MFOEM:000009	A negative emotion, characterised by feelings of unpleasantness and high arousal, in the form of antagonistic feelings and action tendencies.	Emotion process
Boredom* MFOEM:000166	An emotion in which one feels weary and impatient because one is unoccupied or lacks interest in one's current activity.	Emotion process
Compassion MFOEM:000052	An emotion evoked for a person who is in distress.	Emotion process
Concern* MFOEM:000168	An emotion in which one feels nervous interest in something.	Emotion process
Confusion* MFOEM:000173	An emotion in which one feels disoriented about something and is unable to engage in orderly thought or to distinguish, choose or behave decisively.	Emotion process
Contempt MFOEM:000018	A negative emotion generally elicited by the negative evaluation of others and their actions.	Emotion process
Curiosity* MFOEM:000167	An emotion that is experienced when one has a desire to learn or know something.	Emotion process
Despair MFOEM:000030	A negative, high intensity emotion characterised by loss of hope and loss of interest. Associated with action tendencies of harm to self or others.	Emotion process
Disappointment MFOEM:000051	A negative emotion which is triggered by the disconfirmation of the prospect of a desirable event.	Emotion process
Disgust MFOEM:000019	A negative emotion which guards the body against dangerous foods and microbial infections.	Emotion process
Dubious* MFOEM:000170	An emotion that is experienced when one is uncertain whether something is true.	Emotion process
Embarrassment* MFOEM:000054	An emotion in which one feels awkward or flustered in other people's company or because of the attention of others.	Emotion process
Enthusiasm MFOEM:000200	A positive emotion reflecting energy and passion for something.	Emotion process
Expectant* MFOEM:000175	An emotion that is experienced in anticipation of a pleasant or exciting event.	Emotion process
Grief MFOEM:000016	An intense negative emotion following a bereavement, i.e. the loss of a significant person through that person's death.	Emotion process
Guilt MFOEM:000053	A self-conscious emotion that occurs when a person brings about a negative outcome by acts of commission or omission.	Emotion process
Hope* MFOEM:000177	A positive emotion in which one anticipates desired outcomes.	Emotion process
Inspiration* MFOEM:000178	An emotion that stimulates one to produce new and creative ideas or approaches to a problem.	Emotion process
Interest MFOEM:000033	A positive emotion which motivates learning, exploration and curiosity.	Emotion process
Irritation MFOEM:000011	An unpleasant emotion closely related to anger but lower in intensity and without the moral dimension of blame and seriousness that is implicated in anger.	Emotion process
Jealousy MFOEM:000025	A negative emotion aroused when a person feels threatened by a rival in his or her relationship with another individual, in particular an intimate partner. Involves feelings of threat, fear, suspicion, distrust, anxiety, anger, betrayal, and rejection.	Emotion process

Class label (URI)	Class definition	Parent class
Pride MFOEM:000041	A positive emotion associated with the appraisal of one's positive social worth, a signal that one is likely to be socially accepted.	Emotion process
Shame* MFOEM:000055	A negative emotion that is distressing and occurs when one appraises one's behaviour or circumstance as wrong, dishonourable, immodest or indecorous.	Emotion process
Surprise MFOEM:000032	A neutral emotion caused by encountering unexpected events of all kinds.	Emotion process
Worry* MFOEM:000171	A negative emotion in which one is distressed as a result of thinking about actual or potential problems or unpleasant things.	Emotion process
Appraisal process MFOEM:000002	An appraisal process is a mental process that gives rise to an appraisal.	Mental process
Process profile BFO:0000144	b is a process_profile =Def. there is some process c such that b process_profile_of c.	Process
Consciousness MF:0000017	That part of the mental process that confers a subjective perspective, a phenomenology, an experience of the mental process of which it is a part; and intends the object or event that the mental process is about, should such exist; it confers intentionality on the mental process.	Process profile

Notes. *As some classes were not defined in the source ontologies, the researcher and expert (AW) defined these classes.

Appendix 4-12. The labels and definitions of the hierarchically organised MoA Ontology

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
Specifically dependent continuant BFO:0000020								b is a specifically dependent continuant = Def. b is a continuant & there is some independent continuant c which is not a spatial region and which is such that b s-depends_on c at every time t during the course of b's existence.
	Disposition BFO:0000016							b is a disposition means: b is a realizable entity & b's bearer is some material entity & b is such that if it ceases to exist, then its bearer is physically changed, & b's realization occurs when and because this bearer is in some special physical circumstances, & this realization occurs in virtue of the bearer's physical make-up.
		Bodily disposition MF:0000032						A disposition that inheres in some extended organism.
			Capability					A bodily disposition that is realised by the bearer engaging in a particular behaviour when appropriate circumstances occur.
				Close other reinforcement capability				A bodily disposition that is realised by the bearer being able to reward a friend or partner for performing an intended behaviour.
				Coping capability				A bodily disposition which is realised in processes which enable the bearer to overcome barriers to performing a behaviour.
				Information acquisition capability				A bodily disposition that is realised by the bearer being able to engage in processes to obtain information relevant to a behaviour.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
				Physical capability				A bodily disposition that is realised by the organism using physical skills, strength or stamina to perform the behaviour.
				Self-reinforcement capability				A bodily disposition that is realised by the bearer being able to reward themselves for performing an intended behaviour.
				Skill				Capability acquired through training and practice.
				Social capability				A bodily disposition that is realised by the bearer engaging in interpersonal processes that influence ability to perform a behaviour, when appropriate circumstances occur.
			Mental disposition MF:0000033					A bodily disposition that is realized in a mental process.
				Addiction				A chronic acquired mental disorder involving repeated abnormally powerful motivation to engage in a behaviour despite risk or experience of harm.
				Alienation				A mental disposition to view and experience oneself as isolated from and not meaningfully involved in social groups.
				Awareness				A mental disposition to be conscious of events, objects or sensory patterns.
					Awareness of persuasive message			A mental disposition to be conscious of a verbal, written or recorded communication that aims to influence the recipient to think or act in a particular manner.
					Awareness of others' possible needs			A mental disposition to be conscious of the possible or actual deprivation of a necessary or wanted resources of another individual, group, or entity.
				Belief MF:0000041				A disposition to mental processes that represent some proposition X to be true.
					Belief about barriers			A belief about the existence of factors that could restrict or impede the person from engaging in a behaviour.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
						Belief about cost barriers		A belief about the existence of monetary or other cost factors that could restrict or impede the person from engaging in a behaviour.
					Belief about consequences of behaviour			A belief about the outcomes resulting from a behaviour.
						Belief about behaviour meeting needs		A belief about the behaviour resulting in one's needs being met.
						Belief about consequences of behaviour for self-concept		A belief about the impact of performing the behaviour on one's cognitive representation of one's own qualities and characteristics.
						Belief about social consequences of behaviour		A belief about the outcomes of a behaviour in terms of one's social status or social approval.
					Belief about consequences of goal attainment			A belief about the outcomes resulting from achieving a goal.
						Belief about the emotional consequences of goal attainment		A belief about the feelings and emotions that are associated with achieving a goal.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
					Belief about control over one's future			A belief about the extent to which one can direct what happens in one's future.
					Belief about discrepancy between perceived and actual norms			A belief about existence of a discrepancy between what one thought was typical for people who belong to a particular social group and what is actually typical for people who belong to that social group.
					Belief about gain			A belief about the existence of an increase from an initial reference point.
					Belief about having an interpersonal relationship			A belief about the existence and intensity of a social relationship between a person and another person, social group or character.
					Belief about intrinsic enjoyment of behaviour			A belief about extent to which engaging in a behaviour is seen as enjoyable in its own right, regardless of the consequences of the behaviour.
					Belief about likelihood of academic recognition			A belief about the probability of being acknowledged for one's educational achievements.
					Belief about likelihood of consequences of behaviour			A belief about the likelihood a particular behaviour will result in particular outcomes.
						Belief about likelihood of health consequences of behaviour		A belief about the likelihood of a behaviour resulting in a change in a threat to health and wellbeing.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
					Belief about likelihood of experiencing affection			A belief about the probability of experiencing feelings of tenderness and attachment.
					Belief about likelihood of goal achievement with available means			A belief about the probability of attaining a desired standard given the available resources or methods to facilitate doing so.
					Belief about likelihood of personal autonomy			A belief about the probability of being able to exercise autonomy or act unconventionally.
					Belief about likelihood of potential outcomes			A belief regarding the probability that a given event or state will occur in the future.
					Belief about loss			A belief about the existence of a decrease from an initial reference point.
					Belief about message relevance			A belief regarding whether the content of a verbal, written or recorded communication is relevant to oneself.
					Belief about moral imperative for behaviour			A belief about whether a behaviour is necessary because it is morally the right thing to do.
					Belief about one's environment			A belief about the nature of the immediate physical and social settings in which people live, including culture and the people and institutions with whom they interact.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
						Belief about autonomy support in one's environment		A belief about whether the immediate physical and social settings in which people live, including culture and the people and institutions with whom they interact, support self-determination in a person.
						Belief about availability of resources to support behaviour in one's environment		A belief about whether there are resources available in a person's immediate physical and social settings that will facilitate performance of a behaviour.
						Belief about pleasurability of a behaviour in one's environment		A belief about whether the immediate physical and social settings in which people live, including culture and the people and institutions with whom they interact, will result in the behaviour being pleasurable.
					Belief about own health			A belief regarding the state of one's health.
					Belief about responsibility to act			A belief about whether one is personally obliged to take a certain course of action.
					Belief about severity			A belief about how serious the harm associated with an outcome could be.
					Belief about similarity to referent others			A belief about the extent to which one is similar to members of a social group whose behaviour or opinions one wishes to emulate.
					Belief about social influence processes			A belief about whether or how one or more person exerts an influence on the person's behaviour

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
						Belief about social influence processes involving parents and friends		A belief about whether or how parents and friends will attempt to use social influence processes to affect the person's behaviour.
					Belief about social support			A belief about whether others will provide assistance or comfort to help the person cope with a variety of stressors.
					Belief about susceptibility			A belief about how vulnerable one is to a threat.
					Belief about task difficulty			A belief about how much work or skill a task involves.
					Belief about technology use			A disposition to mental processes that represent some proposition X regarding technology and technology use to be true.
					Belief about the availability of behavioural options			A belief about having the option of performing different behaviours.
						Belief about the availability of self-enhancing deviant behavioural options		A belief about having the option of performing different behaviours that would enhance one's self-evaluation but not be considered appropriate or typical for a social group.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
						Belief about the availability of self-enhancing normative behavioural options		A belief about having the option of performing different behaviours that would enhance one's self-evaluation and be considered appropriate or typical for a social group.
					Belief about the desirability of consequences of behaviour			A belief about the desirability or worth of the outcomes of a behaviour.
						Belief about the desirability of the consequences of a new behaviour vs prior behaviour		A belief about the potential benefits of adopting a new behaviour relative to the benefits of the previous behaviour.
						Belief about the relative desirability of the consequences of behaviour		A belief about the desirability of consequences of one behaviour relative to the desirability of consequences of a different behaviour.
					Belief about the timing of the			A belief regarding how long after the performance of behaviour particular consequences will occur.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
					consequences of behaviour			
					Belief about threat			A belief about the nature of a potential harm.
						Belief about environmental threat		A belief about the nature of a potential harm to the circumstances, objects, or conditions by which one is surrounded.
					Belief about value of affection			A belief about the value of experiencing feelings of tenderness and attachment.
					Belief about value of personal autonomy			A belief about the value of personal self-determination.
					Belief about voluntariness of behaviour			A belief regarding the extent that one is free to choose whether to perform the behaviour.
					False consensus			A mental disposition to assume other members of the group share one's behaviours and thoughts more than is actually the case.
					False uniqueness			A mental disposition to assume that one's thoughts or behaviours are more unique than those of one's peers.
					Norm			Belief regarding what is typical for people who belong to a particular social group.
						Descriptive norm		A belief regarding the prevalence of performance of a given behaviour by people within a group.
						Injunctive norm		A belief regarding whether a behaviour is appropriate and correct for people who belong to a particular social group.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
							Cleanline ss injunctive norm	A belief regarding whether a certain level of hygiene is appropriate and correct for people who belong to a particular social group.
							Legal injunctive norm	A belief regarding whether following legal codes is appropriate and correct for people who belong to a particular social group.
						Normative belief		A belief about whether important others think one should perform a behaviour.
						Socially shared norm		A belief regarding standards for behaviour that one sees as mutually agreed by and shared by members of one's social group.
					Self-efficacy			A belief about one's capabilities to engage in a behaviour.
						Recovery self-efficacy		A belief about one's capabilities to resume a behaviour change attempt after a setback.
						Situational self-efficacy		A belief about one's capabilities to engage in a behaviour in a particular situation.
				Intelligence MF:0000025				A mental disposition realised in processes involving understanding complex ideas, adapting effectively to the environment, learning from experience, engaging in various forms of reasoning, and overcome obstacles through the outcome of thinking processes.
				Memory GO:0007613				The activities involved in the mental information processing system that receives (registers), modifies, stores, and retrieves informational stimuli.
					Associative memory			The activities involved in the mental information processing system that receives (registers), modifies, stores, and retrieves informational stimuli regarding the set of entities associated with a particular object or event.
					Episodic memory			The activities involved in the mental information processing system that receives (registers), modifies, stores, and retrieves informational stimuli regarding a personally experienced event at a particular time or place.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
					Memory for message content			The activities involved in the mental information processing system that receives (registers), modifies, stores, and retrieves informational stimuli that were contained in a message.
				Motivation to comply				A mental disposition to consider the likely approval of referent others for a course of action during decision making.
				Motivational orientation				A mental disposition for motivation to be guided by a focus on the presence or absence of outcomes of a certain valence.
					Prevention focused motivational orientation			A mental disposition for motivation to be guided by a focus on the presence or absence of positive outcomes.
					Promotion focused motivational orientation			A mental disposition for motivation to be guided by a focus on the presence or absence of negative outcomes.
				Personal value				A mental disposition regarding what is fundamentally important in life and which informs standards for behaviour.
					Altruistic personal value			A personal value that stems from an apparently unselfish concern for others.
					Egoistic personal value			A personal value that stems from self-interest or self-enhancement motives.
					Health-related personal value			A personal value that concerns one's health.
					Religion-related personal value			A personal value that stems from having a set of beliefs concerning the cause, nature, and purpose of the universe, especially when considered as the creation of a superhuman agency or agencies.
					Tradition-related personal value			A personal value that stems from a set of social customs or other ethnic or family practices handed down from generation to generation.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
				Psychological capability				A mental disposition that is realised in mental processes that influence ability to perform a behaviour.
					Capability to acknowledge behavioural risk status			Psychological capability to recognise and accept that one's behaviour places one at a certain likelihood of future harm.
					Emotion regulation capability			A psychological capability to modulate one's emotions in order to facilitate goal attainment.
					Self-reflective capability			A psychological capability to analyse one's own experiences and thoughts.
					Self-regulatory capability			A psychological capability that involves processes that modulate the frequency, rate or extent of behaviour, the specific actions or reactions of a person in response to external or internal stimuli and that are instigated by the person themselves.
						Future-focused self-regulatory capability		A self-regulatory capability to module behaviour based on thoughts about the future.
						Goal generating capability		A self-regulatory capability to envisage alternative goals and create new strategies for action.
						Self-control capability		A self-regulatory capability to inhibit activated action scripts or action tendencies.
					Self-worth regulation capability			A psychological capability to cope with experiences that reduce one's sense of self-worth.
					Symbol use capability			A psychological capability to use marks or characters to represent objects, functions or processes.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
					Vicarious learning capability			A psychological capability to acquire knowledge or skill from observation.
				Social embeddedness				A mental disposition to view and experience oneself as attached to and involved in a social group.
					Social embeddedness in conventional society			A mental disposition to view and experience oneself as attached to and involved in a large social group whose members follow prevailing norms for thoughts and behaviour.
				Temporal orientation				A mental disposition to focus more on present or future outcomes.
					Temporal orientation to the future			A mental disposition to focus more on future than present outcomes.
					Temporal orientation to the present			A mental disposition to focus more on present than future outcomes.
				Tolerance of transgressions				A mental disposition to tolerate one or more others acting in a manner that goes against a moral code of conduct.
		Emotional action tendency MFOEM:000007						An emotional action tendency is a disposition to behaviour that inheres in an organism by virtue of the physical changes brought about by an emotion process.
		Interdependent action script						Disposition to an interpersonal process in which a sequence of behaviour in one individual elicits a sequence of behaviour in at least one other individual with whom the first is in a close relationship.
	Represent ation							A dependent continuant which is about a portion of reality.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
	MF:0000031							
		Cognitive representation MF:0000031						A representation which specifically depends on an anatomical structure in the cognitive system of an organism.
			Action script					A cognitive representation that guides a sequence of behaviours.
			Appraisal MFOEM:000005					An appraisal is a cognitive representation which represents an evaluation of the relevance of some triggering object or event to the organism.
				Appraisal as being disliked MFOEM:000191				An appraisal that represents a judgement that one is being disliked.
				Appraisal as being liked MFOEM:000192				An appraisal that represents a judgement that one is being liked.
				Appraisal of avoidability of consequences MFOEM:000091				An appraisal which represents a judgement about how avoidable the expected consequences of an event will be.
				Appraisal of causal agency MFOEM:000075				An appraisal that represents an evaluation of who or what caused an event.
					Appraisal as caused by self MFOEM:000076			An appraisal that represents an evaluation that an event was caused by the self.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
					Appraisal as caused by factors external to the person			An appraisal that represents an evaluation that an event was caused by factors external to the person.
				Appraisal of causal intent MFOEM:000082				An appraisal that represents an evaluation of the causal intent of the person who is evaluated to have caused an event.
				Appraisal of congruence with ideals MFOEM:000094				An appraisal which represents a judgement about whether an event is consistent with the person's standards or ideals.
				Appraisal of coping capability				An appraisal that represents an evaluation of the factors that influence one's ability to cope with a threat.
				Appraisal of dangerousness MFOEM:000103				An appraisal which represents an evaluation of the dangerousness of an object or situation.
				Appraisal of desirability of consequences MFOEM:000085				An appraisal that represents an evaluation of the desirability of the expected consequences of an event.
				Appraisal of expectedness MFOEM:000060				An appraisal that represents an evaluation of whether an event was expected to occur.
				Appraisal of familiarity MFOEM:000058				An appraisal that represents an evaluation of how familiar an object or event is.
				Appraisal of goal importance MFOEM:000072				An appraisal that represents an evaluation of whether an event or object is important to the person's goals or needs.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
				Appraisal of impact on social environment				An appraisal that represents an evaluation of the impact of one's behaviour on one's social relationships.
				Appraisal of justice of treatment MFOEM:000100				Appraisal which represents an evaluation of whether the person was treated justly or unjustly by another person.
				Appraisal of loss MFOEM:000106				An appraisal that represents a belief that something or someone that is important to the person has been lost to the person.
				Appraisal of obligation to act				An appraisal that represents an evaluation of how much one is personally obliged to respond to an event or person in need.
				Appraisal of pleasantness MFOEM:000061				An appraisal that represents an evaluation of the pleasantness of an object or event.
				Appraisal of predictability MFOEM:000059				An appraisal that represents an evaluation of how predictable an event was.
				Appraisal of potential outcomes of a future choice				An appraisal that represents an evaluation of the possible states and events that might follow from a choice made in the future.
				Appraisal of social attention MFOEM:000097				An appraisal which represents a judgement about the direction and nature of the social attention surrounding an event.
				Appraisal of suddenness MFOEM:000057				An appraisal which represents an evaluation of how suddenly an event occurred.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
				Appraisal of urgency of response MFOEM:000088				An appraisal that represents an evaluation of the urgency of responding to an event.
			Attitude towards a behaviour					A cognitive representation which represents an overall evaluation of the impact of the possible outcomes of a behaviour to the organism.
			Behavioural intention					A cognitive representation of one's plan to engage or not engage in a particular behaviour.
			Certainty about a decision					A cognitive representation of how sure one feels that one's decision is correct.
			Decision					A cognitive representation of the choice of one proposition from a set of at least two alternative propositions.
				Decision based on behaviour characteristics				A decision based on the perceived feasibility of a behaviour and the desirability of its possible outcomes.
				Decision with respect to means				A decision about how to achieve a goal based on an appraisal of the relevant and available resources or means for goal achievement.
				Independent decision				A decision made independently of decisions made by other members of a social group.
			Desirability representation					A cognitive representation of a possible state of affairs together with the degree of wishing for that state of affairs to obtain.
			Desired standard					A cognitive representation of a desired state that serves as a reference level.
				Desired standard for behaviour				A cognitive representation of one's desired level of behaviour.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
					Desired standard for behaviour based on personal values			A cognitive representation of one's desired level of behaviour in order to act consistently with one's personal values.
				Desired standard for effort				A cognitive representation of one's desired level of effort towards a goal.
				Desired standard for self-image				A cognitive representation of how one wishes to perceive oneself.
			Goal					A cognitive representation of the end state to which one is striving.
				Emulation goal				A goal to imitate referent others.
				Extrinsic goal				A goal related to obtaining external signs of worth.
				Gain-related goal				A goal related to improving and protecting one's resources.
				Hedonic goal				A goal related to feeling better quickly.
				Intrinsic goal				A goal related to obtaining satisfaction of basic needs.
				Normative goal				A goal to act in line with what is considered acceptable.
				Personally set goal				A goal that one has decided upon for oneself.
				Proximal goal				A goal concerning an end state to be achieved in the short term.
			Goal achievability					A cognitive representation of how easy it will be to reach the end state to which one is striving.
			Identity					A cognitive representation relating to how one perceives oneself.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
				Social identity				A cognitive representation relating to how one perceives oneself as belonging to a social group.
			Importance of goal attainment					A cognitive representation of the significance of successfully meeting a goal.
				Importance of academic goal attainment				A cognitive representation of the significance of successfully meeting an educational goal.
				Importance of goal attainment relative to other goals				A cognitive representation of the significance of successfully meeting a goal compared to the significance of meeting other goals.
			Importance of behaviour for self esteem					A cognitive representation of the significance of performing a behaviour to one's sense of one's worth, usefulness or importance.
			Job satisfaction					A cognitive representation of the extent to which one's job fulfils one's expectations and needs.
			Knowledge					A cognitive representation of the nature of the world, or a specific aspect of the world, that corresponds to the actual state of the world and is acquired through experience or learning.
				Knowledge regarding a behaviour				Knowledge regarding a particular set of actions.
					Knowledge regarding behaviour linked to health			Knowledge regarding how a particular set of actions may affect physical or mental wellbeing.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
				Knowledge regarding an innovation				Knowledge regarding a novel invention or way of doing something.
				Knowledge regarding a threat				Knowledge regarding a potential harm.
					Knowledge regarding a health threat			Knowledge regarding a potential harm to physical or mental wellbeing.
					Knowledge regarding an environmental threat			Knowledge regarding methods to prevent a potential harm to the circumstances, objects, or conditions by which one is surrounded.
						Knowledge regarding environmental threat prevention		Knowledge regarding a potential harm to the circumstances, objects, or conditions by which one is surrounded.
					Knowledge regarding threat prevention			Knowledge regarding methods to avert a potential harm.
					Knowledge regarding threat transmission			Knowledge regarding how a potential harm may spread.
				Knowledge regarding treatment				Knowledge regarding a therapy or medication for a health problem.
			Learned stimulus-response association					A cognitive representation of the relationship between an event in a person's environment and a bodily or behaviour reaction, acquired through an associative learning process.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
			Mental image					A cognitive representation that resembles the experience of perceiving some object or event but occurs when the relevant object or event is not actually present to the senses.
			Need					A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining a particular state.
				Aesthetic need				A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining the experience of aesthetically pleasing things.
				Autonomy need				A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining a sense of personal agency and initiative.
					Behavioural autonomy need			A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining a sense of personal agency and initiative when changing one's behaviour.
				Coping strategy need				A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining effective coping strategies.
				Enjoyable context need				A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining opportunities for behaviour to take place in an enjoyable context.
				Need for comfortable daily life				A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining an easy and comfortable everyday life.
				Need for consistency between beliefs and behaviour				A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining consistency between one's opinions or attitudes and behaviours.
				Need for education				A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining a good education and developing general knowledge.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
				Need for enjoyable everyday life				A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining pleasurable and exciting experiences in everyday life.
				Need for good work situation				A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining a satisfying and enjoyable job.
				Need for health				A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining good health.
				Need for healthcare				A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining access to appropriate healthcare.
				Need for healthy natural environment				A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining an environment with clean water, air and soil and healthy animals and plants.
				Need for leisure time				A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining time when one is not working or occupied.
				Need for location access				A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining access to suitable locations to perform the behaviour.
				Need for safety from accidents				A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining protection from accidents.
				Need for safety from crime				A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining freedom from the threat of crime.
				Need for self-esteem				A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining a positive evaluation of oneself and one's qualities and characteristics.
				Need for sense of security				A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining a feeling of being safe from threats.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
				Need for social relatedness				A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining caring relationships with other people.
				Need for social recognition				A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining appreciation from others due to one's skills, achievements or possessions.
				Need to feel competent				A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining the experience of oneself as able and effective.
					Need to feel behaviourally competent			A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining the experience of oneself as capable of performing a behaviour well.
			Perceived conformity to behavioural norms					A cognitive representation of whether one's own behaviour is similar to that of referent others.
			Perceived self-determination of behaviour					A cognitive representation of the degree to which one's behaviour is controlled by one's internal convictions rather than external demands.
			Plan					A cognitive representation of a series of steps to be taken to achieve a goal.
			Risk prototype					A cognitive representation of the typical characteristics and qualities of a person who engages in a behaviour that poses a risk to their wellbeing.
			Self-concept					A cognitive representation of one's own qualities and characteristics.
			Self-esteem					A cognitive representation of how one evaluates the qualities and characteristics in one's self concept.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
				Social identity-related self-esteem				A cognitive representation of how one evaluates one's self concept based on perceived membership of a social group.
			Stereotype					A cognitive representation of the generalised qualities and characteristics of the members of a particular social group or social category.
			Quality of life					A cognitive representation which represents an overall evaluation of how much one obtains satisfaction from one's life.
		Aggregate of cognitive representations						An aggregate of cognitive representations about a concept or entity.
			Cognitive schema					An aggregate of cognitive representations about a concept or entity that serves to guide to perceiving or responding to a complex situation or set of stimuli.
				Worldview schema				An aggregate of cognitive representations that enable one to perceive and respond to the universe as having order, predictability, meaning and permanence.
	Quality PATO:0000001							A dependent entity that inheres in a bearer by virtue of how the bearer is related to other entities.
		System usability						A quality of a technological system regarding the amount of effort required to successfully use the system.
		System result tangibility						A quality of a technological system regarding the extent to which the results of its usage are concrete or discernible.
		Opportunity						A quality of a person's social and physical environment that makes behaviour possible or facilitates it.
			Financial opportunity					A quality of a person's social and physical environment regarding whether the person has sufficient financial resources to engage in a behaviour.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
			Healthcare service accessibility					A quality of a healthcare service regarding how easy it is for a person to approach and use it.
			Physical opportunity					A quality of the physical environment that makes a behaviour possible or facilitates it.
			Social opportunity					A quality of the social environment that influences performance of a behaviour.
				Social involvement opportunity				The extent to which the social environment provides opportunities for a person to actively engage in social groups.
				Social opportunity for equality				The extent to which the social environment provides equal opportunities to act and own property to all people.
			Temporal opportunity					A quality of a person's social and physical environment regarding whether the person has sufficient time to engage in a behaviour.
Process BFO:0000015								An occurrent that has temporal proper parts and for some time t, p s-depends_on some material entity at t.
	Behavioural cue							A stimulus that serves to elicit or guide behaviour.
		Internal behavioural cue						A stimulus that arises from mental processes and serves to elicit or guide behaviour.
	Bodily process OGMS:0000060							A process in which at least one bodily component of an organism participates.
		Behaviour GO:0007610						The specific actions or reactions of an organism in response to external or internal stimuli.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
			Emotional behavioural process MFOEM:000004					An emotional behavioural process is the behaviour of the organism in response to the appraisal, which includes the characteristic facial expressions for particular emotion types.
			Habitual behaviour					A behaviour that is well-learned and can be in automatic sequence with other behaviours, and has become reflexive over time.
		Depletion of self-regulatory capability						A process by which a person's self-regulatory capability is diminished by their having already recently used it.
		Feedback from past personal experience						A process by which personal experiences provide information for and influence subsequent behaviour
		Goal pursuit process						A bodily process in which attempts are made to achieve a desired end state.
			Prevention-focused goal pursuit process					A goal pursuit process focused on maintaining a current satisfactory state and avoiding a worse state.
			Promotion-focused goal pursuit process					A goal pursuit process focused on supporting progress from a current state to a better state.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
			Utility maximising goal pursuit process					A goal pursuit process focused on maximising one's satisfaction with the outcomes of one's choices.
		Interpersonal process MF:0000021						A process in which at least two human beings are agents.
			Communication MF:0000040					An interpersonal process that involves as participant at least two linguistically capable organisms, one of whom produces an utterance that is well-formed in a given language and the other of whom perceives and understands that utterance by virtue of their recognition of the meaning of the utterance through their knowledge of the language.
			Interpersonal approval for behaviour					An interpersonal process in which one or more person indicates a certain approval of another person performing a particular behaviour.
				Interpersonal approval for behaviour by friends				An interpersonal process in which one or more person indicates approval of their friend performing a particular behaviour.
				Interpersonal approval for behaviour by community				An interpersonal process in which a set of people with whom one lives or works indicate approval of one performing a behaviour.
				Interpersonal approval for behaviour by parent				An interpersonal process in which one or more parent indicates approval of their child performing a particular behaviour.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
				Interpersonal approval subsequent to behaviour				An interpersonal process in which one or more person indicates approval subsequent to another person performing a particular behaviour.
			Social influence process					An interpersonal process where one or more person exerts an influence on the behaviour of another.
				Family social influence process				An interpersonal process where one or more family member exerts an influence on the behaviour of another.
				Friend social influence process				An interpersonal process where one or more friend exerts an influence on the behaviour of another.
				Peer social influence process				An interpersonal process where one or more person of the same status or rank exerts an influence on the behaviour of another.
			Social interaction process					An interpersonal process involving reciprocal communication between two or more people.
				Behaviour-influencing social interaction process				An interpersonal process in which one person's reciprocal communication with one or more others may facilitate or hinder the person's behaviour.
				Bonding social interaction process				An interpersonal process involving reciprocal communication between two or more people leading to the establishment of an affective relationship between those individuals.
				Conflict social interaction process				A social interaction process in which participants actions convey openness, trust and empathy, and offer support with regard to other participants' problems.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
				Helping relationship social interaction process				A social interaction process in which participants interactions have involved disagreeing or disapproving with at least one other participant.
				Mutually accommodating social interaction process				A social interaction process in which participants interactions have involved attempting to take account of other participants' preferences, schedules and needs in order to engage in group action.
		Internal reward for a response						A process by which the person experiences an internally-generated positive physical or psychological state subsequent to a response.
		Perceived regulatory fit process						A process by which the manner in which one attempts to achieve a goal creates an experiential sense of rightness associated with pursuing the goal, which in turn increases task engagement.
		Physiological response to emotion process MFOEM:00 0003						A physiological response to emotion process is a bodily process which encompasses all the neurophysiological changes caused by the appraisal, which take place in the central nervous system (CNS), neuro-endocrine system (NES) and autonomous nervous system (ANS).
		Plan enactment						A process by which a person attempts to follow the steps in a plan.
		Searching for information about how to change behaviour						A process in which people seek information and others' opinions about how to alter their behaviour.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
		Searching for solutions to health risks						A process in which people seek methods to reduce the problems associated with behaviours that put health at risk.
		Self-regulation of behaviour						A bodily process that modulates the frequency, rate or extent of behaviour, the specific actions or reactions of an organism in response to external or internal stimuli and that is instigated by the organism itself.
			Behavioural self-regulation of behaviour					A behaviour undertaken to modulate the frequency, rate or extent of a different behaviour, the specific actions or reactions of an organism in response to external or internal stimuli, and that is instigated by the organism itself.
				Avoidant behavioural self-regulation				A behaviour to increase the distance between oneself and an aspect of one's environment or to completely remove an aspect of the environment, in order to modulate the frequency, rate or extent of a different behaviour.
				Environment restructuring self-regulation				A behaviour that alters the rules or structure of one's environment in order to modulate the frequency, rate or extent of a different behaviour.
			Introjected self-regulation					Self-regulation undertaken to manage a sense of guilt, anxiety or obligation.
			Self-reinforcing self-regulation					A bodily process that modulates the frequency, rate or extent of behaviour through self-administering a reward for performing an intended behaviour.
			Value-congruent self-regulation					Self-regulation undertaken to achieve congruence between one's values and the behaviour performed.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
		Mental process MF:0000020						A mental process is a bodily process that is of a type such that it can of itself be conscious.
			Affective process MFOEM:000195					Any process that has positive or negative valence.
				Bodily feeling MFOEM:000202				*No definition developed*
					Pain MFOEM:000203			A bodily process in an organism S, involving two integrated levels: (a) activation of the nociceptive system and associated emotion generating brain components of S, and (b) a simultaneous aversive sensory and emotional experience on the part of S, where (b) is phenomenologically similar to the sort of aversive experience involved in pain with concordant tissue damage.
				Emotion process MFOEM:000001				A complex mental process that is a synchronized aggregate of constituent mental processes including an appraisal process as part, and which gives rise to an action tendency.
					Amusement* MFOEM:000169			A positive emotion that is experienced when a person finds something funny and entertaining.
					Anger MFOEM:000009			A negative emotion, characterised by feelings of unpleasantness and high arousal, in the form of antagonistic feelings and action tendencies.
					Anxiety MFOEM:000028			A negative, aversive emotion provoked by the prospect of future threat.
						Computer anxiety		A negative, aversive emotion provoked by the prospect of using computer technology.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
					Boredom* MFOEM:0001 66			An emotion in which one feels weary and impatient because one is unoccupied or lacks interest in one's current activity.
					Compassion MFOEM:00005 2			An emotion evoked for a person who is in distress.
					Concern* MFOEM:00016 8			An emotion in which one feels nervous interest in something.
					Confusion* MFOEM:00017 3			An emotion in which one feels disoriented about something and is unable to engage in orderly thought or to distinguish, choose or behave decisively.
					Contempt MFOEM:00001 8			A negative emotion generally elicited by the negative evaluation of others and their actions.
					Curiosity* MFOEM:00016 7			An emotion that is experienced when one has a desire to learn or know something.
					Despair MFOEM:00003 0			A negative, high intensity emotion characterised by loss of hope and loss of interest.
					Disappointmen t MFOEM:00005 1			A negative emotion which is triggered by the disconfirmation of the prospect of a desirable event.
					Disgust MFOEM:00001 9			A negative emotion which guards the body against dangerous foods and microbial infections.
					Dubious* MFOEM:00017 0			An emotion that is experienced when one is uncertain whether something is true.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
					Embarrassment* MFOEM:000054			An emotion in which one feels awkward or flustered in other people's company or because of the attention of others.
					Enthusiasm MFOEM:000200			A positive emotion reflecting energy and passion for something.
					Expectant* MFOEM:000175			An emotion that is experienced in anticipation of a pleasant or exciting event.
					Fear MFOEM:000026			An activated, aversive emotion that motivates attempts to cope with events that provide threats to the survival or well-being of organisms.
						Terror* MFOEM:000027		Fear that is intense.
					Grief MFOEM:000016			An intense negative emotion following a bereavement, i.e. the loss of a significant person through that person's death.
					Guilt MFOEM:000053			A self-conscious emotion that occurs when a person brings about a negative outcome by acts of commission or omission.
					Happiness MFOEM:000042			A positive emotion which is experienced in reaction to a positive experience or event.
						Contentment MFOEM:000047		A pleasant emotion, which can be defined as a milder form of joy.
					Hope* MFOEM:000177			A positive emotion in which one anticipates desired outcomes.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
					Inspiration* MFOEM:000178			An emotion that stimulates one to produce new and creative ideas or approaches to a problem.
					Interest MFOEM:000033			A positive emotion which motivates learning, exploration and curiosity.
					Irritation MFOEM:000011			An unpleasant emotion closely related to anger but lower in intensity and without the moral dimension of blame and seriousness that is implicated in anger.
					Jealousy MFOEM:000025			A negative emotion aroused when a person feels threatened by a rival in his or her relationship with another individual, in particular an intimate partner. Involves feelings of threat, fear, suspicion, distrust, anxiety, anger, betrayal, and rejection.
					Negative emotion MFOEM:000212			A negative emotion is an emotion that has a negative valence.
					Pleasure MFOEM:000035			A positively experienced emotion which is sought out (approached) and is associated with happiness, enjoyment, and satisfaction.
						Sexual pleasure MFOEM:000040		A positively experienced emotion which is sought out (approached) and is associated with happiness, enjoyment, and satisfaction as a result of sexual activities.
					Positive emotion MFOEM:000211			A positive emotion is an emotion that has a positive valence.
					Pride MFOEM:000041			A positive emotion associated with the appraisal of one's positive social worth, a signal that one is likely to be socially accepted.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
					Sadness MFOEM:000056			A negative emotion felt when an event is appraised as unpleasant, obstructive to one's goals and concerns, and one feels unable to cope with it or modify it.
					Shame* MFOEM:000055			A negative emotion that is distressing and occurs when one appraises one's behaviour or circumstance as wrong, dishonourable, immodest or indecorous.
					Stress MFOEM:000029			A negative emotion in response to a stressful elicitor.
					Surprise MFOEM:000032			A neutral emotion caused by encountering unexpected events of all kinds.
					Worry* MFOEM:000171			A negative emotion in which one is distressed as a result of thinking about actual or potential problems or unpleasant things.
				Subjective emotional feeling MFOEM:000006				The subjective emotional feeling is that (fiat) part of the emotion process by which the organism experiences its own emotion.
					Cognitive dissonance			An unpleasant subjective emotional feeling experienced due to perceived inconsistency between two concurrently held cognitive representations.
					Feeling an urge			A subjective emotional feeling of desire to engage in a behaviour that arises when an action script is activated but not immediately acted upon.
			Appraisal process MFOEM:000002					An appraisal process is a mental process that gives rise to an appraisal.
			Arousal MF:0000012					A physiological and psychological state of being awake or reactive to stimuli.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
			Attending MF:0000018					A mental process whereby relevant aspects of our mental experience are focused on specific targets.
				Attending disrupted by behavioural alternatives				A mental process whereby relevant aspects of our mental experience become focused on a behaviour other than the currently planned or engaged in course of action.
				Attending to a goal				A mental process whereby relevant aspects of our mental experience are focused on a desired end state.
					Attending to a self-oriented goal			A mental process whereby relevant aspects of our mental experience are focused on a desired end state for oneself.
				Attending to a norm				A mental process whereby relevant aspects of our mental experience are focused on what others do and think about a behaviour.
				Attending to a message				A mental process whereby relevant aspects of our mental experience become focused on a verbal, written or recorded communication.
				Vigilance MF:0000060				The ability to maintain attention and alertness over prolonged periods of time.
			Cognitive process MF:0000008					A mental process that creates, modifies or has as participant some cognitive representation.
				Behavioural intention formation				A cognitive process that brings into being a behavioural intention.
				Comprehension				A cognitive process that creates a representation of the meaning and significance of a communication, object, event or situation.
				Evaluating multiple options				A cognitive process that gives rise to an evaluation and comparison of the nature and significance of two or more options.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
					Evaluating multiple goal means			A cognitive process that gives rise to an evaluation and comparison of two or more resources or methods to facilitate goal achievement
					Evaluating multiple goal options			A cognitive process that gives rise to an evaluation and comparison of the appeal and feasibility or two or more goals.
				Self-esteem maintenance process				A cognitive process that serves to maintain one's sense of worth, usefulness or importance.
			Commitment making					A mental process by which one decides to pursue a goal and develops a sense of being obligated or emotionally impelled to act upon that goal.
			Decision simplification					A mental process that simplifies decision making.
				Decision simplification by combining probabilities of identical outcomes				A mental process that simplifies decision making by combining the probabilities of alternative options with identical outcomes.
				Decision simplification by disregarding shared components				A mental process that simplifies decision making by identifying and disregarding shared components of alternative options.
				Decision simplification by identifying clearly better or worse options				A mental process that simplifies decision making by editing information to identify any clearly superior or inferior options.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
				Decision simplification by separating risky and riskless components				A mental process that simplifies decision making by separating elements of alternative options that involve risk from those that do not involve risk.
				Decision simplification through rounding				A mental process that simplifies decision making by rounding probabilities or outcomes associated with alternative options, or by disregarding options with extremely unlikely outcomes.
			Dissonance reduction process					A mental process through which a perceived inconsistency between two concurrently held cognitive representations is reduced.
				Feedback rejecting dissonance reduction process				A dissonance reduction process through which an inconsistency between the cognitive representation of one's current state based on feedback received and a cognitive representation of the end state to which one is striving is reduced by dismissing the feedback.
				Goal changing dissonance reduction process				A dissonance reduction process through which an inconsistency between the cognitive representation of one's current state and a cognitive representation of the end state to which one is striving is reduced by changing the cognitive representation of the end state to which one is striving.
			Empathising process					A mental process that brings into being, sustains or modifies a cognitive representation of how another person may experience the world.
			Evaluation of goal achievement					A mental process which evaluates the appropriateness of current goal attainment strategies given one's progress towards goal achievement
			Goal activation process					A mental process that brings a goal into attention.

Page 679

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
			Goal setting					A mental process that establishes a cognitive representation of the end state to which one is striving.
			Heuristic process					A mental process that uses simple rules and associations learnt from experience to make judgements.
				Certainty effect heuristic process				A heuristic process using a rule that overweighs outcomes considered to be certain compared to outcomes considered as probabilistic.
				Isolation effect heuristic process				A heuristic process using a rule that tends to ignore the shared characteristics of presented alternatives and focus on the differences between them in order to simplify choices.
				Somatic marker heuristic process				A heuristic process that uses previous emotional experiences of the relevant behaviours to make judgments.
			Imitating values of aspirational social group					A mental process by which one takes on the values of a social group to which one aspires to belong.
			Inference					A mental process that involves applying rules to a set of premises to reach a conclusion.
			Judging MF:0000006					A mental process during which a decision is made and the outcome of which is a belief or opinion. Judging is the evaluation of evidence to make a decision or form a belief.
				Judging as potential peer				Judging whether an individual or individuals should be considered as a person of the same status or rank.
					Judging as peer of similar status or ability			Judging whether an individual or individuals should be considered as a person of the same status or rank in terms of ability.
					Judging as peer influential to one's			Judging whether an individual or individuals should be considered as a person of the same status or rank who influences one's behaviour or self-evaluation.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
					behaviour or self-evaluation			
				Judging consequences of behaviour				A mental process during which a decision is made and the outcome of which is a belief about the consequences of a particular behaviour.
				Judging self-concept in relation to a behaviour				A mental process during which one evaluates how one's performance of a behaviour affects one's cognitive representation of one's own qualities and characteristics.
				Social comparison process				Evaluating oneself or one's social group in relation to the qualities or characteristics of another person or social group.
			Learning GO:0007612					Any process in an organism in which a relatively long-lasting adaptive behavioural change occurs as the result of experience.
				Associative learning				Learning concerning the association between two or more stimuli or between a stimulus and a response.
					Classical conditioning			Associative learning that occurs when the pairing of a conditioned and unconditioned stimulus leads to the conditioned stimulus producing a response that would otherwise have only been produced by the unconditioned stimulus.
						Extinction in classical conditioning		Process in which presenting the conditioned stimulus in the absence of the unconditioned stimulus makes the conditioned response less likely to occur.
					Discrimination learning			Associative learning process in which people learn to distinguish between appropriate responses to similar but different stimuli depending on whether a generalised response is rewarded or not.
					Generalisation (learning)			Process in which the effects of conditioning on behaviour spread to stimuli that differ in certain aspects from the stimulus present during the original conditioning.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
					Operant conditioning			Associative learning in which the likelihood of a particular behavioural response is influenced by the past consequences associated with performing that behaviour.
						Extinction in operant conditioning		Process in which when reinforcement for an operant behaviour has stopped, the behaviour becomes less likely to occur.
				Non-associative learning GO:0046958				A simple form of learning whereby the repeated presence of a stimulus leads to a change in the probability or strength of the response to that stimulus. There is no association of one type of stimulus with another, rather it is a generalized response to the environment.
					Habituation GO:0046959			A decrease in a behavioural response to a repeated stimulus.
					Sensitization GO:0046960			An increase in a behavioural response to a repeated stimulus.
				Observational learning GO:0098597				Learning that occurs through observing the behaviour of others.
					Imitative learning GO:0098596			Learning in which new behaviours are acquired through imitation.
						Imitative learning from valued others		Learning in which new behaviours are acquired through imitation of another person one admires or has a close bond with.
					Vicarious mastery observational learning			Learning that occurs through observing others successfully perform a behaviour.
				Mental categorisin g				A mental process in which objects, events, people, or experiences are grouped into cognitive representations of classes, on the basis of features shared by members of the

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
								same class and features distinguishing the members of one class from those of another.
				Mental categorising of the social environment				A mental process in which aspects of the immediate physical and social settings in which people live, including culture and the people and institutions with whom they interact, are grouped into cognitive representations of classes, on the basis of features shared by members of the same class and features distinguishing the members of one class from those of another.
			Mentally comparing against a standard					A mental process in which current conditions are compared against a particular reference level.
				Mentally comparing behaviour against a standard				A mental process in which current behaviour is compared against a particular reference level.
				Mentally comparing current effort and outcome against a standard				A mental process in which current outcome and efforts to attain that outcome are compared against a desired end.
			Motivation					A mental process that energises and directs behaviour.
				Automatic motivation				A mental process that energises and directs behaviour via emotions and impulses that arise from associative learning or innate dispositions.
				Extrinsic motivation				Motivation in order to attain some external goal or externally imposed constraint.
				Fear reduction motivation				Motivation in order to lessen feelings of fear.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
				Importance-based motivation				Motivation due to the behaviour being seen as personally important.
				Intrinsic motivation				Motivation due to the behaviour itself being interesting or enjoyable.
				Need-based motivation				Motivation to obtain or maintain a level of something required for survival or wellbeing.
				Self-esteem motivation				Motivation to maintain or increase positive self-evaluations and to reduce negative self-evaluations.
				Obligation-based motivation				A mental process that energises and directs behaviour to meet a perceived obligation.
				Threat reduction motivation				Motivation in order to avert a perceived threat.
			Perception MF:0000019					A mental process which is a) produced by a causal process (for example involving light rays or air vibrations) involving a part of the environment of the organism, and b) is experienced by the organism as being so caused, and c) in which the relevant part of the environment is thereby represented to the organism.
				Perception of discomfort				A mental process which is a) produced by a causal process (for example involving light rays or air vibrations) involving a part of the environment of the organism, and b) is experienced by the organism as being so caused and as unpleasant, and c) in which the relevant part of the environment is thereby represented to the organism.
				Perception of physiological effects of smoking				A mental process which is a) produced by the person smoking tobacco, and b) is experienced by the person as being so caused, and c) in which the effect of smoking tobacco on the body is thereby represented to the person.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
			Planning MF:0000027					A mental process that involves mentally manipulating representations of steps in an imagined process which has some objective.
				Problem solving planning				Planning involving forming at least two plans in order to guide action in different circumstances.
			Self-monitoring					A mental process in which one observes and evaluates one's own behaviour.
			Thinking MF:0000013					A mental process that involves the manipulation of mental language and/or mental images.
				Reflective thinking				Thinking that involves generation of inferences based on syllogistic reasoning or decision making based on the evaluation of anticipated consequences or the construction of propositional representations.
			Thought activation					Mental process in which cognitive representations regarding a topic are made salient for further mental processing.
				Norm activation				A mental process in which norms are made salient for further mental processing.
					Descriptive norm activation			A mental process in which beliefs regarding the prevalence of performance of a given behaviour by people within a group are made salient for further mental processes.
				Thought activation with awareness				Mental process in which cognitive representations regarding a topic are made salient for further mental processing and the person is conscious of these thoughts.
					Conscious death thought activation			Mental process in which cognitive representations regarding death are made salient for further mental processing and the person is conscious of these thoughts.
				Thought activation without awareness				Mental process in which cognitive representations regarding a topic are made salient for further mental processing and the person is not conscious of these thoughts.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
					Non-conscious death thought activation			Mental process in which cognitive representations regarding death are made salient for further mental processing and the person is not conscious of these thoughts.
			Wanting MF:0000045					A mental process that involves thinking about a state of affairs that does not yet obtain together with a desire for that state of affairs to obtain.
				Wanting to engage in a behaviour				A mental process that involves thinking about a level of performance of a behaviour that does not currently obtain together with a desire for that level of performance of a behaviour to obtain.
	Process profile BFO:0000144							b is a process_profile =Def. there is some process c such that b process_profile_of c.
		Consciousness MF:0000017						That part of the mental process that confers a subjective perspective, a phenomenology, an experience of the mental process of which it is a part; and intends the object or event that the mental process is about, should such exist; it confers intentionality on the mental process.

Notes. *While the classes were reused from the Emotion Ontology, definitions for some classes were not found in this ontology. Therefore, the researcher and expert developed definitions for these classes.

Appendix 5-1. The classes that were retained from the MoA Ontology v1.1 in v1.2 with changes in their labels and/or definitions

No.	Label in MoA Ontology v1.2	Definition in MoA Ontology v1.2	Parent class in MoA Ontology v1.2	Purpose for inclusion	Changes from MoA Ontology v1.1?	Label in Chapter 4	Definition in Chapter 4	Parent class in MoA Ontology v1.1
1	Personal capability MF:0000043	A disposition inhering in an organism whose realization in the normal case brings benefits to an organism or group of organisms, where "in the normal case" means not only in the normal range on the scale, but also in a context which is normal for the group to which the bearer or user belongs.	Bodily disposition	Upper-level class	Changed: label updated	Capability	A disposition inhering in an organism whose realization in the normal case brings benefits to an organism or group of organisms, where "in the normal case" means not only in the normal range on the scale, but also in a context which is normal for the group to which the bearer or user belongs.	Bodily disposition
2	Mental capability	A capability that necessarily includes mental processes in its realisation.	Personal capability	Upper-level class	Changed: label and definition updated	Psychological capability	A mental disposition that is realised in mental processes that influence ability to perform a behaviour.	Mental disposition
3	Behavioural self-regulation capability	A behaviour undertaken to modulate the frequency, rate or extent of a different behaviour, the specific actions or reactions of an organism in response to external or internal stimuli, and that is instigated by the organism itself.	Self-regulation capability	Lower-level class	Changed: label and definition updated	Self-regulatory capability	A psychological capability that involves processes that modulate the frequency, rate or extent of behaviour, the specific actions or reactions of a person in response to external or internal stimuli and that are instigated by the person themselves.	Psychological capability
4	Emotional self-regulation capability	A self-regulation capability to modulate one's emotions.	Self-regulation capability	Lower-level class	Changed: label and definition updated	Emotion regulation capability	A psychological capability to modulate one's emotions in order to facilitate goal attainment.	Psychological capability
5	Physical capability	A capability to perform a behaviour by virtue of muscular- skeleton attributes or psychomotor control	Personal capability	Lower-level class	Changed: definition updated	Physical capability	A bodily disposition that is realised by the organism using physical skills, strength or stamina to perform the behaviour.	Capability

No.	Label in MoA Ontology v1.2	Definition in MoA Ontology v1.2	Parent class in MoA Ontology v1.2	Purpose for inclusion	Changes from MoA Ontology v1.1?	Label in Chapter 4	Definition in Chapter 4	Parent class in MoA Ontology v1.1
6	Social capability	A capability to engage in interpersonal processes that influence ability to perform a behaviour, when appropriate circumstances occur.	Personal capability	Lower-level class	Changed: definition updated	Social capability	A bodily disposition that is realised by the bearer engaging in interpersonal processes that influence ability to perform a behaviour, when appropriate circumstances occur.	Capability
7	Alienation	A mental disposition to perceive or experience oneself as isolated from and not meaningfully involved in social groups.	Mental disposition	Lower-level class	Changed: definition updated	Alienation	A mental disposition to view and experience oneself as isolated from and not meaningfully involved in social groups.	Mental disposition
8	Behavioural intention	A mental disposition that is a commitment to enact or not enact a behaviour.	Mental disposition	Lower-level class	Changed: label and definition updated	Behavioural intention	A cognitive representation of one's plan to engage or not engage in a particular behaviour.	Cognitive representation
9	Belief about barriers	A belief about the extend to which factors exist that could restrict or impede the person from engaging in a behaviour.	Belief	Lower-level class	Changed: definition updated	Belief about barriers	A belief about the existence of factors that could restrict or impede the person from engaging in a behaviour.	Belief
10	Belief about conformity to behavioural norms	A belief about the extent to which one's own behaviour is similar to that of referent others.	Belief	Lower-level class	Changed: label and definition updated	Perceived conformity to behavioural norms	A cognitive representation of whether one's own behaviour is similar to that of referent others.	Cognitive representation
11	Belief about social consequences of behaviour	A belief about the outcomes of a behaviour in terms of social processes or attributes.	Belief about consequences of behaviour	Lower-level class	Changed: definition updated	Belief about social consequences of behaviour	A belief about the outcomes of a behaviour in terms of one's social status or social approval.	Belief about consequences of behaviour
12	Belief about likelihood of potential outcomes	A belief about the probability that a given event or state will occur in the future.	Belief	Lower-level class	Changed: definition updated	Belief about likelihood of potential outcomes	A belief regarding the probability that a given event or state will occur in the future.	Belief

No.	Label in MoA Ontology v1.2	Definition in MoA Ontology v1.2	Parent class in MoA Ontology v1.2	Purpose for inclusion	Changes from MoA Ontology v1.1?	Label in Chapter 4	Definition in Chapter 4	Parent class in MoA Ontology v1.1
13	Belief about severity of an outcome	A belief about how serious the harm associated with an outcome could be.	Belief	Lower-level class	Changed: label updated	Belief about severity	A belief about how serious the harm associated with an outcome could be.	Belief
14	Belief about susceptibility to a threat	A belief about how vulnerable one is to a threat.	Belief	Lower-level class	Changed: label updated	Belief about susceptibility	A belief about how vulnerable one is to a threat.	Belief
15	Belief about the timing of the consequences of behaviour	A belief about whether how long after the performance of behaviour particular consequences will occur.	Belief	Lower-level class	Changed: definition updated	Belief about the timing of the consequences of behaviour	A belief regarding whether how long after the performance of behaviour particular consequences will occur.	Belief
16	Belief about voluntariness of behaviour	A belief about the extent to which one is free to choose whether to perform the behaviour.	Belief	Lower-level class	Changed: definition updated	Belief about voluntariness of behaviour	A belief regarding the extent that one is free to choose whether to perform the behaviour.	Belief
17	Evaluation of self	A belief about the qualities and characteristics in one's self concept.	Belief	Lower-level class	Changed: label and definition updated	Self-esteem	A cognitive representation of how one evaluates the qualities and characteristics in one's self concept.	Cognitive representation
18	Perceived norm	A belief about what is typical for people who belong to a particular social group.	Belief	Lower-level class	Changed: label and definition updated	Norm	Belief regarding what is typical for people who belong to a particular social group.	Belief
19	Perceived descriptive norm	A belief about the prevalence of performance of a given behaviour by people within a group.	Perceived norm	Lower-level class	Changed: label and definition updated	Descriptive norm	A belief regarding the prevalence of performance of a given behaviour by people within a group.	Norm

No.	Label in MoA Ontology v1.2	Definition in MoA Ontology v1.2	Parent class in MoA Ontology v1.2	Purpose for inclusion	Changes from MoA Ontology v1.1?	Label in Chapter 4	Definition in Chapter 4	Parent class in MoA Ontology v1.1
20	Perceived injunctive norm	A belief about whether a behaviour is appropriate and correct for people who belong to a particular social group.	Perceived norm	Lower-level class	Changed: label and definition updated	Injunctive norm	A belief regarding whether a behaviour is appropriate and correct for people who belong to a particular social group.	Norm
21	Self-efficacy	A belief about one's capabilities to enact a behaviour.	Belief	Lower-level class	Changed: definition updated	Self-efficacy	A belief about one's capabilities to engage in a behaviour.	Belief
22	Situational self-efficacy	A belief about one's capabilities to enact a behaviour in a particular situation.	Self-efficacy	Lower-level class	Changed: definition updated	Situational self-efficacy	A belief about one's capabilities to engage in a behaviour in a particular situation.	Self-efficacy
23	Cognitive schema	A mental disposition about an entity that guides perception, thought or behaviour.	Mental disposition	Lower-level class	Changed: definition updated	Cognitive schema	An aggregate of cognitive representations about a concept or entity that serves to guide to perceiving or responding to a complex situation or set of stimuli.	Aggregate of cognitive representations
24	Action schema	A cognitive schema that guides a sequence of behaviours.	Cognitive schema	Lower-level class	Changed: label and definition updated	Action script	A cognitive representation that guides a sequence of behaviours.	Cognitive representation
25	Behavioural decision	A decision that one behaviour is preferred from at least two behavioural options.	Decision	Lower-level class	Changed: label and definition updated	Decision based on behaviour characteristics	A decision based on the perceived feasibility of a behaviour and the desirability of its possible outcomes.	Decision
26	Goal	A mental disposition to strive towards an end state.	Mental disposition	Lower-level class	Changed: definition updated	Goal	A cognitive representation of the end state to which one is striving.	Cognitive representation
27	Identity	A mental disposition relating to perceptions of oneself.	Mental disposition	Lower-level class	Changed: definition updated	Identity	A cognitive representation relating to how one perceives oneself.	Cognitive representation

No.	Label in MoA Ontology v1.2	Definition in MoA Ontology v1.2	Parent class in MoA Ontology v1.2	Purpose for inclusion	Changes from MoA Ontology v1.1?	Label in Chapter 4	Definition in Chapter 4	Parent class in MoA Ontology v1.1
28	Social identity	Identity that is associated with the sense of belonging to a social group.	Identity	Lower-level class	Changed: definition updated	Social identity	A cognitive representation relating to how one perceives oneself as belonging to a social group.	Identity
29	Knowledge	A mental disposition to understand the nature of the world, or a specific aspect of the world, that corresponds to the actual state of the world and is acquired through experience or learning.	Mental disposition	Lower-level class	Changed: definition updated	Knowledge	A cognitive representation of the nature of the world, or a specific aspect of the world, that corresponds to the actual state of the world and is acquired through experience or learning.	Cognitive representation
30	Learned stimulus-response association	A mental disposition to respond in a particular way to an event to an event in a person's environment, which is acquired through an associative learning process.	Mental disposition	Lower-level class	Changed: definition updated	Learned stimulus-response association	A cognitive representation of the relationship between an event in a person's environment and a bodily or behaviour reaction, acquired through an associative learning process.	Cognitive representation
31	Mental image disposition	A mental disposition to represent a mental image.	Mental disposition	Lower-level class	Changed: label and definition updated	Mental image	A cognitive representation that resembles the experience of perceiving some object or event but occurs when the relevant object or event is not actually present to the senses.	Cognitive representation
32	Willingness to comply	A mental disposition to be inclined to act in accordance with the likely approval of others	Mental disposition	Lower-level class	Changed: label and definition updated	Motivation to comply	A mental disposition to consider the likely approval of referent others for a course of action during decision making.	Mental disposition
33	Psychological need	A mental disposition of a person to act to obtain or maintain a particular state due to this state's importance to the person's wellbeing.	Mental disposition	Lower-level class	Changed: label and definition updated	Need	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining a particular state.	Need

No.	Label in MoA Ontology v1.2	Definition in MoA Ontology v1.2	Parent class in MoA Ontology v1.2	Purpose for inclusion	Changes from MoA Ontology v1.1?	Label in Chapter 4	Definition in Chapter 4	Parent class in MoA Ontology v1.1
34	Autonomy need	A psychological need to have a sense of personal agency and initiative	Psychological need	Lower-level class	Changed: definition updated	Autonomy need	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining a sense of personal agency and initiative.	Need
35	Need for self-esteem	A psychological need to have a positive evaluation of oneself and one's qualities and characteristics.	Psychological need	Lower-level class	Changed: definition updated	Need for self-esteem	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining a positive evaluation of oneself and one's qualities and characteristics.	Need
36	Need for sense of security	A psychological need to feel safe from threats.	Psychological need	Lower-level class	Changed: definition updated	Need for sense of security	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining a feeling of being safe from threats.	Need
37	Need for social relatedness	A psychological need to have caring relationships with other people.	Psychological need	Lower-level class	Changed: definition updated	Need for social relatedness	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining caring relationships with other people.	Need
38	Need to feel competent	A psychological need to experience oneself as able and effective.	Psychological need	Lower-level class	Changed: definition updated	Need to feel competent	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining the experience of oneself as able and effective.	Need
39	Mental plan	A mental disposition to form a representation of a behaviour, the conditions under which it will be enacted and an intention to enact the behaviour under those conditions.	Mental disposition	Lower-level class	Changed: label and definition updated	Plan	A cognitive representation of a series of steps to be taken to achieve a goal.	Cognitive representation

No.	Label in MoA Ontology v1.2	Definition in MoA Ontology v1.2	Parent class in MoA Ontology v1.2	Purpose for inclusion	Changes from MoA Ontology v1.1?	Label in Chapter 4	Definition in Chapter 4	Parent class in MoA Ontology v1.1
40	Self-concept	A mental disposition to represent oneself as having particular qualities and characteristics.	Mental disposition	Lower-level class	Changed: definition updated	Self-concept	A cognitive representation of one's own qualities and characteristics.	Cognitive representation
41	Stereotype	A mental disposition to represent attributes of members of a social group as shared by the virtue of their group membership.	Mental disposition	Lower-level class	Changed: definition updated	Stereotype	A cognitive representation of the generalised qualities and characteristics of the members of a particular social group or social category.	Cognitive representation
42	Risk stereotype	A stereotype of a person who enacts a problem behaviour.	Stereotype	Lower-level class	Changed: definition updated	Risk prototype	A cognitive representation of the typical characteristics and qualities of a person who engages in a behaviour that poses a risk to their wellbeing.	Cognitive representation
43	Social embeddedness	A mental disposition to experience a feeling of being connected by social attachments.	Mental disposition	Lower-level class	Changed: definition updated	Social embeddedness	A mental disposition to view and experience oneself as attached to and involved in a social group.	Mental disposition
44	Desired standard	A cognitive representation of a reference level that an individual wishes to obtain.	Cognitive representation	Lower-level class	Changed: definition updated	Desired standard	A cognitive representation of a desired state that serves as a reference level.	Cognitive representation
45	Opportunity	A quality of a person's environmental system that makes a behaviour possible or facilitates it.	Quality	Upper-level class	Changed: definition updated	Opportunity	A quality of a person's social and physical environment that makes behaviour possible or facilitates it.	Quality
46	Financial opportunity	An opportunity regarding whether the person has sufficient financial resources to enact a behaviour.	Opportunity	Lower-level class	Changed: definition updated	Financial opportunity	A quality of a person's social and physical environment regarding whether the person has sufficient financial resources to engage in a behaviour.	Opportunity
47	Healthcare service accessibility	An opportunity regarding how easy it is for a person to approach and use a healthcare service.	Opportunity	Lower-level class	Changed: definition updated	Healthcare service accessibility	A quality of a healthcare service regarding how easy it is for a person to approach and use it.	Opportunity

No.	Label in MoA Ontology v1.2	Definition in MoA Ontology v1.2	Parent class in MoA Ontology v1.2	Purpose for inclusion	Changes from MoA Ontology v1.1?	Label in Chapter 4	Definition in Chapter 4	Parent class in MoA Ontology v1.1
48	Physical opportunity	An opportunity of the physical environmental system that makes a behaviour possible or facilitates it.	Opportunity	Lower-level class	Changed: definition updated	Physical opportunity	A quality of the physical environment that makes a behaviour possible or facilitates it.	Opportunity
49	Social opportunity	An opportunity of the social environment system that influences performance of a behaviour.	Opportunity	Lower-level class	Changed: definition updated	Social opportunity	A quality of the social environment that influences performance of a behaviour.	Opportunity
50	Temporal opportunity	An opportunity regarding whether the person has sufficient time to enact a behaviour in the social and physical environment.	Opportunity	Lower-level class	Changed: definition updated	Temporal opportunity	A quality of a person's social and physical environment regarding whether the person has sufficient time to engage in a behaviour.	Opportunity
51	Bodily behavioural cue	A stimulus that arises from bodily processes and serves to elicit or guide behaviour.	Process	Lower-level class	Changed: label and definition updated	Behavioural cue	A stimulus that serves to elicit or guide behaviour.	
52	Mental behavioural cue	A stimulus that arises from mental processes and serves to elicit or guide behaviour.	Bodily behavioural cue	Lower-level class	Changed: label updated	Internal behavioural cue	A stimulus that arises from mental processes and serves to elicit or guide behaviour.	Behavioural cue
53	Individual human behaviour	Individual human activity that involves co-ordinated contraction of striated muscles controlled by the brain .	Bodily process	Lower-level class	Changed: label and definition updated	Behaviour	The specific actions or reactions of an organism in response to external or internal stimuli.	Bodily process

No.	Label in MoA Ontology v1.2	Definition in MoA Ontology v1.2	Parent class in MoA Ontology v1.2	Purpose for inclusion	Changes from MoA Ontology v1.1?	Label in Chapter 4	Definition in Chapter 4	Parent class in MoA Ontology v1.1
54	Communication MF:0000040	An interpersonal process that involves the transmission of information between two organisms.	Interpersonal process	Lower-level class	Changed: definition updated	Communication	An interpersonal process that involves as participant at least two linguistically capable organisms, one of whom produces an utterance that is well-formed in a given language and the other of whom perceives and understands that utterance by virtue of their recognition of the meaning of the utterance through their knowledge of the language.	Interpersonal process
55	Interpersonal reciprocal communication	Communication that is mutual between two or more people.	Communication	Lower-level class	Changed: label and definition updated	Social interaction process	An interpersonal process involving reciprocal communication between two or more people.	Interpersonal process
56	Experiential rightness of goal pursuit	A process by which the manner in which one attempts to achieve a goal creates an experiential sense of rightness associated with pursuing the goal, which in turn increases task engagement.	Bodily process	Lower-level class	Changed: label updated	Perceived regulatory fit process	A process by which the manner in which one attempts to achieve a goal creates an experiential sense of rightness associated with pursuing the goal, which in turn increases task engagement.	Bodily process
57	Bodily feeling* MFOEM:000202	An affective process involving sensory experience of physiological stimuli.	Affective process	Lower-level class	Added definition	Bodily feeling	No definition previously found in the Emotion Ontology	Affective process
58	Emotion process MFOEM:000001	A mental process that involves a complex aggregate of constituent processes, is valanced and has an object.	Affective process	Upper-level class	Changed: definition updated	Emotion process	A complex mental process that is a synchronized aggregate of constituent mental processes including an appraisal process as part, and which gives rise to an action tendency.	Affective process

No.	Label in MoA Ontology v1.2	Definition in MoA Ontology v1.2	Parent class in MoA Ontology v1.2	Purpose for inclusion	Changes from MoA Ontology v1.1?	Label in Chapter 4	Definition in Chapter 4	Parent class in MoA Ontology v1.1
59	Anxiety MFOEM:000028	An emotion that is negative, aversive and provoked by the prospect of distal future threat.	Emotion process	Lower-level class	Changed: definition updated	Anxiety	A negative, aversive emotion provoked by the prospect of future threat.	Emotion process
60	Feeling an urge	A subjective emotional feeling that arises when an impulse to enact a behaviour is activated but not immediately acted upon.	Subjective emotional feeling	Lower-level class	Changed: definition updated	Feeling an urge	A subjective emotional feeling of desire to engage in a behaviour that arises when an action script is activated but not immediately acted upon.	Subjective emotional feeling
61	Decision simplification	A cognitive process that simplifies decision making.	Cognitive process	Lower-level class	Changed: definition updated	Decision simplification	A mental process that simplifies decision making.	Mental process
62	Thinking	A cognitive process that involves the manipulation of mental language and/or mental images.	Cognitive process	Lower-level class	Changed: definition updated	Thinking	A mental process that involves the manipulation of mental language and/or mental images.	Mental process
63	Goal setting process	A mental process that establishes a cognitive representation of the end state to which one is striving.	Mental process	Lower-level class	Changed: label updated	Goal setting	A mental process that establishes a cognitive representation of the end state to which one is striving.	Mental process
64	Judging MF:0000006	A mental process during which evidence is evaluated, the outcome of which is a belief or opinion.	Mental process	Lower-level class	Changed: definition updated	Judging	A mental process during which a decision is made and the outcome of which is a belief or opinion. Judging is the evaluation of evidence to make a decision or form a belief.	Mental process
65	Judging consequences of behaviour	Judging during which a belief about the consequences of a behaviour is created or modified.	Judging	Lower-level class	Changed: definition updated	Judging consequences of behaviour	A mental process during which a decision is made and the outcome of which is a belief about the consequences of a particular behaviour.	Judging

No.	Label in MoA Ontology v1.2	Definition in MoA Ontology v1.2	Parent class in MoA Ontology v1.2	Purpose for inclusion	Changes from MoA Ontology v1.1?	Label in Chapter 4	Definition in Chapter 4	Parent class in MoA Ontology v1.1
66	Social comparison process	Judging oneself or one's social group in relation to the qualities or characteristics of another person or social group.	Judging	Lower-level class	Changed: definition updated	Social comparison process	Evaluating oneself or one's social group in relation to the qualities or characteristics of another person or social group.	Judging
67	Associative learning	Learning associations or disassociations between two or more stimuli or between a stimulus and a response.	Learning	Lower-level class	Changed: definition updated	Associative learning	Learning concerning the association between two or more stimuli or between a stimulus and a response.	Learning
68	Extinction in classical conditioning	Associative learning process in which the strength of a conditioned response is reduced because its conditioned stimulus is presented without being accompanied by the unconditioned stimulus.	Associative learning	Lower-level class	Changed: definition updated	Extinction in classical conditioning	Process in which presenting the conditioned stimulus in the absence of the unconditioned stimulus makes the conditioned response less likely to occur.	Classical conditioning
69	Extinction in operant learning	Associative learning process in which the rate of behavioural response in the presence of a discriminative stimulus is reduced because the response is no longer followed by a positive reinforcer.	Associative learning	Lower-level class	Changed: definition updated	Extinction in operant learning	Process in which when reinforcement for an operant behaviour has stopped, the behaviour becomes less likely to occur.	Operant conditioning

Appendix 5-2. Synonyms added to classes in the MoA Ontology v1.2

Class label	Synonym
Behavioural self-regulation capability	Behavioural regulation capability
Emotional self-regulation capability	Emotional regulation capability
Positive evaluation of self	Positive self-esteem
Negative evaluation of self	Low self-esteem; Negative self-esteem
Perceived norm	Belief about norm
Action schema	Action script
Risk stereotype	Risk prototype
Experiential rightness of goal pursuit	Perceived regulatory fit process

Appendix 5-3. Classes from MoA Ontology v1.1 which were not included in v1.2

No.	Label	Definition	Parent class in MoA Ontology v1.1
1	Skill	Capability acquired through training and practice.	Capability
2	Aggregate of cognitive representations	An aggregate of cognitive representations about a concept or entity.	Representation
3	Close other reinforcement capability	A bodily disposition that is realised by the bearer being able to reward a friend or partner for performing an intended behaviour.	Capability
4	Coping capability	A bodily disposition which is realised in processes which enable the bearer to overcome barriers to performing a behaviour.	Capability
5	Information acquisition capability	A bodily disposition that is realised by the bearer being able to engage in processes to obtain information relevant to a behaviour.	Capability
6	Self-reinforcement capability	A bodily disposition that is realised by the bearer being able to reward themselves for performing an intended behaviour.	Capability
7	Awareness of persuasive message	A mental disposition to be conscious of a verbal, written or recorded communication that aims to influence the recipient to think or act in a particular manner.	Awareness
8	Awareness of others' possible needs	A mental disposition to be conscious of the possible or actual deprivation of a necessary or wanted resources of another individual, group, or entity.	Awareness
9	Belief about cost barriers	A belief about the existence of monetary or other cost factors that could restrict or impede the person from engaging in a behaviour.	Belief about barriers
10	Belief about behaviour meeting needs	A belief about the behaviour resulting in one's needs being met.	Belief about consequences of behaviour
11	Belief about consequences of behaviour for self-concept	A belief about the impact of performing the behaviour on one's cognitive representation of one's own qualities and characteristics.	Belief about consequences of behaviour
12	Belief about the emotional consequences of goal attainment	A belief about the feelings and emotions that are associated with achieving a goal.	Belief about consequences of goal attainment
13	Belief about discrepancy between perceived and actual norms	A belief about existence of a discrepancy between what one thought was typical for people who belong to a particular social group and what is actually typical for people who belong to that social group.	Belief
14	Belief about having an interpersonal relationship	A belief about the existence and intensity of a social relationship between a person and another person, social group or character.	Belief
15	Belief about intrinsic enjoyment of behaviour	A belief about extent to which engaging in a behaviour is seen as enjoyable in its own right, regardless of the consequences of the behaviour.	Belief
16	Belief about likelihood of academic recognition	A belief about the probability of being acknowledged for one's educational achievements.	Belief
17	Belief about likelihood of experiencing affection	A belief about the probability of experiencing feelings of tenderness and attachment.	Belief
18	Belief about likelihood of goal achievement with available means	A belief about the probability of attaining a desired standard given the available resources or methods to facilitate doing so.	Belief
19	Belief about likelihood of personal autonomy	A belief about the probability of being able to exercise autonomy or act unconventionally.	Belief

No.	Label	Definition	Parent class in MoA Ontology v1.1
20	Belief about moral imperative for behaviour	A belief about whether a behaviour is necessary because it is morally the right thing to do.	Belief
21	Belief about autonomy support in one's environment	A belief about whether the immediate physical and social settings in which people live, including culture and the people and institutions with whom they interact, support self-determination in a person.	Belief about one's environment
22	Belief about availability of resources to support behaviour in one's environment	A belief about whether there are resources available in a person's immediate physical and social settings that will facilitate performance of a behaviour.	Belief about one's environment
23	Belief about pleasurability of a behaviour in one's environment	A belief about whether the immediate physical and social settings in which people live, including culture and the people and institutions with whom they interact, will result in the behaviour being pleasurable.	Belief about one's environment
24	Belief about own health	A belief regarding the state of one's health.	Belief
25	Belief about responsibility to act	A belief about whether one is personally obliged to take a certain course of action.	Belief
26	Belief about similarity to referent others	A belief about the extent to which one is similar to members of a social group whose behaviour or opinions one wishes to emulate.	Belief
27	Belief about social influence processes	A belief about whether or how one or more person exerts an influence on the person's behaviour	Belief about social influence processes
28	Belief about social influence processes involving parents and friends	A belief about whether or how parents and friends will attempt to use social influence processes to affect the person's behaviour.	Belief about social influence processes
29	Belief about social support	A belief about whether others will provide assistance or comfort to help the person cope with a variety of stressors.	Belief
30	Belief about task difficulty	A belief about how much work or skill a task involves.	Belief
31	Belief about technology use	A disposition to mental processes that represent some proposition X regarding technology and technology use to be true.	Belief
32	Belief about the availability of behavioural options	A belief about having the option of performing different behaviours.	Belief
33	Belief about the availability of self-enhancing deviant behavioural options	A belief about having the option of performing different behaviours that would enhance one's self-evaluation but not be considered appropriate or typical for a social group.	Belief about the availability of behavioural options
34	Belief about the availability of self-enhancing normative behavioural options	A belief about having the option of performing different behaviours that would enhance one's self-evaluation and be considered appropriate or typical for a social group.	Belief about the availability of behavioural options
35	Belief about the desirability of the consequences of a new behaviour vs prior behaviour	A belief about the potential benefits of adopting a new behaviour relative to the benefits of the previous behaviour.	Belief about the desirability of consequences of behaviour
36	Belief about the relative desirability of the consequences of behaviour	A belief about the desirability of consequences of one behaviour relative to the desirability of consequences of a different behaviour.	Belief about the desirability of consequences of behaviour
37	Belief about threat	A belief about the nature of a potential harm.	Belief

No.	Label	Definition	Parent class in MoA Ontology v1.1
38	Belief about environmental threat	A belief about the nature of a potential harm to the circumstances, objects, or conditions by which one is surrounded.	Belief about threat
39	Belief about value of affection	A belief about the value of experiencing feelings of tenderness and attachment.	Belief
40	Belief about value of personal autonomy	A belief about the value of personal self-determination.	Belief
41	False consensus	A mental disposition to assume other members of the group share one's behaviours and thoughts more than is actually the case.	Belief
42	False uniqueness	A mental disposition to assume that one's thoughts or behaviours are more unique than those of one's peers.	Belief
43	Cleanliness injunctive norm	A belief regarding whether a certain level of hygiene is appropriate and correct for people who belong to a particular social group.	Injunctive norm
44	Legal injunctive norm	A belief regarding whether following legal codes is appropriate and correct for people who belong to a particular social group.	Injunctive norm
45	Socially shared norm	A belief regarding standards for behaviour that one sees as mutually agreed by and shared by members of one's social group.	Norm
46	Recovery self efficacy	A belief about one's capabilities to resume a behaviour change attempt after a setback.	Self-efficacy
47	Intelligence	A mental disposition realised in processes involving understanding complex ideas, adapting effectively to the environment, learning from experience, engaging in various forms of reasoning, and overcome obstacles through the outcome of thinking processes.	Mental disposition
48	Memory for message content	The activities involved in the mental information processing system that receives (registers), modifies, stores, and retrieves informational stimuli that were contained in a message.	Memory
49	Altruistic personal value	A personal value that stems from an apparently unselfish concern for others.	Personal value
50	Egoistic personal value	A personal value that stems from self-interest or self-enhancement motives.	Personal value
51	Health-related personal value	A personal value that concerns one's health.	Personal value
52	Religion-related personal value	A personal value that stems from having a set of beliefs concerning the cause, nature, and purpose of the universe, especially when considered as the creation of a superhuman agency or agencies.	Personal value
53	Tradition-related personal value	A personal value that stems from a set of social customs or other ethnic or family practices handed down from generation to generation.	Personal value
54	Capability to acknowledge behavioural risk status	Psychological capability to recognise and accept that one's behaviour places one at a certain likelihood of future harm.	Psychological capability
55	Self-reflective capability	A psychological capability to analyse one's own experiences and thoughts.	Psychological capability
56	Future-focused self-regulatory capability	A self-regulatory capability to module behaviour based on thoughts about the future.	Psychological capability
57	Goal generating capability	A self-regulatory capability to envisage alternative goals and create new strategies for action.	Psychological capability
58	Self-control capability	A self-regulatory capability to inhibit activated action scripts or action tendencies.	Psychological capability

No.	Label	Definition	Parent class in MoA Ontology v1.1
59	Self-worth regulation capability	A psychological capability to cope with experiences that reduce one's sense of self-worth.	Psychological capability
60	Symbol use capability	A psychological capability to use marks or characters to represent objects, functions or processes.	Psychological capability
61	Vicarious learning capability	A psychological capability to acquire knowledge or skill from observation.	Psychological capability
62	Social embeddedness in conventional society	A mental disposition to view and experience oneself as attached to and involved in a large social group whose members follow prevailing norms for thoughts and behaviour.	Social embeddedness
63	Temporal orientation to the future	A mental disposition to focus more on future than present outcomes.	Temporal orientation
64	Temporal orientation to the present	A mental disposition to focus more on present than future outcomes.	Temporal orientation
65	Tolerance of transgressions	A mental disposition to tolerate one or more others acting in a manner that goes against a moral code of conduct.	Mental disposition
66	Interdependent action script	Disposition to an interpersonal process in which a sequence of behaviour in one individual elicits a sequence of behaviour in at least one other individual with whom the first is in a close relationship.	Disposition
67	Appraisal as being disliked	An appraisal that represents a judgement that one is being disliked.	Appraisal
68	Appraisal as being liked	An appraisal that represents a judgement that one is being liked.	Appraisal
69	Appraisal of avoidability of consequences	An appraisal which represents a judgement about how avoidable the expected consequences of an event will be.	Appraisal
70	Appraisal of causal intent	An appraisal that represents an evaluation of the causal intent of the person who is evaluated to have caused an event.	Appraisal
71	Appraisal of congruence with ideals	An appraisal which represents a judgement about whether an event is consistent with the person's standards or ideals.	Appraisal
72	Appraisal of coping capability	An appraisal that represents an evaluation of the factors that influence one's ability to cope with a threat.	Appraisal
73	Appraisal of desirability of consequences	An appraisal that represents an evaluation of the desirability of the expected consequences of an event.	Appraisal
74	Appraisal of familiarity	An appraisal that represents an evaluation of how familiar an object or event is.	Appraisal
75	Appraisal of goal importance	An appraisal that represents an evaluation of whether an event or object is important to the person's goals or needs.	Appraisal
76	Appraisal of impact on social environment	An appraisal that represents an evaluation of the impact of one's behaviour on one's social relationships.	Appraisal
77	Appraisal of justice of treatment	Appraisal which represents an evaluation of whether the person was treated justly or unjustly by another person.	Appraisal
78	Appraisal of loss	An appraisal that represents a belief that something or someone that is important to the person has been lost to the person.	Appraisal
79	Appraisal of pleasantness	An appraisal that represents an evaluation of the pleasantness of an object or event.	Appraisal
80	Appraisal of predictability	An appraisal that represents an evaluation of how predictable an event was.	Appraisal
81	Appraisal of potential outcomes of a future choice	An appraisal that represents an evaluation of the possible states and events that might follow from a choice made in the future.	Appraisal

No.	Label	Definition	Parent class in MoA Ontology v1.1
82	Appraisal of social attention	An appraisal which represents a judgement about the direction and nature of the social attention surrounding an event.	Appraisal
83	Appraisal of suddenness	An appraisal which represents an evaluation of how suddenly an event occurred.	Appraisal
84	Appraisal of urgency of response	An appraisal that represents an evaluation of the urgency of responding to an event.	Appraisal
85	Attitude towards a behaviour	A cognitive representation which represents an overall evaluation of the impact of the possible outcomes of a behaviour to the organism.	Cognitive representation
86	Certainty about a decision	A cognitive representation of how sure one feels that one's decision is correct.	Cognitive representation
87	Decision with respect to means	A decision about how to achieve a goal based on an appraisal of the relevant and available resources or means for goal achievement.	Decision
88	Independent decision	A decision made independently of decisions made by other members of a social group.	Decision
89	Desirability representation	A cognitive representation of a possible state of affairs together with the degree of wishing for that state of affairs to obtain.	Cognitive representation
90	Desired standard for behaviour	A cognitive representation of one's desired level of behaviour.	Desirability representation
91	Desired standard for behaviour based on personal values	A cognitive representation of one's desired level of behaviour in order to act consistently with one's personal values.	Desired standard for behaviour
92	Desired standard for effort	A cognitive representation of one's desired level of effort towards a goal.	Desirability representation
93	Desired standard for self-image	A cognitive representation of how one wishes to perceive oneself.	Desirability representation
94	Emulation goal	A goal to imitate referent others.	Goal
95	Extrinsic goal	A goal related to obtaining external signs of worth.	Goal
96	Gain-related goal	A goal related to improving and protecting one's resources.	Goal
97	Hedonic goal	A goal related to feeling better quickly.	Goal
98	Intrinsic goal	A goal related to obtaining satisfaction of basic needs.	Goal
99	Normative goal	A goal to act in line with what is considered acceptable.	Goal
100	Personally set goal	A goal that one has decided upon for oneself.	Goal
101	Proximal goal	A goal concerning an end state to be achieved in the short term.	Goal
102	Goal achievability	A cognitive representation of how easy it will be to reach the end state to which one is striving.	Cognitive representation
103	Importance of goal attainment	A cognitive representation of the significance of successfully meeting a goal.	Cognitive representation
104	Importance of academic goal attainment	A cognitive representation of the significance of successfully meeting an educational goal.	Importance of goal attainment
105	Importance of goal attainment relative to other goals	A cognitive representation of the significance of successfully meeting a goal compared to the significance of meeting other goals.	Importance of goal attainment
106	Importance of behaviour for self esteem	A cognitive representation of the significance of performing a behaviour to one's sense of one's worth, usefulness or importance.	Cognitive representation
107	Job satisfaction	A cognitive representation of the extent to which one's job fulfils one's expectations and needs.	Cognitive representation

No.	Label	Definition	Parent class in MoA Ontology v1.1
108	Knowledge regarding behaviour linked to health	Knowledge regarding how a particular set of actions may affect physical or mental wellbeing.	Knowledge regarding a behaviour
109	Knowledge regarding a health threat	Knowledge regarding a potential harm to physical or mental wellbeing.	Knowledge regarding a threat
110	Knowledge regarding an environmental threat	Knowledge regarding methods to prevent a potential harm to the circumstances, objects, or conditions by which one is surrounded.	Knowledge regarding a threat
111	Knowledge regarding environmental threat prevention	Knowledge regarding a potential harm to the circumstances, objects, or conditions by which one is surrounded.	Knowledge regarding an environmental threat
112	Knowledge regarding threat prevention	Knowledge regarding methods to avert a potential harm.	Knowledge regarding threat prevention
113	Knowledge regarding threat transmission	Knowledge regarding how a potential harm may spread.	Knowledge regarding threat transmission
114	Aesthetic need	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining the experience of aesthetically pleasing things.	Need
115	Behavioural autonomy need	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining a sense of personal agency and initiative when changing one's behaviour.	Autonomy need
116	Coping strategy need	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining effective coping strategies.	Need
117	Enjoyable context need	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining opportunities for behaviour to take place in an enjoyable context.	Need
118	Need for comfortable daily life	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining an easy and comfortable everyday life.	Need
119	Need for consistency between beliefs and behaviour	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining consistency between one's opinions or attitudes and behaviours.	Need
120	Need for education	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining a good education and developing general knowledge.	Need
121	Need for enjoyable everyday life	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining pleasurable and exciting experiences in everyday life.	Need
122	Need for good work situation	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining a satisfying and enjoyable job.	Need
123	Need for health	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining good health.	Need
124	Need for healthcare	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining access to appropriate healthcare.	Need
125	Need for healthy natural environment	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining an	Need

No.	Label	Definition	Parent class in MoA Ontology v1.1
		environment with clean water, air and soil and healthy animals and plants.	
126	Need for leisure time	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining time when one is not working or occupied.	Need
127	Need for location access	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining access to suitable locations to perform the behaviour.	Need
128	Need for safety from accidents	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining protection from accidents.	Need
129	Need for safety from crime	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining freedom from the threat of crime.	Need
130	Need for social recognition	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining appreciation from others due to one's skills, achievements or possessions.	Need
131	Need to feel behaviourally competent	A cognitive representation of the importance to one's survival or wellbeing of obtaining or maintaining the experience of oneself as capable of performing a behaviour well.	Need to feel competent
132	Perceived self-determination of behaviour	A cognitive representation of the degree to which one's behaviour is controlled by one's internal convictions rather than external demands.	Cognitive representation
133	Social identity-related self-esteem	A cognitive representation of how one evaluates one's self concept based on perceived membership of a social group.	Self-esteem
134	Quality of life	A cognitive representation which represents an overall evaluation of how much one obtains satisfaction from one's life.	Cognitive representation
135	Worldview schema	An aggregate of cognitive representations that enable one to perceive and respond to the universe as having order, predictability, meaning and permanence.	Cognitive schema
136	System usability	A quality of a technological system regarding the amount of effort required to successfully use the system.	Quality
137	System result tangibility	A quality of a technological system regarding the extent to which the results of its usage are concrete or discernible.	Quality
138	Social involvement opportunity	The extent to which the social environment provides opportunities for a person to actively engage in social groups.	Social opportunity
139	Social opportunity for equality	The extent to which the social environment provides equal opportunities to act and own property to all people.	Social opportunity
140	Emotional behavioural process	An emotional behavioural process is the behaviour of the organism in response to the appraisal, which includes the characteristic facial expressions for particular emotion types.	Behaviour
141	Habitual behaviour	A behaviour that is well-learned and can be in automatic sequence with other behaviours, and has become reflexive over time.	Behaviour
142	Depletion of self-regulatory capability	A process by which a person's self-regulatory capability is diminished by their having already recently used it.	Bodily process
143	Feedback from past personal experience	A process by which personal experiences provide information for and influence subsequent behaviour	Bodily process
144	Prevention-focused goal pursuit process	A goal pursuit process focused on maintaining a current satisfactory state and avoiding a worse state.	Goal pursuit process

No.	Label	Definition	Parent class in MoA Ontology v1.1
145	Promotion-focused goal pursuit process	A goal pursuit process focused on supporting progress from a current state to a better state.	Goal pursuit process
146	Utility maximising goal pursuit process	A goal pursuit process focused on maximising one's satisfaction with the outcomes of one's choices.	Goal pursuit process
147	Interpersonal approval for behaviour	An interpersonal process in which one or more person indicates A CERTAIN approval of another person performing a particular behaviour.	Interpersonal process
148	Interpersonal approval for behaviour by friends	An interpersonal process in which one or more person indicates approval of their friend performing a particular behaviour.	Interpersonal approval for behaviour
149	Interpersonal approval for behaviour by community	An interpersonal process in which a set of people with whom one lives or works indicate approval of one performing a behaviour.	Interpersonal approval for behaviour
150	Interpersonal approval for behaviour by parent	An interpersonal process in which one or more parent indicates approval of their child performing a particular behaviour.	Interpersonal approval for behaviour
151	Interpersonal approval subsequent to behaviour	An interpersonal process in which one or more person indicates approval subsequent to another person performing a particular behaviour.	Interpersonal approval for behaviour
152	Family social influence process	An interpersonal process where one or more family member exerts an influence on the behaviour of another.	Social influence process
153	Friend social influence process	An interpersonal process where one or more friend exerts an influence on the behaviour of another.	Social influence process
154	Peer social influence process	An interpersonal process where one or more person of the same status or rank exerts an influence on the behaviour of another.	Social influence process
155	Bonding social interaction process	An interpersonal process involving reciprocal communication between two or more people leading to the establishment of an affective relationship between those individuals.	Social interaction process
156	Conflict social interaction process	A social interaction process in which participants actions convey openness, trust and empathy, and offer support with regard to other participants' problems.	Social interaction process
157	Helping relationship social interaction process	A social interaction process in which participants interactions have involved disagreeing or disapproving with at least one other participant.	Social interaction process
158	Mutually accommodating social interaction process	A social interaction process in which participants interactions have involved attempting to take account of other participants' preferences, schedules and needs in order to engage in group action.	Social interaction process
159	Searching for information about how to change behaviour	A process in which people seek information and others opinions about how to alter their behaviour.	Bodily process
160	Searching for solutions to health risks	A process in which people seek methods to reduce the problems associated with behaviours that put health at risk.	Bodily process
161	Avoidant behavioural self-regulation	A behaviour to increase the distance between oneself and an aspect of one's environment or to completely remove an aspect of the environment, in order to modulate the frequency, rate or extent of a different behaviour.	Behavioural self-regulation of behaviour
162	Environment restructuring self-regulation	A behaviour that alters the rules or structure of one's environment in order to modulate the frequency, rate or extent of a different behaviour.	Behavioural self-regulation of behaviour
163	Amusement	A positive emotion that is experienced when a person finds something funny and entertaining.	Emotion process

No.	Label	Definition	Parent class in MoA Ontology v1.1
164	Computer anxiety	A negative, aversive emotion provoked by the prospect of using computer technology.	Anxiety
165	Boredom	An emotion in which one feels weary and impatient because one is unoccupied or lacks interest in one's current activity.	Emotion process
166	Compassion	An emotion evoked for a person who is in distress. The conditions for compassion involve perceiving the other as in need, and valuing the other's welfare. Associated with altruistic motivation.	Emotion process
167	Concern	An emotion in which one feels nervous interest in something.	Emotion process
168	Confusion	An emotion in which one feels disoriented about something and is unable to engage in orderly thought or to distinguish, choose or behave decisively.	Emotion process
169	Contempt	A negative emotion generally elicited by the negative evaluation of others and their actions.	Emotion process
170	Curiosity	An emotion that is experienced when one has a desire to learn or know something.	Emotion process
171	Despair	A negative, high intensity emotion characterised by loss of hope and loss of interest.	
172	Disappointment	A negative emotion which is triggered by the disconfirmation of the prospect of a desirable event.	Emotion process
173	Dubious	An emotion that is experienced when one is uncertain whether something is true.	Emotion process
174	Embarrassment	An emotion in which one feels awkard or flustered in other people's company or because of the attention of others.	Emotion process
175	Enthusiasm	A positive emotion reflecting energy and passion for something.	Emotion process
176	Expectant	An emotion that is experienced in anticipation of a pleasant or exciting event.	Emotion process
177	Terror	Fear that is intense.	Fear
178	Grief	An intense negative emotion following a bereavement, i.e. the loss of a significant person through that person's death.	Emotion process
179	Guilt	A self-conscious emotion that occurs when a person brings about a negative outcome by acts of commission or omission.	Emotion process
180	Contentment	A pleasant emotion, which can be defined as a milder form of joy.	Happiness
181	Hope	A positive emotion in which one anticipates desired outcomes.	Emotion process
182	Inspiration	An emotion that stimulates one to produce new and creative ideas or approaches to a problem.	Emotion process
183	Interest	A positive emotion which motivates learning, exploration and curiosity.	Emotion process
184	Irritation	An unpleasant emotion closely related to anger but lower in intensity and without the moral dimension of blame and seriousness that is implicated in anger.	Emotion process
185	Jealousy	A negative emotion aroused when a person feels threatened by a rival in his or her relationship with another individual, in particular an intimate partner. Involves feelings of threat, fear, suspicion, distrust, anxiety, anger, betrayal, and rejection.	Emotion process
186	Negative emotion	A negative emotion is an emotion that has a negative valence.	Emotion process

No.	Label	Definition	Parent class in MoA Ontology v1.1
187	Positive emotion	A positive emotion is an emotion that has a positive valence.	Emotion process
188	Pride	A positive emotion associated with the appraisal of one's positive social worth, a signal that one is likely to be socially accepted.	Emotion process
189	Stress	A negative emotion in response to a stressful elicitor.	Emotion process
190	Worry	A negative emotion in which one is distressed as a result of thinking about actual or potential problems or unpleasant things.	Emotion process
191	Attending disrupted by behavioural alternatives	A mental process whereby relevant aspects of our mental experience become focused on a behaviour other than the currently planned or engaged in course of action.	Attending
192	Attending to a goal	A mental process whereby relevant aspects of our mental experience are focused on a desired end state.	Attending
193	Attending to a self-oriented goal	A mental process whereby relevant aspects of our mental experience are focused on a desired end state for oneself.	Attending to a goal
194	Attending to a norm	A mental process whereby relevant aspects of our mental experience are focused on what others do and think about a behaviour.	Attending
195	Attending to a message	A mental process whereby relevant aspects of our mental experience become focused on a verbal, written or recorded communication.	Attending
196	Vigilance	The ability to maintain attention and alertness over prolonged periods of time.	Attending
197	Behavioural intention formation	A cognitive process that brings into being a behavioural intention.	Cognitive process
198	Evaluating multiple options	A cognitive process that gives rise to an evaluation and comparison of the nature and significance of two or more options.	Cognitive process
199	Evaluating multiple goal means	A cognitive process that gives rise to an evaluation and comparison of two or more resources or methods to facilitate goal achievement	Evaluating multiple options
200	Evaluating multiple goal options	A cognitive process that gives rise to an evaluation and comparison of the appeal and feasibility or two or more goals.	Evaluating multiple options
201	Self-esteem maintenance process	A cognitive process that serves to maintain one's sense of worth, usefulness or importance.	Cognitive process
202	Commitment making	A mental process by which one decides to pursue a goal and develops a sense of being obligated or emotionally impelled to act upon that goal.	Mental process
203	Decision simplification by combining probabilities of identical outcomes	A mental process that simplifies decision making by combining the probabilities of alternative options with identical outcomes.	Decision simplification
204	Decision simplification by disregarding shared components	A mental process that simplifies decision making by identifying and disregarding shared components of alternative options.	Decision simplification
205	Decision simplification by identifying clearly better or worse options	A mental process that simplifies decision making by editing information to identify any clearly superior or inferior options.	Decision simplification
206	Decision simplification by separating risky and riskless components	A mental process that simplifies decision making by separating elements of alternative options that involve risk from those that do not involve risk.	Decision simplification
207	Decision simplification through rounding	A mental process that simplifies decision making by rounding probabilities or outcomes associated with	Decision simplification

No.	Label	Definition	Parent class in MoA Ontology v1.1
		alternative options, or by disregarding options with extremely unlikely outcomes.	
208	Feedback rejecting dissonance reduction process	A dissonance reduction process through which an inconsistency between the cognitive representation of one's current state based on feedback received and a cognitive representation of the end state to which one is striving is reduced by dismissing the feedback.	Dissonance reduction process
209	Goal changing dissonance reduction process	A dissonance reduction process through which an inconsistency between the cognitive representation of one's current state and a cognitive representation of the end state to which one is striving is reduced by changing the cog rep of the end state to which one is striving.	Dissonance reduction process
210	Empathising process	A mental process that brings into being, sustains or modifies a cognitive representation of how another person may experience the world.	Mental process
211	Evaluation of goal achievement	A mental process which evaluates the appropriateness of current goal attainment strategies given one's progress towards goal achievement	Mental process
212	Goal activation process	A mental process that brings a goal into attention.	Mental process
213	Certainty effect heuristic process	A heuristic process using a rule that overweighs outcomes considered to be certain compared to outcomes considered as probabilistic.	Heuristic process
214	Isolation effect heuristic process	A heuristic process using a rule that tends to ignore the shared characteristics of presented alternatives and focus on the differences between them in order to simplify choices.	Heuristic process
215	Somatic marker heuristic process	A heuristic process that uses previous emotional experiences of the relevant behaviours to make judgments.	Heuristic process
216	Imitating values of aspirational social group	A mental process by which one takes on the values of a social group to which one aspires to belong.	Mental process
217	Inference	A mental process that involves applying rules to a set of premises to reach a conclusion.	Mental process
218	Judging as potential peer	Judging whether an individual or individuals should be considered as a person of the same status or rank.	Judging
219	Judging as peer of similar status or ability	Judging whether an individual or individuals should be considered as a person of the same status or rank in terms of ability.	Judging as potential peer
220	Judging as peer influential to one's behaviour or self-evaluation	Judging whether an individual or individuals should be considered as a person of the same status or rank who influences one's behaviour or self-evaluation.	Judging as potential peer
221	Judging self-concept in relation to a behaviour	A mental process during which one evaluates how one's performance of a behaviour affects one's cognitive representation of one's own qualities and characteristics.	Judging
222	Imitative learning from valued others	Learning in which new behaviours are acquired through imitation of another person one admires or has a close bond with.	Imitative learning
223	Vicarious mastery observational learning	Learning that occurs through observing others successfully perform a behaviour.	Observational learning
224	Mental categorising of the social environment	A mental process in which aspects of the immediate physical and social settings in which people live, including culture and the people and institutions with whom they interact, are grouped into cognitive representations of classes, on the basis of features shared by members of the same class and features distinguishing the members of one class from those of another.	Mental categorising

No.	Label	Definition	Parent class in MoA Ontology v1.1
225	Mentally comparing behaviour against a standard	A mental process in which current behaviour is compared against a particular reference level.	Mentally comparing against a standard
226	Mentally comparing current effort and outcome against a standard	A mental process in which current outcome and efforts to attain that outcome are compared against a desired end.	Mentally comparing against a standard
227	Fear reduction motivation	Motivation in order to lessen feelings of fear.	Motivation
228	Importance-based motivation	Motivation due to the behaviour being seen as personally important.	Motivation
229	Need-based motivation	Motivation to obtain or maintain a level of something required for survival or wellbeing.	Motivation
230	Self-esteem motivation	Motivation to maintain or increase positive self evaluations and to reduce negative self evaluations.	Motivation
231	Obligation-based motivation	A mental process that energises and directs behaviour to meet a perceived obligation.	Motivation
232	Threat reduction motivation	Motivation in order to avert a perceived threat.	Motivation
233	Perception of discomfort	A mental process which is a) produced by a causal process (for example involving light rays or air vibrations) involving a part of the environment of the organism, and b) is experienced by the organism as being so caused and as unpleasant, and c) in which the relevant part of the environment is thereby represented to the organism.	Perception
234	Perception of physiological effects of smoking	A mental process which is a) produced by the person smoking tobacco, and b) is experienced by the person as being so caused, and c) in which the effect of smoking tobacco on the body is thereby represented to the person.	Perception
235	Problem solving planning	Planning involving forming at least two plans in order to guide action in different circumstances.	Planning
236	Thought activation	Mental process in which cognitive representations regarding a topic are made salient for further mental processing.	Mental process
237	Norm activation	A mental process in which norms are made salient for further mental processing.	Thought activation
238	Descriptive norm activation	A mental process in which beliefs regarding the prevalence of performance of a given behaviour by people within a group are made salient for further mental processes.	Norm activation
239	Thought activation with awareness	Mental process in which cognitive representations regarding a topic are made salient for further mental processing and the person is conscious of these thoughts.	Thought activation
240	Conscious death thought activation	Mental process in which cognitive representations regarding death are made salient for further mental processing and the person is conscious of these thoughts.	Thought activation with awareness
241	Thought activation without awareness	Mental process in which cognitive representations regarding a topic are made salient for further mental processing and the person is not conscious of these thoughts.	Thought activation
242	Non-conscious death thought activation	Mental process in which cognitive representations regarding death are made salient for further mental processing and the person is not conscious of these thoughts.	Thought activation without awareness
243	Wanting to engage in a behaviour	A mental process that involves thinking about a level of performance of a behaviour that does not currently obtain together with a desire for that level of performance of a behaviour to obtain.	Wanting

Appendix 6-1. Annotation manual for the MoA Ontology

What is an Mechanism of Action?

A mechanism of action (MoA) is formally defined as an attribute of the process by which a behaviour change intervention influences the behaviour.

Each class in the MoA ontology can be taken to mean "mechanism of action in which the influence (of the intervention on behaviour) occurs by influencing [name of class]". However, in behaviour change intervention reports, authors often report the name of the class and its definition, rather than fully specifying the influence process (see example in Figure 1).

Figure 1. Example of a relationship between an intervention, a mechanism of action and behaviour as reported in behaviour change intervention reports

We are interested in applying the MoA Ontology to classify MoAs that are reported in behaviour change intervention reports.

General Mechanism of Action Guidance

1. **We want to annotate MoAs that were** measured after the intervention was started or applied. The best place to look for information about measured MoAs is in the methods section, usually under **sections labelled 'Measurement' or 'Questionnaire'**.

2. **Check the methods section** for evidence of a measure for MoAs during the intervention or at its follow-up.

   2.1 If the **methods section does not state when measurements were taken**, check the results section for the timepoints at which the potential MoAs were measured.

   2.2 In some intervention reports, the measurement for a potential MoA (e.g., 'motivation') is **broken down into more granular MoA measurements** (e.g., 'intrinsic motivation' and 'extrinsic motivation').

      2.2.1 To decide whether to annotate the high level or more granular MoAs, check whether the Methods section describes which measurements were reported.

2.2.2   If no information is provided in the Methods section, **check the Results section on which MoAs were measured**.

2.3   Do **NOT annotate baseline characteristics** of participants (e.g., "pre-contemplation stage of change") or **measurements of individual differences**. These are part of the Population Ontology.

3. MoAs should **be annotated if they are targeting any behavioural outcome** of interest in the targeted population.

3.1   If a potential MoA is not clearly described as related to the behaviour in the Methods section, check whether a relationship between this potential MoA and behaviour is hypothesised in the introduction or tested in the results.

3.1.1   If so, annotate this process variable using the MoA Ontology.

4. **Annotate** the MoAs that are reported in the paper **for all intervention groups <u>for the 'whole study.'</u>** The study arms **should NOT be annotated separately** <u>at this stage of the MoA Ontology development.</u>

5. Any given intervention or behaviour change technique can have **multiple MoAs**. **Annotate all these MoAs separately**.

Deciding on which class an MoA should be annotated

MoAs should be classified based on their stated definitions rather than their labels.

Where definitions and labels suggest different classes, use the class that matches the definition.

1. When an MoA is identified in an intervention evaluation report, **check whether the definition for this MoA is provided** in the methods section. If there is no definition provided in the Methods section, check for one in the Introduction.

    1.2 If a definition is found, annotate the MoA's label and definition.

    1.2 If two different definitions are provided, check if one of these definitions was used for the study.

    - e.g., "*Self-regulation is the personal regulation of goal-oriented behavior or performance. For this study, self-regulation refers to the skills used by the participant to implement exercise intentions and to overcome personal and situational barriers to a regular exercise program*" (Hallam & Petosa, 2004).

2. If **no definition of the MoA is provided in the report**, see if there is detail on how the MoA was measured – e.g., questionnaire item wording.

    2.1 If so, decide on the annotate for the MoA based on its label and the information about how it was measured, using the relevant class in the MoA Ontology.
    2.1.1   Annotate the label and measurement of the MoA.

    - For instance, for the following extract: "*The Exercise Self-Efficacy Scale (Marcus, Selby, Niaura, &Rossi, 1992) has 5 items starting with, ''I am confident I can participate in regular exercise when…' (e.g., 'I feel I don't have the time).' Participants' responses ranged from 1 (Not at all confident) to 11 (Very confident)*" (Annesi, Johnson, & McEwen, 2015)

        o **Do not annotate** the 'Exercise Self-efficacy Scale' but the examples of this scale, e.g. ''*I am confident I can participate in regular exercise when…*'' (Annesi et al., 2015), using the class 'situational self-efficacy for a behaviour'

        o However, **if no examples are provided**, then annotate the scale.

3. If no definition of the MoA is provided in the report and there is a mismatch between the label and the measurement, then annotate the MoA according to the measurement.

3.1 However, if only one measurement item is provided and it can be part of the measurement for the MoA (as specified by the label), then annotate the MoA according to the label.

- For instance, the MoA in the following extract would be annotated as 'observational learning' in line with the MoA's label: "*Observational learning was measured using two items previously used by Plotnikoff et al. [6] on a 5-point Likert-type scale in which participants were asked to rate how often they observed others being active in the last three months. Response options ranged from 'never' (1) to 'very often' (5), with an example item being, 'I have observed people who are important to me engaging in regular physical activity.'*" (Liebreich, Plotnikoff, Courneya, & Boulé, 2009).

4. If only the label of an MoA is provided in the report, annotate this MoA based on the label.

5. If there is a mismatch between the definition and the measurement of an MoA, then annotate both the class based on the definition and the class based on the measurement, and record that there was a mismatch.

6. If the paper includes multiple labels for the same MoA (e.g., 'self-efficacy' and 'belief about capability'), annotate all these labels.

6.1 Otherwise, only annotate the MoA once.

7. If the paper includes a MoA that is a **composite of various different MoAs**, check if there is a suitable higher-level class in the MoA Ontology that could be used.

7.1 Otherwise, annotate this MoA as 'Compound MoA' and note it down in the annotation issues log.

- For instance, in one report, the MoA 'barriers to physical activity' was assessed based on 21 situational barriers to physical activity months: "*I have difficulty exercising when I get busy*"; "*I have difficulty figuring out how to fit exercise into my daily life*"; "*I have difficulty exercising when I just want to relax and enjoy myself*" (Crain, Martinson, Sherwood, & O'Connor, 2010). As 'barriers to physical activity' included temporal opportunity and motivational aspects, it should be annotated as compound MoA.

8. If you find a construct that you're unsure whether it's an MoA or not, please note it in the annotation issues log

9. If you find a construct where you are unsure of which MoA class it best fits, please annotate it with the class you think is most likely to be right, but make a note of the issue in the annotation issues log

<u>Recording low and higher confidence for each annotation</u>

1. For each annotated MoA, also record whether the MoA's class could be judged with low or higher confidence.

   1.1 Record an annotation as **low confidence** if one of the following conditions applies: (1) no definition for an MoA is provided, OR (2) the definition is unclear, OR (3) only the label is provided and the label is unclear OR (4) the label, definition and/or measurement of an MoA do not match.
- Please select all the conditions that apply to your annotation.

2. Record an annotation as **higher confidence** when (1) the label and definition for an MoA are provided, clear and compatible, AND (2) if a measurement of the MoA is provided, then its measurement is compatible with the label and definition (i.e. the given measurement items can be a part of the defined MoA).
- Please do NOT record an annotation as high confidence if there is **no definition for the class**.

- The following extracts are examples of information given about the scale to measure an MoA, rather than being definitions of MoAs

       o *"Asthma knowledge was a 35-item yes/no scale including general knowledge about the nature of asthma disease, e.g., methods of preventing triggering events, signs/symptoms of asthma, and its environmental and pharmacological control"* (Chiang, Huang, Yeh, & Lu, 2004).

       o *"Self-efficacy was a 15-item six-point rating scale, including the parents' confidence with managing their child's asthma"* (Chiang et al., 2004).

  - *"Briefly, smoking- related knowledge was measured by 20 questions with 'Yes/No' responses about tobacco ingredients, smoking-associated diseases and other facts about smoking"* (Wen et al., 2010).

Guidance for using specific classes in the MoA Ontology

Anatomical structure= A material anatomical entity that is a single connected structure with inherent 3D shape generated by coordinated expression of the organism's own genome.

Only annotate anatomical structure if the MoA works through a change in an anatomical structure. For instance, if an intervention evaluation states that knee surgeries were carried out to change the leg's structure and thereby influence behaviour, 'anatomical structure' may be annotated.

Disposition= b is a disposition means: b is a realizable entity & b's bearer is some material entity & b is such that if it ceases to exist, then its bearer is physically changed, & b's realization occurs when and because this bearer is in some special physical circumstances, & this realization occurs in virtue of the bearer's physical make-up.

As "disposition" is a very high-level class, it is unlikely to be used to annotate MoAs in intervention evaluation reports.

Cognitive representation= A representation which specifically depends on an anatomical structure in the cognitive system of an organism.

In the MoA Ontology, a cognitive representation refers to the activated content of a mental disposition. For instance, when a person thinks about a "belief", the content of the belief that is being thought about is the cognitive representation.

- Only annotate "cognitive representation" if the intervention evaluation reports refer to momentary assessments of the activated content of mental dispositions (e.g., in reaction time tasks).

Mental plan vs. planning =

A "mental plan" is the outcome of process labelled as "planning" in the MoA Ontology. However, in intervention evaluation reports, the term "planning" can be used to refer to a "mental plan". If no definition is provided in a report, read which measurements were used to assess the MoA and accordingly annotate that MoA.

- For instance, in one paper: *"Action planning was measured by asking adolescents whether they had specified "when," "where," "how," and "how often" they would perform the focal sleep hygiene behaviors"* (Lin et al., 2018)

- In this report, the assessed MoA was the formed plans for a behaviour (Mental plan: "A mental disposition to form a representation of a behaviour, the conditions under which it will be enacted and an intention to enact the behaviour under those conditions.") rather than the planning process.

Behavioural intention vs. Mental plan =

If a behaviour change intervention report includes an MoA that is assessed by asking whether a person has formed a plan without further specifications, then annotate this MoA as "behavioural intention".

- However, if the measurement addresses whether a person has formed a plan that includes specific conditions, then consider coding "mental plan".

Belief about the consequences of behaviour vs. evaluative belief about the consequences of behaviour

In intervention reports, participants' beliefs are sometimes assessed by asking whether they think a positive outcome will occur as a result of behaviour. These measurement items assess beliefs about a valenced outcome. However, the items do not require participants to evaluate the outcomes as positive or negative by themselves. Unless such beliefs are defined differently, they should be annotated as "**belief about the consequences of behaviour**" and not "evaluative belief about the consequences of behaviour".

- For instance, one paper included the MoA "perceived positive outcome", which should be annotated as "belief about the consequences of a behaviour": *"Exploratory factor analyses revealed 2 unique factors among the 6 variables on attitudes: perceived positive outcomes (i.e., self-evaluations of likely consequences of behavior) and subjective norms (i.e., perceived prevalence of a behavior). ;;; agreed with the following statements about e-cigarettes: (1) "I would enjoy using e-cigarettes," (2) "Using e-cigarettes would help me to deal with problems or stress," (3) "Using e- cigarettes would help me make new friends," and (4) "Using e-cigarettes would help me wake up and feel energized*" (Kelder et al., 2020).

Environmental system vs. Belief about one's environment

Annotate "environmental system", when participants are asked objective information about their environment (e.g., "how many pathways are there for you to walk?") – even if a measure is based on self-report.
- However, if the information they are asked about is subjective (e.g., "How accessible are the walkways in your area?"), then we annotate these MoAs as "belief about one's environment".

Social influence process vs. Belief about social support vs Social environmental system vs social opportunity

For MoAs that are labelled as "social support" and not defined, check whether the measurement includes perceptions of social support (e.g., how supported the individual feels). If so, annotate "belief about social support"

- Otherwise, check whether the MoA's measurement only includes questions that objectively measure or asses the frequency of social support (e.g., how often a parent reminds their child about exercising)

    - For instance, in the following extract "*The scale measures how often participants received various types of support for PA from their family in the previous month (e.g., encouragement to stick to PA program, reminders to be active, co-participation in PA*)," support for PA would be annotated as "social influence process" (Young et al, 2016).

    - As the following extract asks participants about the frequency of social support, it should also be annotated as "social influence process": "*Abstinence-specific social support: Participants indicate on a 4-point scale how frequently their spouse, partner, or close friend provided positive support (e.g., "Helped me think of substitutes for smoking") and negative support (e.g., "Criticized my smoking") in the past 7 days*" (Hendricks, Delucchi, & Hall, 2010).

    - The following extract also asks participants about the frequency of social support and therefore should be annotated as "social influence process": "*Social support was evaluated via a five-item questionnaire [49] with participants rating how often others provide health behavior-related support/encouragement (1—almost never to 5—almost always)*" (Pope, Barr-Anderson, Lewis, Pereira, & Gao, 2019).

- Do not annotate "social opportunity" unless the norms or social characteristics of the environment that explicitly influence behaviour have changed.

- Only annotate "social environmental system" if the social environment (e.g., "social networks") have changed.

Only label provided for 'social support' in intervention reports

The term "social support" is used to label beliefs about social support and actual social support in an environment. When no definition or measurement is provided for an MoA labelled as "social support", this MoA should be annotated using the class **"social influence process"** based strictly on the label.

Pain

Pain can only be measured through a perception of pain. Therefore, instances of "perceived pain" should be annotated as "pain".

- For instance, in the following extract, perceived pain should be annotated using the class "pain": "*Subjective experience of exercise: Perceived pain experienced during exercise was assessed using a single-item 12-point Borg CR10 scale ranging from 0 (no pain at all) to 10 (extremely intense pain) [38]*" (Bryan et al., 2013).

Affective process vs. Emotional process

Emotion process has an object, whereas the parent class affective process also captures

processes that are experienced but not necessarily about or in response to anything (e.g.,

mood).

- For instance, in the following extract, participant's feelings about the PE class, "positive and negative affect" should be annotated as "emotion process": "*Positive and negative affect was assessed on a 9 item scale (e.g. in this PE class I feel happy)*" (Smith et al., 2015).

Depression, anxiety and stress

If depression and anxiety are referred to in terms of symptoms (without further specification) rather than emotional processes, then annotate depression and anxiety as compound MoA. Symptoms can include behavioural and emotional processes, so without further information we cannot annotate depression, anxiety or stress more granularly, see example in the following extract:

- "*The DASS (Lovibond & Lovibond, 1995) is a self-report survey designed to measure symptoms of depression, anxiety and stress. Each of the three DASS scales contains seven items and participants are asked to use 4-point scales to rate the extent to which they have experienced each emotional state over the past week; scores for de-pression, anxiety and stress are calculated by summing the scores*" (Murphy et al., 2019).

Only label provided for "attitude" in intervention reports

If no definition or measurement is provided for "attitude" in an intervention report, annotate this MoA as "**mental disposition**", as the term "attitude" can be used for mental dispositions that involve affective, mental and behavioural components.

- In the following extract, "attitude" should be annotated as "mental disposition": "*We designed this questionnaire to elicit information on the behavioral con-*

structs identified within the TPB model, including: knowledge of environmental issues and behaviors; attitudes towards pro-environmental actions; subjective social norms around performing pro-environmental behaviors; and perceived control of wider environmental issues (Appendixes 1 and 2)" (Dunn, Mills, & Veríssimo, 2020).

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Appendix 6-2. Key terms searched for to identify behaviour change intervention reports to annotate from COCHRANE Central and Web of Science

No.	Search term	Fields searched	Justification of search at each step
1	theory or theoretical	All	Identifying studies using on theories
2	behaviour* or behavior* or action*	Title or abstract	Identifying studies with a behavioural outcome. By including 'action' as a search term, sociological papers could be identified.
3	intervention* or program* or practice* or policy or policies	Title or abstract	Identifying studies about interventions. Broad terms were used to include different types of interventions.
4	mediat* or moderat* or influenc* or mechanism* or domain* or determinant* or variable*	Title or abstract	Identifying studies that specify and assess relationships between aspects of the behaviour change intervention, including between behaviour change techniques, MoAs and behaviours.
5	(random* adj control* adj (trial OR study)) OR (clinical adj trial) OR (compar* adj (group OR study OR trial)) OR (control* adj (group OR study OR trial)) OR (match* adj (group OR study OR trial)) OR (random* adj assign*)	Title or abstract	Identifying intervention evaluations with at least two groups in Web of Science.
6	Not protocol	Title	Excluding protocols where possible
7	Not systematic review	Title	Excluding systematic reviews from the Web of Science where possible

Appendix 6-3. The MoA Ontology refined through annotations of hypothesised MoAs in intervention reports

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
Anatomical structure UBERON:0000061								A material anatomical entity that is a single connected structure with inherent 3D shape generated by coordinated expression of the organism's own genome.
Environmental system ENVO:01000254								A system which has the disposition to surround and interact with one or more material entities.
	Social environment system BCIO:006001							An environmental system that consists of people, social and cultural institutions and processes involving these that influence the life of people and social groups.
		Family environment system BCIO:006002						A social environmental system that consists of persons related as members of a domestic group, or a number of domestic groups linked through descent from a common ancestor, marriage, or adoption.
		Friendship network BCIO:006003						A social environmental system that consists of persons who share a bond of mutual affection and are in contact or communication among which transmission of knowledge, behaviour, values or of an infectious agent is possible.
Disposition BFO:0000016								b is a disposition means: b is a realizable entity & b's bearer is some material entity & b is such that if it ceases to exist, then its bearer is physically changed, & b's realization occurs when and because this bearer is in some special physical circumstances, & this realization occurs in virtue of the bearer's physical make-up.
	Bodily disposition MF:0000032							A disposition that inheres in some extended organism.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
		Personal capability MF:0000043						A disposition inhering in an organism whose realization in the normal case brings benefits to an organism or group of organisms, where "in the normal case" means not only in the normal range on the scale, but also in a context which is normal for the group to which the bearer or user belongs.
			Mental capability MF:0000048					A capability that necessarily includes mental processes in its realisation.
				Mental skill BCIO:006004				A mental capability acquired through training and practice.
				Self-regulation capability BCIO:006005				A mental capability that involves processes that modulate the frequency, rate or extent of a response to external or internal stimuli and that are instigated by the person themselves.
					Behavioural self-regulation capability BCIO:006006			A self-regulation capability to modulate one's behaviour.
					Cognitive self-regulation capability BCIO:006007			A self-regulation capability to modulate one's cognitive processes.
					Emotional self-regulation capability BCIO:006008			A self-regulation capability to modulate one's emotions.
			Physical capability BCIO:006009					A capability to perform a behaviour by virtue of muscular-skeleton attributes or psychomotor control

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
				Physical skill BCIO:006010				A physical capability acquired through training and practice.
			Social capability BCIO:006011					A capability to engage in interpersonal processes that influence ability to perform a behaviour, when appropriate circumstances occur.
				Social skill BCIO:006012				A social capability acquired through training and practice.
		Mental disposition MF:0000033						A bodily disposition that is realized in a mental process.
			Addiction ADDICTO:0000349					A chronic acquired mental disorder involving repeated abnormally powerful motivation to engage in a behaviour despite risk or experience of harm.
			Alienation BCIO:006014					A mental disposition to perceive or experience oneself as isolated from and not meaningfully involved in social groups.
			Awareness BCIO:006015					A mental disposition to be conscious of events, objects or sensory patterns.
			Behavioural intention BCIO:006016					A mental disposition that is a commitment to enact or not enact a behaviour.
			Belief MF:0000041					A disposition to mental processes that represent some proposition X to be true.
				Belief about anticipated emotion BCIO:006140				A belief about the potential emotional processes experienced as result of an event.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
				Belief about barriers BCIO:006017				A belief about the extent to which factors exist that could restrict or impede the person from engaging in a behaviour.
				Belief about conformity to behavioural norms BCIO:006018				A belief about the extent to which one's own behaviour is similar to that of referent others.
				Belief about consequences of behaviour BCIO:006019				A belief about the outcomes resulting from a behaviour.
					Belief about social consequences of behaviour BCIO:006020			A belief about the outcomes of a behaviour in terms of social processes or attributes.
				Belief about consequences of goal attainment BCIO:006021				A belief about the outcomes resulting from achieving a goal.
				Belief about control over one's future BCIO:006022				A belief about the extent to which one can direct what happens in one's future.
				Belief about gain BCIO:006023				A belief about the existence of an increase from an initial reference point.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
				Belief about likelihood of potential outcomes BCIO:006026				A belief about the probability that a given event or state will occur in the future.
					Belief about likelihood of consequences of behaviour BCIO:006024			A belief about the likelihood a particular behaviour will result in particular outcomes.
						Belief about likelihood of health consequences of behaviour BCIO:006025		A belief about the likelihood of a behaviour resulting in a change in a threat to health and wellbeing.
				Belief about loss BCIO:006027				A belief about the existence of a decrease from an initial reference point.
				Belief about message BCIO:006141				A belief regarding aspects of a verbal, graphic, written or recorded communication.
					Belief about the credibility of a message's source BCIO:006142			A belief about whether a verbal, graphic, written or recorded communication is provided by people or institutions who are trustworthy.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
					Belief about message relevance BCIO:006028			A belief regarding whether the content of a verbal, graphic, written or recorded communication is relevant to oneself.
					Belief about message trustworthiness BCIO:006143			A belief about whether a verbal, graphic, written or recorded communication provides reliable information.
				Belief about need satisfaction BCIO:006144				A belief regarding whether one's psychological needs have been met.
				Belief about one's environment BCIO:006029				A belief about the nature of the immediate physical and social settings in which people live, including culture and the people and institutions with whom they interact.
					Belief about one's social environment BCIO:006145			A belief about the aspects of one's immediate social settings in which people live, including culture and the people and institutions with whom they interact.
						Belief about social support BCIO:006146		A belief about whether others will provide assistance or comfort to help the person cope with one or more stressors.
						Perceived norm BCIO:006039		A belief about what is typical for people who belong to a particular social group.
							Perceived descriptive norm	A belief about the prevalence of performance of a given behaviour by people within a group.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
							BCIO:006040	
							Perceived injunctive norm BCIO:006041	A belief about whether a behaviour is appropriate and correct for people who belong to a particular social group.
							Normative belief BCIO:006042	A belief about whether important others think one should perform a behaviour.
				Belief about responsibility to act BCIO:0050001				A belief about whether someone is obliged to take a certain course of action.
				Belief about severity of an outcome BCIO:006030				A belief about how serious the harm associated with an outcome could be.
				Belief about susceptibility to a threat BCIO:0050002				A belief about vulnerability to a threat.
					Belief about personal susceptibility BCIO:006031			A belief about how vulnerable one is to a threat.
					Belief about others' susceptibility			A belief about how vulnerable others are to a threat.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
					BCIO:005000 0			
				Belief about the timing of the consequences of behaviour BCIO:006033				A belief about how long after the performance of behaviour particular consequences will occur.
				Belief about threat BCIO:0050003				A belief about a potential harm.
				Belief about voluntariness of behaviour BCIO:006034				A belief about the extent to which one is free to choose whether to perform the behaviour.
				Evaluative belief BCIO:006038				A belief about whether a particular aspect of the world is positive or negative.
					Evaluation of self BCIO:006035			An evaluative belief about one's attributes.
						Positive evaluation of self BCIO:006036		A belief about one's positive attributes.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
						Negative evaluation of self BCIO:006037		A belief about one's negative attributes.
					Evaluative belief about behaviour BCIO:006147			An evaluative belief about whether a behaviour is positive or negative.
					Evaluative belief about behavioural outcomes BCIO:006148			A belief about whether the consequences of the behaviour are positive or negative.
						Belief about the personal desirability of consequences of behaviour BCIO:006149		A belief about the worth of the outcomes of a behaviour to oneself.
					Evaluative belief about others BCIO:006150			An evaluative belief about the attributes of others.
					Evaluative belief about a stereotype BCIO:006151			An evaluative belief about a set of attributes considered to generally inhere in the members of a social group.
				Belief about control over behaviour				A belief about one's capabilities and opportunities within an environmental system to perform a behaviour or achieve the outcomes resulting from a behaviour.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
				BCIO:006152				
					Belief about control over the environment BCIO:006153			A belief about one's resources and opportunities within an environment to perform a behaviour.
					Self-efficacy belief BCIO:006043			A belief about one's capabilities to organise and execute a behaviour and achieve the outcomes associated with this behaviour.
					Self-efficacy belief for a behaviour BCIO:006154			A belief about one's capabilities to organise and execute a behaviour.
						Situational self-efficacy belief for a behaviour BCIO:006044		Self-efficacy belief for a behaviour under certain conditions.
			Cognitive schema BCIO:006045					A mental disposition about an entity that guides perception, thought or behaviour.
				Action schema BCIO:006046				A cognitive schema that guides a sequence of behaviours.
			Decision BCIO:006047					A mental disposition to represent one proposition as preferred from at least two.
				Behavioural decision BCIO:006048				A decision that one behaviour is preferred from at least two behavioural options.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
			Goal BCIO:006049					A mental disposition to strive towards an end state.
			Identity BCIO:006050					A mental disposition relating to perceptions of oneself.
				Social identity BCIO:006051				Identity that is associated with the sense of belonging to a social group.
			Knowledge BCIO:006052					A mental disposition to understand the nature of the world, or a specific aspect of the world, that corresponds to the actual state of the world and is acquired through experience or learning.
				Knowledge regarding a behaviour BCIO:006053				Knowledge regarding a particular set of actions.
				Knowledge regarding an innovation BCIO:006054				Knowledge regarding a novel invention or way of doing something.
				Knowledge regarding a threat BCIO:006055				Knowledge regarding a potential harm.
				Knowledge regarding treatment BCIO:006056				Knowledge regarding a therapy or medication for a health problem.
			Learned stimulus-response co-occurrence					A mental disposition to think and behave in a particular way in response to an event in a person's environment, which is acquired through associative learning.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
			BCIO:006057					
				Learned stimulus-behaviour co-occurrence BCIO:006155				A mental disposition to behave in a particular way in response to an event in a person's environment, which is acquired through habit learning.
				Learned stimulus-thought co-occurrence BCIO:006156				A mental disposition to think in a particular way in response to an event in a person's environment.
			Mental image disposition BCIO:006058					A mental disposition to represent a mental image.
			Willingness to comply BCIO:006059					A mental disposition to be inclined to act in accordance with the likely approval of others
			Motivational orientation BCIO:006060					A mental disposition for motivation to be guided by a focus on the presence or absence of outcomes of a certain valence.
				Prevention focused motivational orientation BCIO:006061				A mental disposition for motivation to be guided by a focus on the presence or absence of negative outcomes.
				Promotion focused motivational orientation				A mental disposition for motivation to be guided by a focus on the presence or absence of positive outcomes.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
				BCIO:006062				
			Personal value BCIO:006063					A mental disposition regarding what is fundamentally important in life and which informs standards for behaviour.
			Psychological need BCIO:006064					A mental disposition of a person to act to obtain or maintain a particular state due to this state's importance to the person's wellbeing.
				Autonomy need BCIO:006065				A psychological need to have a sense of personal agency and initiative.
				Need for self-esteem BCIO:006066				A psychological need to have a positive evaluation of oneself and one's qualities and characteristics.
				Need for sense of security BCIO:006067				A psychological need to feel safe from threats.
				Need for social relatedness BCIO:006068				A psychological need to have caring relationships with other people.
				Need to feel competent BCIO:006069				A psychological need to experience oneself as able and effective.
			Mental plan BCIO:006070					A mental disposition to form a representation of a behaviour, the conditions under which it will be enacted and an intention to enact the behaviour under those conditions.
				Mental plan for coping with barriers				A mental plan regarding a strategy to deal with conditions that could prevent the performance of a behaviour.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
				BCIO:006157				
			Self-concept BCIO:006071					A mental disposition to represent oneself as having particular qualities and characteristics.
			Stereotype BCIO:006072					A mental disposition to represent attributes of members of a social group as shared by the virtue of their group membership.
				Risk stereotype BCIO:006072				A stereotype of a person who enacts a problem behaviour.
			Social embeddedness BCIO:006074					A mental disposition to experience a feeling of being connected by social attachments.
			Subjective need BCIO:006075					A mental disposition to experience a feeling of anticipated relief from, or avoidance of, mental or physical discomfort.
			Temporal orientation BCIO:006076					A mental disposition to focus more on present or future outcomes.
	Emotional action tendency MFOEM:000007							A disposition to behaviour that inheres in an organism by virtue of the physical changes brought about by an emotion process .
Representation MF:0000030								A dependent continuant which is about a portion of reality.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
	Cognitive representation MF:0000031							A representation which specifically depends on an anatomical structure in the cognitive system of an organism.
		Appraisal MFOEM:000005						A cognitive representation which represents an evaluation of the relevance of some triggering object or event to the organism.
			Appraisal of causal agency MFOEM:000075					An appraisal that represents an evaluation of who or what caused an event.
				Appraisal as caused by self MFOEM:000076				An appraisal that represents an evaluation that an event was caused by the self.
				Appraisal as caused by factors external to the person BCIO:006077				An appraisal that represents an evaluation that an event was caused by factors external to the person.
			Appraisal of dangerousness MFOEM:000103					An appraisal which represents an evaluation of the dangerousness of an object or situation.
			Appraisal of expectedness MFOEM:000060					An appraisal that represents an evaluation of whether an event was expected to occur.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
			Appraisal of obligation to act BCIO:006078					An appraisal that represents an evaluation of how much one is personally obliged to respond to an event or person in need.
		Desired standard BCIO:006079						A cognitive representation of a reference level that an individual wishes to obtain.
		Mental image BCIO:006080						A cognitive representation of the visual appearance of some objects or events when these are not immediately present to the senses.
Role BFO:0000023								b is a role means: b is a realizable entity & b exists because there is some single bearer that is in some special physical, social, or institutional set of circumstances in which this bearer does not have to be& b is not such that, if it ceases to exist, then the physical make-up of the bearer is thereby changed.
	Personal role BCIO:006081							A role that inheres in a human being by virtue of their social and institutional circumstances.
		Personal social role BCIO:006082						A personal role that is realised in human social processes.
			Occupational role BCIO:006083					A social role that involves the person's occupation.
		Personal financial resource BCIO:006084						A personal role in which the individual has access to a material or an immaterial entity which may confer economic benefits.
Quality								A dependent entity that inheres in a bearer by virtue of how the bearer is related to other entities.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
BFO:000001 9								
	Bodily quality MF:0000074							A quality that inheres in some extended organism.
		Mental quality MF:0000075						A bodily quality that inheres in those structures of the extended organism that are essential for mental functioning.
	Location BCIO:006085							A spatial quality inhering in a bearer by virtue of the bearer's spatial location relative to other objects in the vicinity.
	Opportunity BCIO:006086							A quality of a person's environmental system that makes a behaviour possible or facilitates it.
		Financial opportunity BCIO:006087						An opportunity regarding whether the person has sufficient financial resources to enact a behaviour.
		Healthcare service accessibility BCIO:006088						An opportunity regarding how easy it is for a person to approach and use a healthcare service.
		Physical opportunity BCIO:006089						An opportunity of the physical environmental system that makes a behaviour possible or facilitates it.
		Social opportunity BCIO:006090						An opportunity of the social environment system that influences the performance of a behaviour.
		Temporal opportunity BCIO:006091						An opportunity regarding whether the person has sufficient time to enact a behaviour in the social and physical environment.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
Bodily process OGMS:0000060								A process in which at least one bodily component of an organism participates.
	Bodily behavioural cue BCIO:006092							A stimulus that arises from bodily processes and serves to elicit or guide behaviour.
		Mental behavioural cue BCIO:006093						A stimulus that arises from mental processes and serves to elicit or guide behaviour.
	Individual human behaviour BCIO:006094							Individual human activity that involves co-ordinated contraction of striated muscles controlled by the brain.
		Habitual behaviour BCIO:006158						A behaviour that is strongly influenced by a learnt stimulus-behaviour association.
		Normative behaviour BCIO:006095						An individual human behaviour that is commonly enacted by people that are part of a social environmental system.
	Goal pursuit process BCIO:006096							A bodily process in which attempts are made to achieve a desired end state.
	Interpersonal process MF:0000021							A process in which at least two human beings are agents.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
		Communication MF:0000040						An interpersonal process that involves the transmission of information between two organisms.
			Linguistic communication MF:0000086					A communication process in which the information that is communicated is enannotated in language.
			Non-linguistic communication MF:0000089					A communication process in which information is transmitted without being enannotated in the meaning units of any language.
			Interpersonal reciprocal communication BCIO:006097					Communication that is mutual between two or more people.
				Behaviour-influencing social interaction process BCIO:006098				An interpersonal process in which one person's reciprocal communication with one or more others may facilitate or hinder the person's behaviour.
		Social influence process BCIO:006099						An interpersonal process where one or more person exerts an influence on the behaviour of another.
	Internal reward for a response BCIO:006100							A process by which the person experiences an internally-generated positive physical or psychological state subsequent to a response.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
	Experiential rightness of goal pursuit BCIO:006101							A process by which the manner in which one attempts to achieve a goal creates an experiential sense of rightness associated with pursuing the goal, which in turn increases task engagement.
	Physiological response to emotion process MFOEM:000003							A bodily process which encompasses all the neurophysiological changes caused by the appraisal, which take place in the central nervous system (CNS), neuro-endocrine system (NES) and autonomous nervous system (ANS).
	Plan enactment BCIO:006102							A process by which a person attempts to follow the steps in a plan.
	Self-regulation of behaviour BCIO:006103							A bodily process that modulates the frequency, rate or extent of behaviour, the specific actions or reactions of an organism in response to external or internal stimuli and that is instigated by the organism itself.
		Behavioural self-regulation of behaviour BCIO:006104						A behaviour undertaken to modulate the frequency, rate or extent of a different behaviour, the specific actions or reactions of an organism in response to external or internal stimuli, and that is instigated by the organism itself.
		Introjected self-regulation BCIO:006105						Self-regulation undertaken to manage a sense of guilt, anxiety or obligation.
		Self-reinforcing self-regulation						A bodily process that modulates the frequency, rate or extent of behaviour through self-administering a reward for performing an intended behaviour.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
		BCIO:006106						
		Value-congruent self-regulation BCIO:006107						Self-regulation undertaken to achieve congruence between one's values and the behaviour performed.
	Mental process MF:0000020							A bodily process that is of a type such that it can of itself be conscious.
		Affective process MFOEM:000195						Any process that has positive or negative valence.
			Bodily feeling MFOEM:000202					An affective process involving sensory experience of physiological stimuli.
				Pain MFOEM:000203				A bodily process in an organism S, involving two integrated levels: (a) activation of the nociceptive system and associated emotion generating brain components of S, and (b) a simultaneous aversive sensory and emotional experience on the part of S, where (b) is phenomenologically similar to the sort of aversive experience involved in pain with concordant tissue damage.
			Emotion process MFOEM:000001					A mental process that is a synchronized aggregate of constituent mental processes, including an appraisal process, which is valanced, has an object, and gives rise to an action tendency
				Anger MFOEM:000009				A negative emotion, characterised by feelings of unpleasantness and high arousal, in the form of antagonistic feelings and action tendencies.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
				Anxiety MFOEM:000028				An emotion that is negative, aversive and provoked by the prospect of distal future threat.
				Disgust MFOEM:000019				A negative emotion which guards the body against dangerous foods and microbial infections.
				Fear MFOEM:000026				An activated, aversive emotion that motivates attempts to cope with events that provide threats to the survival or well-being of organisms.
				Feeling nervous MFOEM:000124				A subjective feeling of being not at ease, of being anxious or nervous or agitated.
				Guilt MFOEM:000053				A self-evaluative emotion that occurs when a person brings about a negative outcome by acts of commission or omission .
				Happiness MFOEM:000042				A positive emotion which is experienced in reaction to a positive experience or event.
				Pleasure MFOEM:000035				A positively experienced emotion which is sought out (approached) and is associated with happiness, enjoyment, and satisfaction.
					Sexual pleasure MFOEM:000040			A positively experienced emotion which is sought out (approached) and is associated with happiness, enjoyment, and satisfaction as a result of sexual activities.
					Enjoyment of behaviour			Pleasure that is experienced as a result of engaging in a behaviour.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
					BCIO:006159			
				Sadness MFOEM:000056				A negative emotion felt when an event is appraised as unpleasant, obstructive to one's goals and concerns, and one feels unable to cope with it or modify it.
				Shame MFOEM:000055				A negative emotion that is distressing and occurs when one appraises one's behaviour or circumstance as wrong, dishonourable, immodest or indecorous.
				Surprise MFOEM:000032				A neutral emotion caused by encountering unexpected events of all kinds.
			Subjective emotional feeling MFOEM:000006					A (fiat) part of the emotion process by which the organism experiences its own emotion.
				Cognitive dissonance BCIO:006108				An unpleasant subjective emotional feeling experienced due to perceived inconsistency between two concurrently held cognitive representations.
				Craving BCIO:006160				A subjective experience of powerful want or need for something or urge to engage in a behaviour.
				Feeling an urge BCIO:006109				A subjective emotional feeling that arises when an impulse to enact a behaviour is activated but not immediately acted upon.
		Appraisal process MFOEM:000002						A mental process that gives rise to an appraisal.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
		Arousal MF:0000012						A physiological and psychological state of being awake or reactive to stimuli.
		Attending MF:0000018						A mental process whereby relevant aspects of our mental experience are focused on specific targets.
		Avoidance mental process BCIO:006161						A mental process that reduces the frequency by which an aversive cognitive representation is evoked.
		Cognitive process MF:0000008						A mental process that creates, modifies or has as participant some cognitive representation.
			Comprehension BCIO:006110					A cognitive process that creates a representation of the meaning and significance of a communication, object, event or situation.
			Decision simplification BCIO:006111					A cognitive process that simplifies decision making.
			Mental distancing BCIO:006162					A cognitive process that involves detaching oneself from one's immediate thoughts.
				Targeted mental distancing BCIO:006163				Mental distancing that involves identifying particular immediate thoughts and detaching from these thoughts.
			Thinking MF:0000013					A cognitive process that involves the manipulation of mental language and/or mental images.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
				Reflective thinking BCIO:006112				Thinking that involves generation of inferences based on syllogistic reasoning or decision making based on the evaluation of anticipated consequences or the construction of propositional representations.
		Dissonance reduction process BCIO:006113						A mental process through which a perceived inconsistency between two concurrently held cognitive representations is reduced.
		Goal setting process BCIO:006114						A mental process that establishes a cognitive representation of the end state to which one is striving.
		Heuristic process BCIO:006115						A mental process that uses simple rules and associations learnt from experience to make judgements.
		Judging MF:0000006						A mental process during which evidence is evaluated, the outcome of which is a belief or opinion.
			Decision-making BCIO:006116					Judging during which a decision is created.
			Judging consequences of behaviour BCIO:006117					Judging during which a belief about the consequences of a behaviour is created or modified.
			Social comparison process BCIO:006118					Judging oneself or one's social group in relation to the qualities or characteristics of another person or social group.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
		Learning GO:0007612						Any process in an organism in which a relatively long-lasting adaptive behavioural change occurs as the result of experience.
			Associative learning BCIO:006119					Learning that involves changing strength of association between two or more mental processes.
				Classical conditioning BCIO:006120				Associative learning that occurs when the pairing of a conditioned and unconditioned stimulus leads to the conditioned stimulus producing a response that would otherwise have only been produced by the unconditioned stimulus.
				Discrimination learning BCIO:006121				Associative learning process in which people learn to distinguish between appropriate responses to similar but different stimuli depending on whether a generalised response is rewarded or not.
				Extinction in classical conditioning BCIO:006122				Associative learning process in which the strength of a conditioned response is reduced because its conditioned stimulus is presented without being accompanied by the unconditioned stimulus.
				Extinction in operant learning BCIO:006123				Associative learning process in which the rate of behavioural response in the presence of a discriminative stimulus is reduced because the response is no longer followed by a positive reinforcer.
				Generalisation (learning) BCIO:006124				Process in which the effects of conditioning on behaviour spread to stimuli that differ in certain aspects from the stimulus present during the original conditioning.
				Habit learning BCIO:0050004				Associative learning that involves strengthening an association between a stimulus and an impulse through repetition of co-occurrence of the stimulus and the behaviour.
				Operant conditioning BCIO:006125				Associative learning in which the likelihood of a particular behavioural response is influenced by the past consequences associated with performing that behaviour.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
			Non-associative learning GO:0046958					A simple form of learning whereby the repeated presence of a stimulus leads to a change in the probability or strength of the response to that stimulus. There is no association of one type of stimulus with another, rather it is a generalized response to the environment.
				Habituation GO:0046959				A decrease in a behavioural response to a repeated stimulus.
				Sensitization GO:0046960				An increase in a behavioural response to a repeated stimulus.
			Observational learning GO:0098597					Learning that occurs through observing the behaviour of others.
				Imitative learning GO:0098596				Learning in which new behaviours are acquired through imitation.
		Memory GO:0007613						The activities involved in the mental information processing system that receives (registers), modifies, stores, and retrieves informational stimuli.
			Associative memory BCIO:006126					The activities involved in the mental information processing system that receives (registers), modifies, stores, and retrieves informational stimuli regarding the set of entities associated with a particular object or event.
			Episodic memory BCIO:006127					The activities involved in the mental information processing system that receives (registers), modifies, stores, and retrieves informational stimuli regarding a personally experienced event at a particular time or place.
			Semantic memory BCIO:006128					The activities involved in the mental information processing system that receives (registers), modifies, stores, and retrieves meanings, understandings, and conceptual facts about the world

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
			Procedural memory BCIO:006129					The activities involved in the mental information processing system that receives (registers), modifies, stores, and automatically retrieves informational stimuli regarding how to perform a complex activity without conscious awareness
			Iconic memory BCIO:006130					The activities involved in the mental information processing system that receives (registers), modifies, stores, and retrieves very brief sensory memory of some visual stimuli
		Mental categorising BCIO:006131						A mental process in which objects, events, people, or experiences are grouped into classes, on the basis of features shared by members of the same class and features distinguishing the members of one class from those of another.
		Mental imagery MF:0000083						A mental process that evokes the visual representation of objects or events when these are not immediately present to the senses.
		Mentally comparing against a standard BCIO:006132						A mental process in which current conditions are compared against a particular reference level.
		Motivation BCIO:006133						A mental process that energises and directs behaviour.
			Automatic motivation BCIO:006134					A mental process that energises and directs behaviour via emotions and impulses that arise from associative learning or innate dispositions.
			Autonomous motivation BCIO:0050001					Motivation that is internally generated and based on a behaviour being interesting or valuable to an individual.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
				Intrinsic motivation BCIO:006136				Autonomous motivation due to a behaviour's inherent enjoyment or satisfaction for oneself.
				Fundamental need-based motivation BCIO:0050004				Autonomous motivation for behaviours that are perceived as satisfying core psychological needs.
				Behavioural importance-based motivation BCIO:0050002				Autonomous motivation due to the perceived value or importance of the behaviour to oneself.
			Controlled motivation BCIO:0050003					Motivation that is based on rewards, approval or punishments regarding a behaviour.
				Extrinsic motivation BCIO:006135				Controlled motivation due to externally administered rewards, approval or punishments.
				Approval-based motivation BCIO:0050000				Controlled motivation to gain or maintain a positive evaluation of self or feel others approval of oneself.
		Perception MF:0000019						A mental process which is a) produced by a causal process (for example involving light rays or air vibrations) involving a part of the environment of the organism, and b) is experienced by the organism as being so caused, and c) in which the relevant part of the environment is thereby represented to the organism.
		Planning MF:0000027						A mental process that involves mentally manipulating representations of steps in an imagined process which has some objective.

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
		Self-monitoring BCIO:006137						A mental process in which one observes and evaluates one's own behaviour.
		Wanting MF:0000045						A mental process that involves thinking about a state of affairs that does not yet obtain together with a desire for that state of affairs to obtain.
	Subliminal process MF:0000088							A bodily process that involves neuronal activity in response to a sensory stimulus but which is not the subject of consciousness.
Process profile BFO:0000144								b is a process_profile =Def. there is some process c such that b process_profile_of c.
	Consciousness MF:0000017							That part of the mental process that confers a subjective perspective, a phenomenology, an experience of the mental process of which it is a part; and intends the object or event that the mental process is about, should such exist; it confers intentionality on the mental process.

Appendix 6-4. Synonyms, examples or comments added for classes in the MoA Ontology

No.	Label	Definition	Added synonym	Added example or comment
1	Fundamental need-based motivation*	Autonomous motivation for behaviours that are perceived as satisfying core psychological needs.	Integrated motivation; Integrated regulation	
2	Behavioural importance-based motivation*	Autonomous motivation due to the perceived value or importance of the behaviour to oneself.	Identified motivation; identified regulation	
3	Approval-based motivation*	Controlled motivation to gain or maintain a positive evaluation of self or feel others approval of oneself.	Introjected motivation; introjected regulation	
4	Evaluative belief about behavioural outcomes	A belief about whether the consequences of the behaviour are positive or negative.	Evaluative beliefs about the consequences of behaviour	
5	Learned stimulus-response co-occurrence	A mental disposition to respond in a particular way to an event in a person's environment, which is acquired through an associative learning process.		**Comment:** The responses to an event can include thinking and impulses to respond.
6	Extrinsic motivation	Controlled motivation due to externally administered rewards, approval or punishments.	External motivation	
7	Belief about consequences of behaviour	A belief about the outcomes resulting from a behaviour.	Response efficacy	
8	Belief about severity of an outcome	A belief about how serious the harm associated with an outcome could be.	Belief about threat severity	
9	Mental plan	A mental disposition to form a representation of a behaviour, the conditions under which it will be enacted and an intention to enact the behaviour under those conditions.	Action plan	
10	Pleasure	A positively experienced emotion which is sought out (approached) and is associated with happiness, enjoyment, and satisfaction.	Enjoyment	
11	Willingness to comply	A mental disposition to be inclined to act in accordance with the likely approval of others	Motivation to comply	
12	Psychological need	A mental disposition of a person to act to obtain or maintain a particular state due to this state's importance to the person's wellbeing.		**Comment:** Psychological needs can be satisfied or thwarted.
13	Social influence process**	An interpersonal process where one or more person exerts an influence on the behaviour of another.		**Example:** Social support from social network
14	Cognitive representation**	A representation which specifically depends on an anatomical structure in the cognitive system of an organism.		**Comment:** When a mental disposition is activated, the content of that belief is a cognitive representation.

Notes. *Classes added to the MoA Ontology in the current study
**Classes that were unchanged apart from the example and comment added to these classes

Appendix 7-1. The countries in which potential participants worked

Country in which the potential participants' institutions were based in	No.
United States	285
United Kingdom	69
Canada	36
Netherlands	31
Australia	28
Germany	21
Ireland	12
France	8
Italy	7
Spain	7
Malta	3
Sweden	3
Norway	2
Portugal	2
Austria	1
Belgium	1
Finland	1
New Zealand	1
Poland	1
Serbia	1
Singapore	1
South Africa	1
South Australia	1
Switzerland	1
Taiwan	1

Appendix 7-2. Potential participants selectively approached during recruitment

Recruitment Round 1				
Country	**No. of people**	**Proportion of no. people from country/ Total no. of people**	**No. people from country approached / Total people approached**	**No. of people to be approached from country**	**No. of people approached from country/People identified from country**
United States	285	0.54286	0.36	18	0.063157895
United Kingdom	69	0.13143	0.1	5	0.072463768
Canada	36	0.06857	0.06	3	0.083333333
Netherlands	31	0.05905	0.06	3	0.096774194
Australia	29	0.05524	0.06	3	0.103448276
Germany	21	0.04	0.04	2	0.095238095
Ireland	12	0.02286	0.02	1	0.083333333
Rest of the world	42	0.08	0.3	15	0.357142857

Recruitment Round 2				
Country	**No. of people**	**Proportion of no. people from country/ Total no. of people**	**No. people from country approached / Total people approached**	**No. of people to be approached from country**	**No. of people approached from country/People identified from country**
United States	267	0.562105	0.38	19	0.001423
United Kingdom	64	0.134737	0.1	5	0.001563
Canada	33	0.069474	0.08	4	0.002424
Netherlands	28	0.058947	0.06	3	0.002143
Australia	26	0.054737	0.04	2	0.001538
Germany	19	0.04	0.04	2	0.002105
Ireland	11	0.023158	0.02	1	0.001818
Rest of the world	27	0.056842	0.28	14	0.01037

		Recruitment Round 3				
Country	No. of people	Proportion of no. people from country/ Total no. of people	No. people from country approached / Total people approached	No. of people to be approached from country	No. of people approached from country/People identified from country	Rationale for contacting fewer people from a specific country
United States	248	0.58352941	0.48	24	0.096774194	
United Kingdom	59	0.13882353	0	0	0	4 eligible potential participants already agreed to participate from the UK
Canada	29	0.06823529	0.06	3	0.103448276	1 eligible potential participant already agreed to participate from Canada
Netherlands	25	0.05882353	0.12	6	0.24	
Australia	24	0.05647059	0.12	6	0.25	
Germany	17	0.04	0.08	4	0.235294118	
Ireland	10	0.02352941	0.04	2	0.2	
Rest of the world	13	0.03058824	0.1	5	0.384615385	Potential participants were not contacted when someone from their country already agreed to participate in the study.

Appendix 7-3. Screening questions for participants

1. Do you have a PhD or equivalent degree? If you specialised in a subject, please specify this in the space below.

2. Please list three publications that you were a lead author (first, second or corresponding author) on relating to (a) developing, refining or evaluating behavioural theories, (b) interventions using behavioural theories or (c) systematic reviews, scoping reviews or meta-analysis of interventions using theory. At least one of these studies should have been published in the last five years.
   Instead of listing studies, you can also provide us with your Orcid-ID in the space below, and we will identify the relevant studies for you.

3. Please specify in which country the institution you most recently worked on behavioural research is based. If you work at two or more institutions, please note down the location of the institution that relates most closely to your work in behaviour change.

4. Have you co-authored any papers with the main developers of the MoA Ontology (Alison Wright, Susan Michie, Robert West, Janna Hastings and Paulina Schenk) since 2018, or do you work at University College London? Please respond with 'Yes' or 'No'.

Appendix 7-4. MoA Ontology blocks presented to participants

Block 1 of the MoA Ontology presented to participants

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
Anatomical structure								A material anatomical entity that is a single connected structure with inherent 3D shape generated by coordinated expression of the organism's own genome.
Environmental system								A system which has the disposition to surround and interact with one or more material entities.
	Social environment system							An environmental system that consists of people, social and cultural institutions and processes involving these that influence the life of people and social groups.
		Family environment system						A social environmental system that consists of persons related as members of a domestic group, or a number of domestic groups linked through descent from a common ancestor, marriage, or adoption.
		Friendship network						A social environmental system that consists of persons who share a bond of mutual affection and are in contact or communication among which transmission of knowledge, behaviour, values or of an infectious agent is possible.
Personal role								A role that inheres in a human being by virtue of their social and institutional circumstances.
	Personal social role							A personal role that is realised in human social processes.
		Occupational role						A social role that involves the person's occupation.
	Personal financial resource							A personal role in which the individual has access to a material or an immaterial entity which may confer economic benefits.
Location								A spatial quality inhering in a bearer by virtue of the bearer's spatial location relative to other objects in the vicinity.

Block 2 of the MoA Ontology presented to participants

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
Opportunity								A quality of a person's environmental system that makes a behaviour possible or facilitates it.
	Financial opportunity							An opportunity regarding whether the person has sufficient financial resources to enact a behaviour.
	Healthcare service accessibility							An opportunity regarding how easy it is for a person to approach and use a healthcare service.
	Physical opportunity							An opportunity of the physical environmental system that makes a behaviour possible or facilitates it.
	Social opportunity							An opportunity of the social environment system that influences the performance of a behaviour.
	Temporal opportunity							An opportunity regarding whether the person has sufficient time to enact a behaviour in the social and physical environment.

Block 3 of the MoA Ontology presented to participants

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
Cognitive represent ation								A representation which specifically depends on an anatomical structure in the cognitive system of an organism.
	Appraisal							A cognitive representation which represents an evaluation of the relevance of some triggering object or event to the organism.
		Appraisal of causal agency						An appraisal that represents an evaluation of who or what caused an event.
			Appraisal as caused by self					An appraisal that represents an evaluation that an event was caused by the self.
			Appraisal as caused by factors external to the person					An appraisal that represents an evaluation that an event was caused by factors external to the person.
		Appraisal of dangerousness						An appraisal which represents an evaluation of the dangerousness of an object or situation.
		Appraisal of expectedness						An appraisal that represents an evaluation of whether an event was expected to occur.
		Appraisal of obligation to act						An appraisal that represents an evaluation of how much one is personally obliged to respond to an event or person in need.
	Desired standard							A cognitive representation of a reference level that an individual wishes to obtain.
	Mental image							A cognitive representation of the visual appearance of some objects or events when these are not immediately present to the senses.

Block 4 of the MoA Ontology presented to participants

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
Bodily disposi tion								A disposition that inheres in some extended organism.
	Personal capabilit y							A disposition inhering in an organism whose realization in the normal case brings benefits to an organism or group of organisms, where "in the normal case" means not only in the normal range on the scale, but also in a context which is normal for the group to which the bearer or user belongs.
		Mental capability						A capability that necessarily includes mental processes in its realisation.
			Mental skill					A mental capability acquired through training and practice.
			Self-regulation capability					A mental capability that involves processes that modulate the frequency, rate or extent of a response to external or internal stimuli and that are instigated by the person themselves.
				Behavioural self-regulation capability				A self-regulation capability to modulate one's behaviour.
				Cognitive self-regulation capability				A self-regulation capability to modulate one's cognitive processes.
				Emotional self-regulation capability				A self-regulation capability to modulate one's emotions.
		Physical capability						A capability to perform a behaviour by virtue of muscular- skeleton attributes or psychomotor control.
			Physical skill					A physical capability acquired through training and practice.
		Social capability						A capability to engage in interpersonal processes that influence ability to perform a behaviour, when appropriate circumstances occur.
			Social skill					A social capability acquired through training and practice.

Block 5 of the MoA Ontology presented to participants

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
Bodily dispositio								A disposition that inheres in some extended organism.
	Mental disposition							A bodily disposition that is realized in a mental process.
		Addiction						A chronic acquired mental disorder involving repeated abnormally powerful motivation to engage in a behaviour despite risk or experience of harm.
		Alienation						A mental disposition to perceive or experience oneself as isolated from and not meaningfully involved in social groups.
		Awareness						A mental disposition to be conscious of events, objects or sensory patterns.
		Behavioural intention						A mental disposition that is a commitment to enact or not enact a behaviour.
		Cognitive schema						A mental disposition about an entity that guides perception, thought or behaviour.
			Action schema					A cognitive schema that guides a sequence of behaviours.
		Mental plan						A mental disposition to form a representation of a behaviour, the conditions under which it will be enacted and an intention to enact the behaviour under those conditions.
			Mental plan for coping with barriers					A mental plan regarding a strategy to deal with conditions that could prevent the performance of a behaviour.
		Social embeddedness						A mental disposition to perceive or experience some objects or events visually when these are not immediately present to the senses.

Block 6 of the MoA Ontology presented to participants

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
	Mental disposition							A bodily disposition that is realized in a mental process.
		Decision						A mental disposition to represent one proposition as preferred from at least two.
			Behavioural decision					A decision that one behaviour is preferred from at least two behavioural options.
		Goal						A mental disposition to strive towards an end state.
		Identity						A mental disposition relating to perceptions of oneself.
			Social identity					Identity that is associated with the sense of belonging to a social group.
		Knowledge						A mental disposition to understand the nature of the world, or a specific aspect of the world, that corresponds to the actual state of the world and is acquired through experience or learning.
			Knowledge regarding a behaviour					Knowledge regarding a particular set of actions.
			Knowledge regarding an innovation					Knowledge regarding a novel invention or way of doing something.
			Knowledge regarding a threat					Knowledge regarding a potential harm.
			Knowledge regarding treatment					Knowledge regarding a therapy or medication for a health problem.
		Self-concept						A mental disposition to represent oneself as having particular qualities and characteristics.

Block 7 of the MoA Ontology presented to participants

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
	Mental disposition							A bodily disposition that is realized in a mental process.
		Learned stimulus-response co-occurrence						A mental disposition to think and behave in a particular way in response to an event in a person's environment, which is acquired through associative learning.
			Learned stimulus-behaviour co-occurrence					A mental disposition to behave in a particular way in response to an event in a person's environment, which is acquired through habit learning.
			Learned stimulus-thought co-occurrence					A mental disposition to think in a particular way in response to an event in a person's environment.
		Mental image disposition						A mental disposition to represent a mental image.
		Willingness to comply						A mental disposition to be inclined to act in accordance with the likely approval of others.
		Motivational orientation						A mental disposition for motivation to be guided by a focus on the presence or absence of outcomes of a certain valence.
			Prevention focused motivational orientation					A mental disposition for motivation to be guided by a focus on the presence or absence of positive outcomes.
			Promotion focused motivational orientation					A mental disposition for motivation to be guided by a focus on the presence or absence of negative outcomes.
		Personal value						A mental disposition regarding what is fundamentally important in life and which informs standards for behaviour.

Block 8 of the MoA Ontology presented to participants

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
	Mental disposition							A bodily disposition that is realized in a mental process.
		Psychological need						A mental disposition of a person to act to obtain or maintain a particular state due to this state's importance to the person's wellbeing.
			Autonomy need					A psychological need to have a sense of personal agency and initiative.
			Need for self-esteem					A psychological need to have a positive evaluation of oneself and one's qualities and characteristics.
			Need for sense of security					A psychological need to feel safe from threats.
			Need for social relatedness					A psychological need to have caring relationships with other people.
			Need to feel competent					A psychological need to experience oneself as able and effective.
		Stereotype						A mental disposition to represent attributes of members of a social group as shared by the virtue of their group membership.
			Risk stereotype					A stereotype of a person who enacts a problem behaviour.
		Subjective need						A mental disposition to experience a feeling of anticipated relief from, or avoidance of, mental or physical discomfort.
		Temporal orientatio						A mental disposition to focus more on present or future outcomes.
Emotional action tendency								A disposition to behaviour that inheres in an organism by virtue of the physical changes brought about by an emotion process.

Block 9 of the MoA Ontology presented to participants

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
	Mental disposition							A bodily disposition that is realized in a mental process.
		Belief						A disposition to mental processes that represent some proposition X to be true.
			Belief about anticipated emotion					A belief about the potential emotional processes experienced as result of an event.
			Belief about barriers					A belief about the extent to which factors exist that could restrict or impede the person from engaging in a behaviour.
			Belief about conformity to behavioural norms					A belief about the extent to which one's own behaviour is similar to that of referent others.
			Belief about consequences of behaviour					A belief about the outcomes resulting from a behaviour.
				Belief about social consequences of behaviour				A belief about the outcomes of a behaviour in terms of social processes or attributes.
			Belief about consequences of goal attainment					A belief about the outcomes resulting from achieving a goal.
			Belief about control over one's future					A belief about the extent to which one can direct what happens in one's future.
			Belief about responsibility to act					A belief about whether someone is obliged to take a certain course of action.

Block 10 of the MoA Ontology presented to participants

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
		Belief						A disposition to mental processes that represent some proposition X to be true.
			Belief about gain					A belief about the existence of an increase from an initial reference point.
			Belief about likelihood of potential outcomes					A belief about the probability that a given event or state will occur in the future.
				Belief about likelihood of consequences of behaviour				A belief about the likelihood a particular behaviour will result in particular outcomes.
					Belief about likelihood of health consequences of behaviour			A belief about the likelihood of a behaviour resulting in a change in a threat to health and wellbeing.
			Belief about loss					A belief about the existence of a decrease from an initial reference point.
			Belief about message					A belief regarding aspects of a verbal, graphic, written or recorded communication.
				Belief about the credibility of a message's source				A belief about whether a verbal, graphic, written or recorded communication is provided by people or institutions who is trustworthy.
				Belief about message relevance				A belief regarding whether the content of a verbal, graphic, written or recorded communication are relevant to oneself.
				Belief about message trustworthiness				A belief about whether a verbal, graphic, written or recorded communication provides reliable information.
			Belief about need satisfaction					A belief regarding whether one's psychological needs have been met.

Block 11 of the MoA Ontology presented to participants

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
		Belief						A disposition to mental processes that represent some proposition X to be true.
			Belief about one's environment					A belief about the nature of the immediate physical and social settings in which people live, including culture and the people and institutions with whom they interact.
				Belief about one's social environment				A belief about the aspects of one's immediate social settings in which people live, including culture and the people and institutions with whom they interact.
					Belief about social support			A belief about whether others will provide assistance or comfort to help the person cope with one or more stressors.
					Perceived norm			A belief about what is typical for people who belong to a particular social group.
						Perceived descriptive norm		A belief about the prevalence of performance of a given behaviour by people within a group.
						Perceived injunctive norm		A belief about whether a behaviour is appropriate and correct for people who belong to a particular social group.
						Normative belief		A belief about whether important others think one should perform a behaviour.
			Belief about threat					A belief about a potential harm.
			Belief about severity of an outcome					A belief about how serious the harm associated with an outcome could be.
			Belief about susceptibility to a threat					A belief about vulnerability to a threat.
				Belief about personal susceptibility				A belief about how vulnerable one is to a threat.
				Belief about others' susceptibility				A belief about how vulnerable others are to a threat.
			Belief about the timing of the consequences of behaviour					A belief about how long after the performance of behaviour particular consequences will occur.
			Belief about voluntariness of behaviour					A belief about the extent to which one is free to choose whether to perform the behaviour.

Block 12 of the MoA Ontology presented to participants

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
		Belief						A disposition to mental processes that represent some proposition X to be true.
			Evaluative belief					A belief about whether a particular aspect of the world is positive or negative.
				Evaluation of self				An evaluative belief about one's attributes.
					Positive evaluation of self			A belief about one's positive attributes.
					Negative evaluation of self			A belief about one's negative attributes.
				Evaluative belief about behaviour				An evaluative belief about whether a behaviour is positive or negative.
				Evaluative belief about behavioural outcomes				A belief about whether the consequences of the behaviour are positive or negative.
					Belief about the personal desirability of consequences of behaviour			A belief about the worth of the outcomes of a behaviour to oneself.
				Evaluative belief about others				An evaluative belief about the attributes of others.
				Evaluative belief about a stereotype				An evaluative belief about a set of attributes considered to generally inhere in the members of a social group.
			Belief about control over behaviour					A belief about one's capabilities and opportunities within an environmental system to perform a behaviour or achieve the outcomes resulting from a behaviour.
				Belief about control over the environment				A belief about one's resources and opportunities within an environment to perform a behaviour.
				Self-efficacy belief				A belief about one's capabilities to organise and execute a behaviour and achieve the outcomes associated with this behaviour.
				Self-efficacy belief for a behaviour				A belief about one's capabilities to organise and execute a behaviour.
					Situational self-efficacy belief for a behaviour			Self-efficacy belief for a behaviour under certain conditions.

Block 13 of the MoA Ontology presented to participants

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
Bodily quality								A quality that inheres in some extended organism.
	Mental quality							A bodily quality that inheres in those structures of the extended organism that are essential for mental functioning.
Bodily process								A process in which at least one bodily component of an organism participates.
	Bodily behavioural cue							A stimulus that arises from bodily processes and serves to elicit or guide behaviour.
		Mental behavioural cue						A stimulus that arises from mental processes and serves to elicit or guide behaviour.
	Individual human behaviour							Individual human activity that involves co-ordinated contraction of striated muscles controlled by the brain.
		Habitual behaviour						A behaviour that is strongly influenced by a learnt stimulus-behaviour association.
		Normative behaviour						An individual human behaviour that is commonly enacted by people that are part of a social environmental system.
	Goal pursuit process							A bodily process in which attempts are made to achieve a desired end state.
	Internal reward for a response							A process by which the person experiences an internally-generated positive physical or psychological state subsequent to a response.
	Experiential rightness of goal pursuit							A process by which the manner in which one attempts to achieve a goal creates an experiential sense of rightness associated with pursuing the goal, which in turn increases task engagement.

Block 14 of the MoA Ontology presented to participants

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
Bodily process								A process in which at least one bodily component of an organism participates.
	Interpersonal process							A process in which at least two human beings are agents.
		Communication						An interpersonal process that involves the transmission of information between two organisms.
			Linguistic communication					A communication process in which the information that is communicated is encoded in language.
			Non-linguistic communication					A communication process in which information is transmitted without being encoded in the meaning units of any language.
			Interpersonal reciprocal communication					Communication that is mutual between two or more people.
				Behaviour-influencing social interaction process				An interpersonal process in which one person's reciprocal communication with one or more others may facilitate or hinder the person's behaviour.
		Social influence process						An interpersonal process where one or more person exerts an influence on the behaviour of another.
	Plan enactment							A process by which a person attempts to follow the steps in a plan.
	Physiological response to emotion process							A bodily process which encompasses all the neurophysiological changes caused by the appraisal, which take place in the central nervous system (CNS), neuro-endocrine system (NES) and autonomous nervous system (ANS).

Block 15 of the MoA Ontology presented to participants

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
	Mental process							A bodily process that is of a type such that it can of itself be conscious.
		Affective process						Any process that has positive or negative valence.
			Bodily feeling					An affective process involving sensory experience of physiological stimuli.
				Pain				A bodily process in an organism S, involving two integrated levels: (a) activation of the nociceptive system and associated emotion generating brain components of S, and (b) a simultaneous aversive sensory and emotional experience on the part of S, where (b) is phenomenologically similar to the sort of aversive experience involved in pain with concordant tissue damage.
			Subjective emotional feeling					A (fiat) part of the emotion process by which the organism experiences its own emotion.
				Cognitive dissonance				An unpleasant subjective emotional feeling experienced due to perceived inconsistency between two concurrently held cognitive representations.
				Craving				A subjective experience of powerful want or need for something or urge to engage in a behaviour.
				Feeling an urge				A subjective emotional feeling that arises when an impulse to enact a behaviour is activated but not immediately acted upon.

Block 16 of the MoA Ontology presented to participants

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
Bodily process								A process in which at least one bodily component of an organism participates.
	Self-regulation of behaviour							A bodily process that modulates the frequency, rate or extent of behaviour, the specific actions or reactions of an organism in response to external or internal stimuli and that is instigated by the organism itself.
		Behavioural self-regulation of behaviour						A behaviour undertaken to modulate the frequency, rate or extent of a different behaviour, the specific actions or reactions of an organism in response to external or internal stimuli, and that is instigated by the organism itself.
		Introjected self-regulation						Self-regulation undertaken to manage a sense of guilt, anxiety or obligation.
		Self-reinforcing self-regulation						A bodily process that modulates the frequency, rate or extent of behaviour through self-administering a reward for performing an intended behaviour.
		Value-congruent self-regulation						Self-regulation undertaken to achieve congruence between one's values and the behaviour performed.
	Mental process							A bodily process that is of a type such that it can of itself be conscious.
		Appraisal process						An appraisal process is a mental process that gives rise to an appraisal.
		Arousal						A physiological and psychological state of being awake or reactive to stimuli.
		Attending						A mental process whereby relevant aspects of our mental experience are focused on specific targets.
		Avoidance mental process						A mental process that reduces the frequency by which an aversive cognitive representation is evoked.
		Heuristic process						A mental process that uses simple rules and associations learnt from experience to make judgements.

Block 17 of the MoA Ontology presented to participants

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
	Mental process							A bodily process that is of a type such that it can of itself be conscious.
		Cognitive process						A mental process that creates, modifies or has as participant some cognitive representation.
			Comprehension					A cognitive process that creates a representation of the meaning and significance of a communication, object, event or situation.
			Decision simplification					A cognitive process that simplifies decision making.
			Mental distancing					A cognitive process that involves detaching oneself from one's immediate thoughts.
				Targeted mental distancing				Mental distancing that involves identifying particular immediate thoughts and detaching from these thoughts.
			Thinking					A cognitive process that involves the manipulation of mental language and/or mental images.
				Reflective thinking				Thinking that involves generation of inferences based on syllogistic reasoning or decision making based on the evaluation of anticipated consequences or the construction of propositional representations.

Block 18 of the MoA Ontology presented to participants

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
		Affective process						Any process that has positive or negative valence.
			Emotion process					A mental process that is a synchronized aggregate of constituent mental processes, including an appraisal process, which is valenced, has an object, and gives rise to an action tendency.
				Anger				A negative emotion, characterised by feelings of unpleasantness and high arousal, in the form of antagonistic feelings and action tendencies.
				Anxiety				An emotion that is negative, aversive and provoked by the prospect of distal future threat.
				Disgust				A negative emotion which guards the body against dangerous foods and microbial infections.
				Fear				An activated, aversive emotion that motivates attempts to cope with events that provide threats to the survival or well-being of organisms.
				Feeling nervous				A subjective feeling of being not at ease, of being anxious or nervous or agitated.
				Guilt				A self-evaluative emotion that occurs when a person brings about a negative outcome by acts of commission or omission.
				Happiness				A positive emotion which is experienced in reaction to a positive experience or event.
				Pleasure				A positively experienced emotion which is sought out (approached) and is associated with happiness, enjoyment, and satisfaction.
					Sexual pleasure			A positively experienced emotion which is sought out (approached) and is associated with happiness, enjoyment, and satisfaction as a result of sexual activities.
					Enjoyment of behaviour			Pleasure that is experienced as a result of engaging in a behaviour.
				Sadness				A negative emotion felt when an event is appraised as unpleasant, obstructive to one's goals and concerns, and one feels unable to cope with it or modify it.
				Shame				A negative emotion that is distressing and occurs when one appraises one's behaviour or circumstance as wrong, dishonourable, immodest or indecorous.
				Surprise				A neutral emotion caused by encountering unexpected events of all kinds.

Block 19 of the MoA Ontology presented to participants

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
	Mental process							A bodily process that is of a type such that it can of itself be conscious.
		Memory						The activities involved in the mental information processing system that receives (registers), modifies, stores, and retrieves informational stimuli.
			Associative memory					The activities involved in the mental information processing system that receives (registers), modifies, stores, and retrieves informational stimuli regarding the set of entities associated with a particular object or event.
			Episodic memory					The activities involved in the mental information processing system that receives (registers), modifies, stores, and retrieves informational stimuli regarding a personally experienced event at a particular time or place.
			Semantic memory					The activities involved in the mental information processing system that receives (registers), modifies, stores, and retrieves meanings, understandings, and conceptual facts about the world.
			Procedural memory					The activities involved in the mental information processing system that receives (registers), modifies, stores, and automatically retrieves informational stimuli regarding how to perform a complex activity without conscious awareness.
			Iconic memory					The activities involved in the mental information processing system that receives (registers), modifies, stores, and retrieves very brief sensory memory of some visual stimuli.

Block 20 of the MoA Ontology presented to participants

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
	Mental process							A bodily process that is of a type such that it can of itself be conscious.
		Learning						Any process in an organism in which a relatively long-lasting adaptive behavioural change occurs as the result of experience.
			Associative learning					Learning that involves changing strength of association between two or more mental processes.
				Classical conditioning				Associative learning that occurs when the pairing of a conditioned and unconditioned stimulus leads to the conditioned stimulus producing a response that would otherwise have only been produced by the unconditioned stimulus.
				Discrimination learning				Associative learning process in which people learn to distinguish between appropriate responses to similar but different stimuli depending on whether a generalised response is rewarded or not.
				Extinction in classical conditioning				Associative learning process in which the strength of a conditioned response is reduced because its conditioned stimulus is presented without being accompanied by the unconditioned stimulus.
				Extinction in operant learning				Associative learning process in which the rate of behavioural response in the presence of a discriminative stimulus is reduced because the response is no longer followed by a positive reinforcer.
				Generalisation (learning)				Process in which the effects of conditioning on behaviour spread to stimuli that differ in certain aspects from the stimulus present during the original conditioning.
				Habit learning				Associative learning that involves strengthening an association between a stimulus and an impulse through repetition of co-occurrence of the stimulus and the behaviour.
				Operant conditioning				Associative learning in which the likelihood of a particular behavioural response is influenced by the past consequences associated with performing that behaviour.
			Non-associative learning					A simple form of learning whereby the repeated presence of a stimulus leads to a change in the probability or strength of the response to that stimulus. There is no association of one type of stimulus with another, rather it is a generalized response to the environment.
				Habituation				A decrease in a behavioural response to a repeated stimulus.
				Sensitization				An increase in a behavioural response to a repeated stimulus.
			Observational learning					Learning that occurs through observing the behaviour of others.
				Imitative learning				Learning in which new behaviours are acquired through imitation.

Block 21 of the MoA Ontology presented to participants

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
	Mental process							A bodily process that is of a type such that it can of itself be conscious.
		Dissonance reduction process						A mental process through which a perceived inconsistency between two concurrently held cognitive representations is reduced.
		Goal setting process						A mental process that establishes a cognitive representation of the end state to which one is striving.
		Mental categorising						A mental process in which objects, events, people, or experiences are grouped into classes, on the basis of features shared by members of the same class and features distinguishing the members of one class from those of another.
		Mental imagery						A mental process that evokes the visual representation of objects or events when these are not immediately present to the senses.
		Mentally comparing against a standard						A mental process in which current conditions are compared against a particular reference level.
		Perception						A mental process which is a) produced by a causal process (for example involving light rays or air vibrations) involving a part of the environment of the organism, and b) is experienced by the organism as being so caused, and c) in which the relevant part of the environment is thereby represented to the organism.
		Planning						A mental process that involves mentally manipulating representations of steps in an imagined process which has some objective.

Block 22 of the MoA Ontology presented to participants

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
	Mental process							A bodily process that is of a type such that it can of itself be conscious.
		Motivation						A mental process that energises and directs behaviour.
			Automatic motivation					A mental process that energises and directs behaviour via emotions and impulses that arise from associative learning or innate dispositions.
			Autonomous motivation					Motivation that is internally generated and based on a behaviour being interesting or valuable to an individual.
				Intrinsic motivation				Autonomous motivation due to a behaviour's inherent enjoyment or satisfaction for oneself.
				Fundamental need-based motivation				Autonomous motivation for behaviours that are perceived as satisfying core psychological needs.
				Behavioural importance-based motivation				Autonomous motivation due to the perceived value or importance of the behaviour to oneself.
			Controlled motivation					Motivation that is based on external rewards, punishments or pressure regarding a behaviour.
				Extrinsic motivation				Controlled motivation due to externally administered rewards, approval or punishments.
				Approval-based motivation				Controlled motivation to gain or maintain a positive evaluation of self or feel others approval of oneself.

Block 23 of the MoA Ontology presented to participants

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Definitions
	Mental process							A bodily process that is of a type such that it can of itself be conscious.
		Judging						A mental process during which evidence is evaluated, the outcome of which is a belief or opinion.
			Decision-making					Judging during which a decision is created.
			Judging consequences of behaviour					Judging during which a belief about the consequences of a behaviour is created or modified.
			Social comparison process					Judging oneself or one's social group in relation to the qualities or characteristics of another person or social group.
		Self-monitoring						A mental process in which one observes and evaluates one's own behaviour.
		Wanting						A mental process that involves thinking about a state of affairs that does not yet obtain together with a desire for that state of affairs to obtain.
	Subliminal process							A bodily process that involves neuronal activity in response to a sensory stimuli but which is not the subject of consciousness.
Consciousness								That part of the mental process that confers a subjective perspective, a phenomenology, an experience of the mental process of which it is a part; and intends the object or event that the mental process is about, should such exist; it confers intentionality on the mental process.

Appendix 7-5. Participant questions about the MoA Ontology stakeholder training and responses provided

Question 1: Can you please clarify the difference between an ontology and a taxonomy? Is it that an ontology includes relationships between classes?

Response 1:

o The key difference between ontologies and taxonomies is the types of relationships they can contain.

o Taxonomies can only contain hierarchical relationships between classes (e.g., 'belief about threat' is a subclass of 'belief').

o Ontologies can contain hierarchical relationships between classes (such as the 'belief about threat' example) but can also have other types of relationships between classes (e.g., 'mental process' involves [relationship] 'consciousness').

o In the case of the MoA ontology, it just so happens that most of the relationships between classes are hierarchical.

Question 2: It's confusing that Mechanisms of Action can be constructs or processes of change. Processes of change could be considered techniques, couldn't they? For example, in the videos you used "associative learning" and "peer influence" as examples of MOA, but are they not strategies for changing behavior? For example, if I use peer influence as a BCT, I would expect it to alter participants' attitudes (the MOA) and thereby influence behavior.

Response 2:

o We also noted this as something potentially confusing when developing the MoA Ontology. In the literature, the same label (e.g., "associative learning") has been used to mean either a BCT or an MoA.

o The MoA Ontology is part of a bigger programme of work building a Behaviour Change Intervention Ontology. One of my colleagues is working on turning the BCT taxonomy into an ontology of BCTs. When this is finished, we hope it will help disambiguate MoAs from BCTs.

- During the review task, if you do spot any MoAs where you think the labels might be confusing as they could also be used to refer to a BCT, and the definition isn't sufficiently clear to suggest that the class is not a BCT, it'd be great if you could point them out.

Question 3: I would call attitudes the mediator rather than the mechanism of action, because of the paper by Sheeran, Rothman, and Klein (2017) that defined a MOA as the whole combination of technique, mediator, and outcome. I understand -if you want us to call mediators MOA, but perhaps this should be explicit.

Response 3:

- This is a good point, which we glossed over a little in the training. We see MoAs as the processes that start when a BCT has been applied and continue until the behaviour occurs.

- We would not think that the behaviour change technique or behavioural outcome would be part of the MoA, only the pathways between the technique and the behavioural outcome.

- Strictly speaking, the classes in the MoA Ontology are the things that MoAs work through (i.e., what Sheeran, Klein & Rothman (2017) call "targets"). In other words, 'attitude' in the MoA ontology can be read as "MoA through attitude".

- We didn't want to call the constructs "mediators" to future-proof the ontology for interventions with complex hypothesised interacting mechanisms. For example, an intervention could have two BCTs that change threat appraisal and coping appraisal, respectively. The hypothesised mechanism of the intervention is that increasing coping appraisal will moderate the impact of increasing threat appraisal on risk-reducing behaviour

Question 4: You state that personality traits can't be MOA, which I understand, but I know there are researchers who conduct interventions to change personality traits, at least temporarily. For example, getting people to "act extroverted" in certain situations improves mental health and other outcomes. Or increasing perceived control (like health locus of control but specific to a procedure or situation) improves outcomes.

Response 4:

o This is a thought-provoking point, thank you. We treated personality traits as not being MoAs when their definition in a given theory suggested that they were stable and unchanging.

o Experiments asking people to "act extroverted" are interesting, in that given the typical instructions used ("act bold, talkative, and assertive"), acting extroverted seems to initially be a behaviour, which then may or may not influence positive affect and one's self-concept. In this instance, the MoAs could be a behaviour, affect and self-concept.

o We have several classes relating to perceived control in the MoA Ontology. If you think any key ones are missing, it would be great if you could suggest them during the review.

Question 5: I know we aren't supposed to worry about the highest levels of classes (their labels and definitions), but I would like to know them in order to judge what makes sense and what might be missing. For example, what is meant by "Quality" under "specifically dependent continuant"? And are all of these higher-level classes really relevant to mechanisms of action? [It] would be good [to have more information on "process", "quality", "role" and "disposition"] as well as "entity", "specifically dependent continuant", "independent continuant".

Response 5:

The classes outlined below are very broad and help to philosophically distinguish between things that exist in the universe. Ontologies use these broad classes, as they can be shared across different scientific disciplines (i.e., they are not domain specific) to categorise "things that exist" (i.e., entities).

We used these classes to broadly categorise the MoAs we identified from theories. If you would like to provide comments about how we categorised MoAs, we would appreciate your comments. However, if these broad classes are confusing, please feel free to ask for further clarifications.

1. Entity:

Things that exist in the universe. Anything that exists is called an "entity". Examples of entities are "objects", "processes" and "qualities".

Entities are broadly categorised into "continuants" (e.g., objects, qualities and dispositions) and "occurrents" (e.g., processes).

1.1 Continuant:

An entity that continues to exist through time. They may gain or lose parts (e.g., an organism gains and loses cells), but at each point in time they exist completely (unlike processes which develop over time).

"Independent continuant" and "specifically dependent continuant" are subclasses of "continuant".

1.1.1 Independent continuant:

A continuant that exists by itself without depending on another entity to exist. For instance, a tomato exists by itself without requiring another entity for its existence. In contrast, certain entities (e.g., qualities) depend on independent continuants for their existence. For instance, the existence of the quality of a tomato (e.g., the colour red) depends on the existence of that tomato.

1.1.2 Specifically dependent continuant:

A continuant that depends on one or more independent continuants to exist. For instance, the colour of a tomato is a specifically dependent continuant: the colour depends on the tomato for its existence.

"Quality", "role" and "disposition" are subclasses of specifically dependent continuant.

1.1.2.1 Quality:

An entity that is fully exhibited or manifested in an independent continuant at all times. Examples for quality are colour and body temperature. A tomato will always have a colour; a person will always have a body temperature (whether this temperature is within the normal range or elevated).

In contrast, both role and disposition are "realizable entities", meaning that an independent continuant will exhibit a role or disposition in certain circumstances.

1.1.2.2 Role:

A realizable entity that is possessed by an independent continuant because of some external circumstances. For instance, a person could be assigned a role by someone else who has more power in a social context.

A role is optional, as a bearer (the entity that has a role) does not have to be in given external circumstances. Examples for roles would be "lawyer", "nurse" or "being bankrupt". Someone has these roles because they are in certain associated kinds of natural, social or institutional contexts.

1.1.2.3 Disposition:

A realizable entity that is expressed or manifested through a process in an independent continuant when appropriate triggers are encountered. A disposition can be conceived as an internally grounded realizable entities (unlike roles which are externally grounded). An independent continuant has a disposition due to its physical make up. For instance, a belief (a mental disposition) can be thought about (process) when encountering specific information. This belief is based on neural connections (a physical make-up) in the brain.

Dispositions can be weaker or stronger: those on the weaker end of the spectrum are not realized in every suitable triggering situation.

1.2 Process:

An entity that exists in time by occurring or happening, has temporal parts, and always depends on some material entity. For instance, "experiencing a headache" (a process) is dependent on a person. If the person did not exist, the headache would not exist.

Question 6: I'll have to review the slides on "representation" vs "disposition". In the literature, cognitive representations are often equated with beliefs or perceptions.

Answer 6:

Thank you for pointing this out. Yes, in psychology, we often use the terms "cognitive representation" and "belief" or "perception" interchangeably. However, the Mental Functioning Ontology, one of the ontologies we drew on, distinguished these terms.

As outlined in the presentation slides, a belief is defined as "a disposition to mental processes that represent some proposition X to be true." This disposition can be triggered when a person encounters certain circumstances. For instance, a person was thinking about going to go to the beach, which activated their belief that using sunscreen is important. The cognitive representation would be the activated content of that belief (the momentarily represented content of the belief).

Appendix 7-6. The class labels, definitions, informal definitions and synonyms of MoA Ontology following updates from the stakeholder review

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
Material entity BFO:0000 040							An independent continuant that is spatially extended whose identity is independent of that of other entities and can be maintained through time.		
	Material anatomical entity UBERON:0 000465						Anatomical entity that has mass.		
		Anatomical structure UBERON:000 0061					A material anatomical entity that is a single connected structure with inherent 3D shape generated by coordinated expression of the organism's own genome.	A part of a person's body.	
	System RO:000257 7						A material entity consisting of multiple components that are causally integrated.		
		Environmental system ENVO:010002 54					A system which has the disposition to surround and interact with one or more material entities.	The social and physical environment surrounding a person.	
			Ecosystem ENVO:0100 1110				An environmental system which includes both living and non-living components.		
			Social environment al system BCIO:00600 1				An environmental system that consists of people, their pets, social and cultural institutions and processes that influence the life of people and social groups.		

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
				Family environmental system BCIO:006002			A social environmental system that consists of persons related as members of a domestic group, or a number of domestic groups linked through descent from a common ancestor, marriage, adoption or other legal arrangements.		
				Friendship network BCIO:006003			A social environmental system that consists of persons who share a bond of mutual affection and are in contact or communication.		
				Professional network BCIO:050213			A social environmental system that consists of persons who have shared interests relating to their occupational roles and are in contact or communication.		
Bodily disposition MF:0000032							A disposition that inheres in some extended organism.	An attribute of a body that influences the way that it functions.	
	Personal capability MF:0000043						A bodily disposition whose realization ordinarily brings benefits to an organism or group of organisms, where "ordinarily" means within a typical range or context.	The ability of someone to perform some useful and/or beneficial activity.	
		Mental capability MF:0000048					A personal capability that includes mental processes in its realisation.		
			Mental skill BCIO:006004				A mental capability acquired through training or practice.		

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
			Self-regulation capability BCIO:006005				A mental capability that involves processes that modulate the frequency, rate or extent of a response to external or internal stimuli and that are instigated by the person themselves.		
				Attentional self-regulation capability BCIO:050214			A self-regulation capability to modulate one's attention toward internal or external stimuli.		
				Behavioural self-regulation capability BCIO:006006			A self-regulation capability to modulate one's behaviour.		Behavioural regulation capability
				Cognitive self-regulation capability BCIO:006007			A self-regulation capability to modulate one's cognitive processes.		
				Emotional self-regulation capability BCIO:006008			A self-regulation capability to modulate one's emotional responses to a stimulus.		Emotional regulation capability
				Self-regulatory skill BCIO:050222			A self-regulation capability that is acquired through training or practice.		
		Behavioural capability BCIO:050215					A personal capability that includes behaviours in its realisation.		
			Physical behavioural capability BCIO:006009				A behavioural capability that involves a musculoskeletal process in its realisation.		

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
				Physical skill BCIO:006010			A physical capability acquired through training or practice.		
			Social behavioural capability BCIO:006011				A personal capability includes interpersonal behaviour in its realisation.		
				Social skill BCIO:006012			A social capability acquired through training or practice.		
	Mental disposition MF:0000033						A bodily disposition that is realized in a mental process.		
		Addiction ADDICTO:0000349					A mental disposition towards repeated episodes of abnormally high levels of motivation to engage in a behaviour, acquired as a result of engaging in the behaviour, where the behaviour results in risk or occurrence of serious net harm.		
		Awareness BCIO:006015					A mental disposition that is realized by attending to events, objects or sensory patterns in experience.		
		Behavioural intention BCIO:006016					A mental disposition to commit to enact or not enact a behaviour.		
		Belief MF:0000041					A mental disposition to represent a proposition to be true.	Conviction about something being true.	
			Belief about barriers				A belief about a factor could restrict or impede a person from engaging in a behaviour.		

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
			BCIO:006017						
			Belief about conformity to behavioural norms BCIO:006018				A belief about the extent to which one's own behaviour is similar to that of referent others.		
			Belief about consequences of an occurrence BCIO:050217				A belief about the outcomes resulting from an occurrence.		
				Belief about anticipated emotion BCIO:006140			A belief about the potential emotions experienced as result of an event.		
					Belief about anticipated regret BCIO:050216		A belief about the potential regret experienced as a result of an event.		
				Belief about consequences of behaviour BCIO:006019			A belief about the outcomes resulting from a behaviour.		Response efficacy
					Belief about emotional		A belief about the outcomes of behaviour in terms of resulting emotions.		

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
					consequences of behaviour BCIO:050218				
					Belief about health consequences of behaviour BCIO:050219		A belief about the outcomes of behaviour in terms of one's health and wellbeing.		
					Belief about social consequences of behaviour BCIO:006020		A belief about the outcomes of a behaviour in terms of social processes.		
					Belief about the timing of the consequences of behaviour BCIO:006033		A belief about outcomes in terms of how long after the performance of a behaviour they will occur.		
				Belief about consequences of goal			A belief about the outcomes resulting from achieving a goal.		

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
				attainment BCIO:006021					
				Belief about likelihood of consequences of an occurrence BCIO:006026			A belief about the probability that a given event or state will occur or not occur in the future.		
					Belief about likelihood of consequences of behaviour BCIO:006024		A belief about the probability a particular behaviour will result or not result in particular outcomes.		
						Belief about likelihood of emotional consequences of behaviour BCIO:050220	A belief about the probability of a behaviour resulting or not resulting in a change to emotions.		

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
						Belief about likelihood of health consequences of behaviour BCIO:006025	A belief about the probability of a behaviour resulting or not resulting in a change to health or wellbeing.		
						Belief about likelihood of social consequences of behaviour BCIO:050221	A belief about the probability of a behaviour resulting or not resulting in a change to social outcomes.		
			Belief about control over one's future BCIO:006022				A belief about the extent to which one can direct what happens in one's future.		
			Belief about gain BCIO:006023				A belief about the existence of an increase from an initial reference point.		Perceived gain
			Belief about reduction BCIO:006027				A belief about the existence of a decrease from an initial reference point.		Perceived loss; belief about loss
			Belief about message				A belief regarding aspects of a verbal, graphic, written or recorded communication.		

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
			BCIO:006141						
				Belief about the credibility of a message's source BCIO:006142			A belief about whether a verbal, graphic, written or recorded communication is provided by people or institutions who provide reliable information.		
				Belief about message relevance BCIO:006028			A belief regarding whether the content of a verbal, graphic, written or recorded communication are relevant to oneself.		
				Belief about message trustworthiness BCIO:006143			A belief about whether a verbal, graphic, written or recording communication provides information that can be relied on as honest or truthful.		
			Belief about need satisfaction BCIO:006144				A belief regarding whether one or more of the person's needs have been met.		
			Belief about sufficient time for a behaviour BCIO:050226				A belief about having enough time or a suitable period of time to enact a behaviour.		
			Belief about one's environment BCIO:006029				A belief about the nature of the immediate physical and social settings in which people live, including culture and the people and institutions with whom they interact.		

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
				Belief about healthcare accessibility BCIO:050224			A belief about one's environment in terms of how easy it is for a person to approach and use a healthcare service.		
				Belief about one's social environment BCIO:006145			A belief about the aspects of one's immediate social settings in which people live, including culture and the people and institutions with whom they interact.		
					Belief about social support BCIO:006146		A belief about whether others will provide or are available to provide assistance or comfort to help the person cope with one or more stressors or enhance their wellbeing.		
					Perceived norm BCIO:006039		A belief about what is typical for people who belong to a particular group.		Belief about norm
						Perceived descriptive norm BCIO:006040	A belief about the prevalence of performance of a given behaviour by people within a group.		
						Perceived injunctive norm BCIO:006041	A belief about whether a behaviour is appropriate and correct for people who belong to a particular group.		
						Normative belief BCIO:006042	A belief about whether important others think one should perform a behaviour.		

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
				Belief about one's physical environment BCIO:050225			A belief about parts of one's environment that do not involve people or organisations.		
			Belief about responsibility to act BCIO:0050001				A belief about whether oneself or another person is obligated to take a certain course of action.		
			Belief about severity of an outcome BCIO:006030				A belief about how serious the harm associated with an outcome could be.		Belief about threat severity
			Belief about susceptibility to a threat BCIO:0050002				A belief about vulnerability to a threat.		Belief about susceptibility to a risk
				Belief about personal susceptibility BCIO:006031			A belief about one's personal vulnerability to a threat.		
				Belief about others' susceptibility BCIO:0050000			A belief about how vulnerable others are to a threat.		
			Belief about threat BCIO:0050003				A belief about a potential harm.		

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
			Evaluative belief BCIO:006038				A belief about whether a particular aspect of the world is positive or negative.		
				Evaluation of self BCIO:006035			An evaluative belief about one's attributes.		Self-concept
				Evaluative belief about behaviour BCIO:006147			An evaluative belief about whether a behaviour is positive or negative.		
				Evaluative belief about behavioural outcomes BCIO:006148			An evaluative belief about whether the consequences of the behaviour are positive or negative.		
					Belief about the personal desirability of consequences of a behaviour BCIO:006149		An evaluative belief about the value of the outcomes of a behaviour to oneself.		
				Evaluative belief about others BCIO:006150			An evaluative belief about the attributes of others.		
			Belief about voluntariness of				A belief about the extent to which one is free to choose whether to perform the behaviour.		Belief about autonomy in

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
			behaviour BCIO:006034						performing behaviours
			Belief about control over behaviour BCIO:006152				A belief about one's capabilities and opportunities within an environmental system to perform a behaviour or achieve the outcomes resulting from a behaviour.		
			Self-efficacy belief for a behaviour and its associated outcomes BCIO:006043				A belief about one's capabilities to organise and execute a behaviour and achieve the outcomes associated with this behaviour.		
			Self-efficacy belief for a behaviour BCIO:006154				A belief about one's capabilities to organise and execute a behaviour.		
				Situational self-efficacy belief for a behaviour BCIO:006044			Self-efficacy belief for a behaviour when a particular situation that may affect the behaviour is encountered.		
		Cognitive schema BCIO:006045					A mental disposition that when activated, guides an interconnected network of perception, thought, emotion or behaviour.	A collection of interconnected perceptions, thoughts, emotions and behaviours.	

Page 790

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
			Action schema BCIO:006046				A cognitive schema that when activate, guides a sequence of behaviours.		Action script
			Stereotype BCIO:006072				A cognitive schema that when activated, guides perception, thought, emotion or behaviour toward members of a social group as having certain shared attributes, by virtue of their group membership.		
		Decision BCIO:006047					A mental disposition to represent one proposition as preferred from at least two.	A conclusion or resolution reached after consideration of options.	
			Behavioural decision BCIO:006048				A decision that one behaviour is preferred from at least two behavioural options.		
		Disengagement due to workload BCIO:050227					A mental disposition to be detached from other people due to exhaustion experienced in one's working environment.		
		Knowledge BCIO:006052					A mental disposition to understand the nature of the world, or a specific aspect of the world, that corresponds to the actual state of the world and is acquired through experience or learning.	An understanding of something that results from experience or learning.	
			Knowledge regarding a behaviour				Knowledge regarding a particular set of actions.		

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
			BCIO:006053						
			Knowledge regarding an innovation BCIO:006054				Knowledge regarding a novel invention or way of doing something.		
			Knowledge regarding a threat BCIO:006055				Knowledge regarding a potential harm.		
			Knowledge regarding treatment BCIO:006056				Knowledge regarding a therapy or medication for a health problem.		
		Learned stimulus-response co-occurrence BCIO:006057					A mental disposition to think or behave in a particular way in response to an internal or external event in the person's environment, which is acquired through associative learning.		
			Learned stimulus-behaviour co-occurrence BCIO:006155				A mental disposition to behave in a particular way in response to an internal or external event in the person's environment, which is acquired through habit learning.	A tendency for something in the environment to prompt a behaviour as a result of learning.	Habit

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
			Learned stimulus-thought co-occurrence BCIO:006156				A mental disposition to think in a particular way in response to an internal or external event in the person's environment, which is acquired through associative learning.		Mental habit
		Mental imagery disposition BCIO:006058					A mental disposition to evokes the representation of the sensory characteristics of objects or events when these are not immediately present to the senses.	A tendency to experience mental images.	
		Motivational orientation towards types of outcomes BCIO:006060					A mental disposition for motivation to be guided by a focus on the presence or absence of outcomes of a certain valence.		
			Prevention focused motivational orientation BCIO:006061				A mental disposition for motivation to be guided by a focus on the presence or absence of positive outcomes.		
			Promotion focused motivational orientation BCIO:006062				A mental disposition for motivation to be guided by a focus on the presence or absence of negative outcomes.		
		Personal value BCIO:006063					A mental disposition to regard certain things as fundamentally important in life, which informs standards for behaviour.		
		Psychological need BCIO:006064					A mental disposition of a person to act to obtain or maintain a particular state due to		

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
							this state's importance to the person's wellbeing.		
			Need for autonomy BCIO:006065				A psychological need to have a sense of personal agency and initiative.		
			Need for self-esteem BCIO:006066				A psychological need to have a positive evaluation of oneself and one's qualities and characteristics.		
			Need for a sense of safety BCIO:006067				A psychological need to feel safe from threats.		
			Need for a sense of belonging and attachment BCIO:006068				A psychological need to have caring relationships with other people.		
			Need to feel competent BCIO:006069				A psychological need to experience oneself as capable and effective.		Need for mastery
		Mental plan BCIO:050228					A mental disposition that is realized in mental processes mentally manipulating representations of steps in an imagined process which has some goal.		
			Mental plan for a behaviour				A mental plan that is realized in mental processes representing a behaviour, the conditions under which the behaviour will be		Action plan

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
			BCIO:006070				enacted and an intention to enact the behaviour under those conditions.		
				Mental plan for coping with barriers BCIO:006157			A mental plan regarding a strategy to deal with conditions that could prevent the performance of a behaviour.		
		Social embeddedness BCIO:006074					A mental disposition to experience a feeling of being connected by social attachments.		
		Social alienation BCIO:006014					A mental disposition to perceive or experience oneself as isolated from and not meaningfully involved in social groups.		
		Temporal orientation to the future BCIO:050230					A mental disposition to focus more on future than present outcomes.		
		Temporal orientation to the present BCIO:050231					A mental disposition to focus more on present than future outcomes.		
		Willingness to comply BCIO:006059					A mental disposition to act in accordance with the likely approval of others.		Motivation to comply
	Emotional action tendency MFOEM:000007						A bodily disposition to behaviour that inheres in an organism by virtue of the physical changes brought about by an emotion process.	A tendency to enact a behaviour that is experienced during or after an emotion.	

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
Cognitive represent ation MF:00000 31							A representation which specifically depends on an anatomical structure in the cognitive system of an organism.	A mental representation of something that is experienced or imagined about one's inner or outer world.	
	Appraisal MFOEM:00 0005						A cognitive representation which represents an evaluation of the relevance of some triggering object or event to the organism.	An evaluation of a phenomenon or event's relevance and significance to oneself.	
		Appraisal of avoidability of consequences MFOEM:0000 91					An appraisal which represents a judgement about how avoidable the expected consequences of an event will be.		
		Appraisal of causal agency MFOEM:0000 75					An appraisal that represents an evaluation of who or what caused an event.		
			Appraisal as caused by self MFOEM:00 0076				An appraisal that represents an evaluation that an event was caused by oneself.		
			Appraisal as caused by an other MFOEM:00 0078				An appraisal that represents an evaluation that an event was caused by another person.		

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
			Appraisal as caused by external non-human factors BCIO:050223				An appraisal that represents an evaluation that an event was caused by natural events and not by humans.		
		Appraisal of dangerousness MFOEM:000103					An appraisal which represents an evaluation of how threatening an object or situation is.		
		Appraisal of desirability of consequences MFOEM:000085					An appraisal that represents an evaluation of the desirability of the expected consequences of an event.		
		Appraisal of expectedness MFOEM:000060					An appraisal that represents an evaluation of whether an event was expected to occur.		
		Appraisal of goal importance MFOEM:000072					An appraisal that represents an evaluation of whether an event or object is important to the person's goals or needs.		
		Appraisal of obligation to act BCIO:006078					An appraisal that represents an evaluation of how much one is personally obliged to respond to an event or person in need.		
		Appraisal of pleasantness					An appraisal that represents an evaluation of the pleasantness of an object or event.		

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
		MFOEM:0000 61							
	Desired standard BCIO:006079						A cognitive representation of a reference level that an individual wishes to obtain.		
	Goal BCIO:006049						A cognitive representation of an end state towards which one is striving.		
	Mental image BCIO:006080						A cognitive representation of the sensory characteristics of objects or events that are not immediately present to the senses.		
	Self-identity BCIO:006050						A cognitive representation that a person has about themselves.		
		Professional identity BCIO:050229					A self-identity that is associated with one's occupational role.		
		Social identity BCIO:006051					A self-identity in which the representation involves a relation between the identity holder and another person or group.		
Personal role BCIO:006 081							A role that inheres in a human being by virtue of their social and institutional circumstances.	A role that someone has within an organisation or social grouping.	
	Occupation al role BCIO:015430						A role that is realised in a person by doing a specified type of work or working in a specified way.		

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
	Social role BCIO:006082						A personal role that is realised in human social processes.		
Location BCIO:006085							A spatial quality that inheres in a bearer by virtue of its position relative to other entities.	Where a person, animal or object is.	
Environmental disposition ENVO:01000452							A disposition which is realised by an environmental system or system parts thereof.		
	Behavioural opportunity BCIO:006086						An environmental disposition of that enables or facilitates a behaviour.		
		Physical behavioural opportunity BCIO:006089					A behavioural opportunity that involves time and parts of the environmental system that do not involve people or organisations.	Properties of a person's environment that involve the objects in their environment, the space they inhabit, the time available or the material resources available to them and influence the person's ability	

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
								to enact a behaviour.	
			Financial behavioural opportunity BCIO:006087				A physical behavioural opportunity that involves the person having sufficient financial resources.	Properties of a person's environment that involve the material resources available to them and influence the person's ability to enact a behaviour.	
			Temporal behavioural opportunity BCIO:006091				A physical behavioural opportunity that involves the person having sufficient time or a suitable period.	Properties of a person's environment that involve the time available and influence the person's ability to enact a behaviour.	
		Healthcare access BCIO:006088					A behavioural opportunity regarding how easy it is for a person to approach and use a healthcare service.	Properties of a person's environment that enable or facilitate accessing healthcare services.	

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
		Social behavioural opportunity BCIO:006090					A behavioural opportunity that involves the social environmental system.	Properties of a person's environment relating to the social world they inhabit, including the rules and norms that are operating and social cues.	
Bodily process OGMS:0000060							A process in which at least one bodily component of an organism participates.	A process in which at least one bodily component of a person participates.	
	Bodily behavioural cue BCIO:006092						A stimulus that arises from bodily processes and serves to elicit or guide behaviour.		
		Mental behavioural cue BCIO:006093					A stimulus that arises from mental processes and serves to elicit or guide behaviour.		
	Individual human behaviour BCIO:006094						A bodily process of a human that involves co-ordinated contraction of striated muscles controlled by the brain.		

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
		Habitual behaviour BCIO:006158					A behaviour that results from a learnt stimulus-behaviour co-occurrence.		
		Inter-personal behaviour BCIO:036025					An individual human behaviour that involves an interaction between two or more people.		
			Communication behaviour BCIO:036034				An inter-personal behaviour that involves the intentional transmission of information.		
				Linguistic communication behaviour BCIO:050237			A communication behaviour in which the information that is communicated is encoded in language.		
				Non-linguistic communication behaviour BCIO:050238			A communication behaviour in which information is transmitted without being encoded in the meaning units of any language.		
			Social influence behaviour BCIO:006099				An interpersonal behaviour where a person exerts an influence on the behaviour of another.		
		Normative behaviour BCIO:006095					An individual human behaviour that is commonly enacted by people that are part of a social environmental system.		
	Goal pursuit process BCIO:006096						A bodily process in which attempts are made to achieve a desired end state.		
	Internal reward for a						A bodily process by which the person experiences an internally-generated positive		

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
	response BCIO:006100						physical or psychological state subsequent to a response.		
	Physiological process involved in an emotion MFOEM:000003						A bodily process that encompasses all the neurophysiological changes accompanying an emotion, which take place in the central nervous system (CNS), neuro-endocrine system (NES) and autonomous nervous system (ANS).	A process that occurs in a person's body when they are experiencing an emotion.	
	Plan enactment BCIO:006102						A bodily process by which a person attempts to follow the steps in a plan.		
	Self-regulation of behaviour BCIO:006103						A bodily process that modulates the frequency, rate or extent of behaviour, the specific actions or reactions of a person in response to external or internal stimuli and that is instigated by the person.		
		Behavioural self-regulation of behaviour BCIO:006104					Self-regulation of behaviour through the performance of a different behaviour.	A behaviour undertaken to modulate the frequency, rate or extent of a different behaviour, the specific actions or reactions of a person in response to external or internal stimuli, and that is	

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
								instigated by the person.	
		Introjected self-regulation BCIO:006105					Self-regulation of behaviour undertaken to manage a sense of guilt, anxiety or obligation.		
		Self-reinforcing self-regulation BCIO:006106					Self-regulation of behaviour through self-administering a reward for performing an intended behaviour.	A bodily process that modulates the frequency, rate or extent of behaviour through self-administering a reward for performing an intended behaviour.	
		Value-congruent self-regulation BCIO:006107					Self-regulation undertaken to achieve consistency between one's values and the behaviour performed.		
	Mental process						A bodily process that occurs in the brain, and that can of itself be conscious, or can give	A process that takes place in	

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
	MF:0000020						rise to a process that can of itself be conscious or can give rise to behaviour.	the brain and can involve consciousness.	
		Affective process MFOEM:000195					A mental process that has positive or negative valence.		
			Emotion process MFOEM:000001				An affective process that is a synchronized aggregate of constituent mental processes, including an appraisal process, which is valenced, has an object, and gives rise to an action tendency.		
				Anger MFOEM:000009			A negative emotion, characterised by feelings of unpleasantness and high arousal, in the form of antagonistic feelings and action tendencies.		
				Anxiety MFOEM:000028			A negative emotion that is aversive and provoked by the prospect of distal threat.		
				Disgust MFOEM:000019			A negative emotion that is characterised by a need to get rid of, or distance oneself from, a stimulus that is appraised as repulsing.		
					Animal-nature disgust MFOEM:000021		Disgust elicited by poor hygiene, inappropriate sex, gore or violations of bodily boundaries, and death or the odor of decay.		
					Core disgust MFOEM:000020		Disgust elicited by "contaminated" food substances: rotten food, culturally variable "bad" food, certain animals associated with		

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
							rotten food (maggots, rats), and every body product except tears.		
					Interpersonal disgust MFOEM:000022		Disgust elicited by contact with others, especially contact with strangers or other individuals or groups we are averse to.		
					Moral disgust MFOEM:000023		Disgust elicited by some kinds of especially egregious moral violations.		
				Fear MFOEM:000026			A negative emotion that is aversive and characterised by feelings of threat and impending doom, and by an urge to get out of the situation.		
				Guilt MFOEM:000053			A negative self-evaluative emotion that occurs when a person brings about a negative outcome by acts of commission or omission that violate internal or external moral standards.		
				Happiness MFOEM:000042			A positive emotion which is experienced in reaction to a positive experience or event.		
				Sadness MFOEM:000056			A negative emotion felt when an event is appraised as unpleasant and resulting in loss or failure.		
				Shame MFOEM:000055			A negative emotion that is distressing and occurs when one appraises one's behaviour or circumstance as wrong, dishonourable, immodest or indecorous.		

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
				Surprise MFOEM:000032			An emotion caused by encountering unexpected events.		
					Positive surprise MFOEM:000209		Surprise with a positive valence.		Wonder; astonishment
					Negative surprise MFOEM:000210		Surprise with a negative valence.		
				Pleasure MFOEM:000035			A positive emotion which is sought out and is associated with happiness and satisfaction.		Enjoyment
					Pleasure associated with behaviour BCIO:006159		Pleasure that is experienced as a result of engaging in a behaviour.		Enjoyment of behaviour
					Sexual pleasure MFOEM:000040		Pleasure that is experienced as a result of sexual activities.		
				Regret BCIO:050232			A negative emotion that occurs when a person wishes they chose or acted differently in the past, due to the consequences of that choice or action being unfavourable.		
			Subjective affective feeling MFOEM:000006				An affective process that involves the experience of internal or external sensory stimuli.	The conscious experience that a person has of feelings in their body (e.g.,	

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
								hunger), their mood and their emotions, in response to internal or external stimuli.	
				Cognitive dissonance BCIO:006108			An unpleasant subjective affective feeling experienced due to perceived inconsistency between two concurrently held cognitive representations.		
				Craving BCIO:006160			A subjective affective feeling of desiring or needing something.		
				Feeling an urge BCIO:006109			A subjective affective feeling that arises when an impulse to enact a behaviour is activated but not immediately acted upon.		
				Feeling nervous MFOEM:000124			A subjective affective feeling of being not at ease or agitated.		
				Feeling sadness BCIO:050233			A subjective affective feeling of sadness.		
				Feeling tired MFOEM:000080			A subjective affective feeling of tiredness, needing sleep.		
					Feeling exhausted MFOEM:000112		Feeling tired to an extremely strong degree.		
				Hunger MFOEM:000205			A subjective affective feeling that involves discomfort and is associated with a need to consume food.		

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
				Subjective need BCIO:006075			A subjective affective feeling that involves experiencing anticipated relief or continued comfort by obtaining or maintaining a particular state.	A feeling of anticipated relief or avoidance of discomfort.	
				Pain MFOEM:000203			A subjective affective feeling in an organism S, involving two integrated levels: (a) activation of the nociceptive system and associated emotion generating brain components of S, and (b) a simultaneous aversive sensory and emotional experience on the part of S, where (b) is phenomenologically similar to the sort of aversive experience involved in pain with concordant tissue damage.	An unpleasant experience typically associated with tissue damage.	
		Appraisal process MFOEM:000002					A mental process that gives rise to an appraisal.	Evaluating something's relevance to oneself.	
		Arousal MF:0000012					A mental process that involves heightened responding to an internal or external stimulus.		
		Attending MF:0000018					A mental process whereby relevant aspects of one's mental experience are focused on specific targets.		
		Avoidance mental process BCIO:006161					A mental process that reduces the frequency by which an aversive cognitive representation is evoked.		
		Cognitive process MF:0000008					A mental process that creates, modifies or has as participant some cognitive representation.		

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
			Comprehension BCIO:006110				A cognitive process that creates a representation of the meaning and significance of a communication, object, event or situation.		
			Decision simplification BCIO:006111				A cognitive process used prior to decision-making that reduces the perceived scope or complexity of available options.		
			Mental distancing BCIO:006162				A cognitive process that involves intentionally detaching oneself from one's immediate thoughts.		Decentring
				Targeted mental distancing BCIO:006163			Mental distancing that involves identifying particular immediate thoughts and intentionally detaching from these thoughts.		Targeted decentring
			Thinking MF:0000013				A cognitive process that involves the manipulation of mental language and/or mental images.		
				Reflective thinking BCIO:006112			Thinking that involves the generation of inferences by reasoning based on one or more statements, evaluating anticipated consequences or considering the relationships between concepts.		
		Dissonance reduction process BCIO:006113					A mental process through which a perceived inconsistency between two concurrently held cognitive representations is reduced.		
		Goal setting process BCIO:006114					A mental process that establishes a cognitive representation of the desired end state.		

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
		Heuristic process BCIO:006115					A mental process that uses simple rules and associations learnt from experience to make judgements.		
		Impulse BCIO:050234					A mental process that is sudden and compels an organism to think or behave in some way.		
		Judging MF:0000006					A mental process during which information is evaluated, the outcome of which is a belief or opinion.		
			Decision-making BCIO:006116				Judging during which one proposition is selected as preferred from at least two.		
			Social comparison process BCIO:006118				Judging oneself or one's social group in relation to the qualities or characteristics of another person or social group.		
		Learning BCIO:050239					A mental process in which a lasting mental or behavioural change occurs as the result of experience.		
			Associative learning BCIO:006119				Learning that involves changing strength of association between two or more mental processes.		
				Classical conditioning BCIO:006120			Associative learning process that occurs when the pairing of a conditioned and unconditioned stimulus leads to the conditioned stimulus producing a response that would otherwise have only been produced by the unconditioned stimulus.		
				Extinction in classical			Associative learning process in which the strength of a conditioned response is reduced because its conditioned stimulus is presented		

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
				conditioning BCIO:006122			without being accompanied by the unconditioned stimulus.		
				Operant conditioning BCIO:006125			Associative learning process in which the likelihood of a particular behavioural response is influenced by the past consequences associated with performing that behaviour.		
				Extinction in operant learning BCIO:006123			Associative learning process in which the rate of behavioural response in the presence of a discriminative stimulus is reduced because the response is no longer followed by a reinforcer.		
				Discrimination learning BCIO:006121			Associative learning process in which people learn to distinguish between appropriate responses to similar but different stimuli depending on whether a generalised response is rewarded or not.		
				Generalisation in learning BCIO:006124			Associative learning process in which prior learning that an antecedent stimulus signals certain consequences of behaviour spreads to a stimulus that differs in certain aspects from the original antecedent stimulus.		
				Habit learning BCIO:0050004			Associative learning process that involves strengthening an association between a stimulus and an impulse through repetition of co-occurrence of the stimulus and the behaviour.		
			Non-associative learning GO:0046958				A simple form of learning whereby the repeated presence of a stimulus leads to a change in the probability or strength of the response to that stimulus. There is no association of one type of stimulus with		

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
							another, rather it is a generalized response to the environment.		
				Habituation GO:0046959			A decrease in a behavioural response to a repeated stimulus.		
				Sensitization GO:0046960			An increase in a behavioural response to a repeated stimulus.		
			Observation al learning GO:0098597				Learning that occurs through observing the behaviour of others.		
				Imitative learning GO:0098596			Observational learning in which new behaviours are acquired through imitation.		
		Memory GO:0007613					The activities involved in the mental information processing system that receives (registers), modifies, stores, and retrieves informational stimuli.		
			Associative memory BCIO:006126				A memory process that deals with the receipt, storage, retrieval and modification of information regarding a set of entities associated with a particular object or event.		
			Episodic memory BCIO:006127				A memory process that deals with the receipt, storage, retrieval and modification of information regarding a personally experienced event at a particular time or place.		
			Semantic memory BCIO:006128				A memory process that deals with the receipt, storage, retrieval and modification of information associated with meanings, understandings or conceptual facts about the world.		
			Procedural memory				A memory process that deals with the receipt, storage, retrieval and modification of		

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
			BCIO:006129				information regarding how to perform a complex activity without conscious awareness.		
			Iconic memory BCIO:006130				A memory process that deals with the receipt, storage, retrieval and modification of information regarding a brief visual stimulus,		
		Mental categorising BCIO:006131					A mental process in which objects, events, people, or experiences are grouped into classes, on the basis of features shared by members of the same class and features distinguishing the members of one class from those of another.		
		Mental imagery MF:0000083					A mental process that evokes the representation of the sensory characteristics of objects or events when these are not immediately present to the senses.		
		Mentally comparing against a standard BCIO:006132					A mental process in which conditions are compared against a particular reference level.		
		Motivation BCIO:006133					A mental process that energises and directs behaviour.		
			Automatic motivation BCIO:006134				Motivation that arises from emotions and impulses that result from associative learning or innate dispositions.		
			Autonomous motivation BCIO:005000 01				Motivation that is internally generated and based on a behaviour being interesting or valuable to an individual.		

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
				Intrinsic motivation BCIO:006136			Autonomous motivation due to a behaviour's inherent enjoyment, satisfaction or benefits to oneself.		
				Fundamental need-based motivation BCIO:0050004			Autonomous motivation due to a behaviour being perceived to satisfy core psychological need.		Integrated motivation; integrated regulation
			Extrinsic motivation BCIO:0050003				Motivation that is based on external rewards, punishments or pressure regarding a behaviour.		Controlled motivation
				Approval-based motivation BCIO:0050000			Extrinsic motivation to gain or maintain social approval or a positive self-evaluation.		Introjected motivation; introjected regulation
		Perception MF:0000019					A mental process which is a) produced by a causal process involving a part of the environment of the organism, and b) is experienced by the organism as being so caused, and c) in which the relevant part of the environment is thereby represented to the organism.	A sensory experience involving a part of a person's environment.	
		Planning MF:0000027					A mental process that involves mentally manipulating representations of steps in an imagined process which has some goal.		
		Self-binding BCIO:050236					A mental process that involves creating adverse consequences for oneself if one does not stick to an intended course of action.		Pre-commitment

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Definitions	Informal definition	Synonym
		Self-monitoring BCIO:006137					A mental process in which one observes one's own behaviour or mental processes.		
		Subliminal process MF:0000088					A mental process that involves neuronal activity in response to a sensory stimulus but which is not the subject of consciousness.		
		Non-judgemental acknowledgement BCIO:050235					A mental process that involves taking notice of one's affective, mental or bodily experience without judging it as good or bad.		Acceptance
		Wanting MF:0000045					A mental process that involves thinking about a state of affairs that is not yet the case together with a desire for that state of affairs to come about.		
Consciousness MF:0000017							That part of the mental process that confers a subjective perspective, a phenomenology, an experience of the mental process of which it is a part; and intends the object or event that the mental process is about, should such exist; it confers intentionality on the mental process.	A subjective experience of one's inner or outer world, which can include experience of one's own mental processes.	

Appendix 7-7. All comments, examples and non-hierarchical relationships with other classes specified for classes in the MoA Ontology

Label	Comment	Example	Non-hierarchical relationships with other classes
Anatomical structure	The formal definition for this definition does not include the influence of the environment on anatomical structure, as the class was reused from the Uber-anatomy ontology. This ontology defines anatomical structure for all organisms, including those whose anatomical structure might not be directly influenced by an interaction between genes and the environment. An example for this class serving as a mechanism of action would be in an intervention that targets change in anatomical structure. For instance, a gastric bypass surgery can change the structure of the stomach and intestines, and thereby change eating behaviours.	The structure of the stomach and intestines	
Environmental system	The term 'disposition' is used to describe that an environmental system **can** surround and interact with one or more material entities. This conditionality is important, as an entity does not necessarily have to be in an specific environment system at all times. The class 'environmental system' relates to what is found in the physical and social environment (e.g., how many streets are there for you to walk on), while the class 'opportunity' is about the features of the environment and how they interact with the person (e.g., whether an environment enables a person to take walks). 'environmental system' includes physical and social aspects of the environment. As all subclasses of 'environmental system' will have physical aspects, a separate subclass for 'physical environmental system' would not capture a unique aspect of its parent class.		
Bodily disposition	Extended organism refers to an organism and its microbiome (e.g., the bacteria that live in one's digestive system) Bodily disposition would include features, such as a person's strength (which can be used in a specific context), but not weight. A person would have a certain weight independent of most circumstances they are in.		
Personal capability	The phrase 'ordinarily brings benefits to an organism or group of organisms' is used to explain that capabilities normally provide a benefit. For instance, having a musical ability is ordinarily an ability that is positive for a person (e.g., they receive positive feedback about their ability). However, in certain exceptional cases (e.g., a neighbour becoming annoyed with a person playing the piano and expressing this annoyance), the ability might not bring benefits.		
Mental skill	The term 'skill' specifically refers to acquired capabilities, as behavioural theories suggested that the main difference between capabilities and skills was that skills were learned.		
Self-regulation capability	Modulate' refers to 'modifying or controlling influence on or change the strength' and involves processes*		

Label	Comment	Example	Non-hierarchical relationships with other classes
Mental disposition	Mental disposition' is a subclass of 'bodily disposition', as mental dispositions occur in the body.		
Awareness	The events attended to can include internal and external events.		
Social environmental system			
Belief about threat			'belief about threat' has part 'belief about severity of an outcome' and 'belief about susceptibility to a threat'*
Belief about severity of an outcome			'belief about severity of an outcome' is part of 'belief about threat'*
Belief about susceptibility to a threat			'belief about susceptibility to a threat' is part of 'belief about threat'*
Belief about control over behaviour			'belief about control over behaviour' has part 'self-efficacy belief for a behaviour'
Self-efficacy belief for a behaviour and its associated outcomes	The phrase 'to organize' refers to the ability to organize mental processes and sequences of actions. 'self-efficacy belief for a behaviour' is part of 'self-efficacy belief for a behaviour and its associated outcomes.' However, the latter also includes a belief about the outcomes associated with behaviour.		'self-efficacy belief for a behaviour and its associated outcomes' has part 'self-efficacy belief for a behaviour'
Self-efficacy belief for a behaviour	The phrase 'to organize' refers to the ability to organize mental processes and sequences of actions. 'self-efficacy belief for a behaviour' is part of 'self-efficacy belief for a behaviour and its associated outcomes.' However, the latter also includes a belief about the outcomes associated with behaviour.		'self-efficacy belief for a behaviour' is part of 'self-efficacy belief for a behaviour and its associated outcomes.' and 'belief about control over behaviour'
Belief about consequences of an occurrence	Consequences can be either positive or negative.		
Belief about anticipated emotion	Belief about anticipated emotions' is about the consequences of anything, not just behaviour. In contrast, the class 'belief about emotional consequences of behaviour' is about the emotions resulting from behaviours.		
Belief about consequences of behaviour	Consequences can be either positive or negative.		

Label	Comment	Example	Non-hierarchical relationships with other classes
Belief about social consequences of behaviour	Consequences can be either positive or negative.		
Belief about consequences of goal attainment	Consequences can be either positive or negative. Belief about consequences of goal attainment is about what types of outcomes will be achieved, rather than the value or the likelihood of these outcomes. For instance, a person may believe that studying every night will help achieve good grades. However, the value of achieving such grade may vary, and would fall under 'evaluative belief'.		
Belief about likelihood of consequences of an occurrence	Consequences can be either positive or negative.		
Belief about gain	The perceived gain could be in anything internal or external, such as health or wealth. The classes 'belief about gain' and 'belief about reduction' do not necessarily involve likelihood. Likelihoods relate to the future, However, 'belief about gain' might be about an existing gain. For instance, in situation where the following trade is offered: "I've given you $2, are you willing to trade it for a 50% chance of winning $6?" it'd be "I have $2 more than I started with", there is an existing gain that is compared to a future one.		
Belief about reduction	The perceived loss could be in anything internal or external, such as wealth or health. The classes 'belief about gain' and 'belief about reduction' do not necessarily involve likelihood. Likelihoods relate to the future. However, 'belief about reduction' might be about an existing loss.		
Perceived norm	A person does not need to belong to a group to have a perception of their norms. For instance, the perceived norm could be in a group one aspires to belong to, and so the person might attempt to conform to it in an attempt to be accepted as a member of that group.		
Evaluation of self	One's attributes can be evaluated as positive or negative.		
Belief about the personal desirability of consequences of a behaviour	'Desirability' can range from highly desirable to highly undesirable.		
Stereotype	The attributes of members are not definitional. For instance, a psychologist studying psychology is not a stereotype*		
Decision	Decision is defined as a 'mental disposition', a realisable entity, because a person requires a process to form, think about or reconsider a decision.		

Label	Comment	Example	Non-hierarchical relationships with other classes
Knowledge	Knowledge is defined as a 'mental disposition', a realisable entity, because a person requires a process to access the information stored in their brain. A person knows something, when the relevant information has been retrieved from their memory. There are instances where a person might have learned something but is unable to retrieve the information at a specific moment.		
Learned stimulus-response co-occurrence	The responses to an event can include thinking and impulses to respond*		
Learned stimulus-behaviour co-occurrence	Learned stimulus-behaviour co-occurrence can vary in strength.		
Psychological need	Psychological needs can be satisfied or thwarted*		
Mental plan	A mental plan is the outcome of a planning process.		
Emotional action tendency	Emotional action tendency involves dispositions that proceed a behaviour relating to emotions. For instance, fight or flight action tendencies influence a person's behaviour in response to a threat.	Flight and fight action tendencies	
Cognitive representation	The use of the phrase 'an anatomical structure in the cognitive system' in the formal definition means that a specific cognitive representation will depend on parts of the brain, rather than involving the whole brain.		
Appraisal	Appraisals are a part of emotion processes, representing how a triggering stimulus is relevant to oneself. Appraisal captures the 'aboutness' of an emotion process. There is no intended sequence of the entities that are part of the emotion process (e.g., an appraisal does not necessarily precede a physiological process part of the emotion process).		
Appraisal of dangerousness	Dangerousness or level of threat may refer to physical, emotional or social dangers or threats.		
Desired standard	Examples of 'reference level' are the level of a behaviour and the blood glucose level.		
Social identity	Social identity' can involve a sense of one's rank or status in reference to other groups.		
Personal role	A role can be assigned without being realised. A person realises a role by doing something.		
Occupational role	A role can be assigned without being realised. A person realises a role by doing something.		
Social role	A role can be assigned without being realised. A person realises a role by doing something.		

For instance, a stimulus (the image of a tiger) can produce different emotion processes depending on how the relevance of this stimulus is evaluated. The image of a tiger on TV would not be evaluated as dangerous. However, the image of a tiger two meters away from a person would be relevant to a person in terms of its dangerousness. Therefore, the appraisal of the dangerousness of the tiger would be part of the emotion process 'fear'.

Label	Comment	Example	Non-hierarchical relationships with other classes
Location	An intervention could be used to rearrange objects in an environment, changing the location of a person relative to these objects and thereby increasing the likelihood of a behaviour.		
Behavioural opportunity	The term 'enables' is used in the definition to specify that 'behavioural opportunity' is a necessary condition for behaviour to occur. Although other MoAs will help bring behaviour about, there has to be a 'behavioural opportunity' for behaviour to occur. The term 'facilitates' is used to specify that 'behavioural opportunity' will make the behaviour easier. Higher behavioural opportunity will increase the likelihood of behaviour across situations and people. The class 'environmental system' relates to what is found in the physical and social environment (e.g., how many streets are there for you to walk on), while the class 'behavioural opportunity' is about the features of the environment and how they interact with the person (e.g., whether an environment enables a person to take walks).		
Physical behavioural opportunity	A 'behavioural opportunity' is a feature of the environmental system. While the class 'environmental system' is about what is found in an environment, the behavioural opportunity is a feature of the environment which interacts with the person and enables or prevents a behaviour.		
Financial behavioural opportunity	As 'financial behavioural opportunity' will involve some physical monetary entity (e.g., money borrowed from someone), it is a physical behavioural opportunity. While financial resources (e.g., money) have intrinsically social dimensions, the 'financial behavioural opportunity' does not involve a social aspect.		
Healthcare access	The 'healthcare services' refers to services provided for the purposes of preventing, detecting, curing or controlling a health problem or enhancing wellbeing.		
Individual human behaviour	The striated muscles referred to do not ordinarily involve the cardiac muscles. Behaviour can be an MoA or outcome depending on how 'behaviour' is described in an intervention. The Behaviour Change-Intervention Ontology includes the class 'outcome behaviour' (definition: Human behavior that is an intervention outcome.), which would not be an MoA. When an intervention targets one behaviour to achieve an outcome behaviour (e.g., exercise for smoking cessation), the former qualifies as an MoA.		
Habitual behaviour	A learnt stimulus-behaviour co-occurrence can lead to activation or execution of a habitual behaviour. Habitual behaviour can be an MoA or outcome depending on how 'habitual behaviour' is described in an intervention. The Behaviour Change-Intervention Ontology includes the class 'outcome behaviour' (definition: Human behavior that is an intervention outcome.), which would not be an MoA. When an intervention targets a habitual behaviour to achieve an outcome behaviour, the former qualifies as an MoA.		
Normative behaviour	Normative behaviour can be an MoA or outcome depending on how 'normative behaviour' is described in an intervention. The Behaviour Change-Intervention Ontology includes the class 'outcome behaviour' (definition: Human behavior that is an intervention outcome.), which would not be an MoA. When an intervention targets a normative behaviour to achieve an outcome behaviour, the former qualifies as an MoA.		

Label	Comment	Example	Non-hierarchical relationships with other classes
Goal pursuit process	Goal pursuit process' is a bodily process, as it may involve more than just mental processes (i.e., other processes in the body).		
Behavioural self-regulation of behaviour	Behavioural self-regulation of behaviour can be an MoA or outcome depending on how 'behavioural self-regulation of behaviour' is described in an intervention. The Behaviour Change-Intervention Ontology includes the class 'outcome behaviour' (definition: Human behavior that is an intervention outcome.), which would not be an MoA. When an intervention targets behavioural self-regulation of behaviour to achieve an outcome behaviour, the former qualifies as an MoA.		
Mental process	Mental processes can vary in the degree to which they involve consciousness. A 'mental process' is a subclass of 'bodily process', as mental processes occur within the body, specifically involving the brain.		
Affective process	Valence refers to the 'the subjective value of an event, object, person, or other entity in the life space of the individual' (https://dictionary.apa.org/valence). Valence ranges from negative to positive.		
Emotion process	There is no intended sequence of the entities that are part of the emotion process (e.g., an appraisal process does not necessarily precede a physiological process part of the emotion process). Emotion processes are distinguished from other affective processes (e.g., mood) by having an object. Even if an emotion is experienced due to physiological reasons, they would be felt as being about something or someone. For instance, a person might be angry at a situation that they would normally not be angry at, because they are hungry. However, that person would still be angry at a specific situation. Valence refers to the 'the subjective value of an event, object, person, or other entity in the life space of the individual' (https://dictionary.apa.org/valence). Valence ranges from negative to positive.		
Anxiety	Experiencing 'anxious mood' can give rise to 'anxiety'. An 'anxious mood' does not have an object but involves generalised feeling of anxiety that a person experiences. In contrast, 'anxiety' will be about something, even if this object is not well-specified. The term 'distal' can refer to future threats or geographically distant threats. Distinguished from fear since it is triggered by a distal threat whereas fear is triggered by an immediate threat. Often gradual and long-lasting, whereas fear usually has sudden onset and offset.		
Fear	Distinguished from anxiety since it usually has sudden onset and offset. Anxiety is often gradual and long-lasting and is triggered by a distal threat.		
Subjective affective feeling	Subjective affective feeling can have greater or weaker physiological or mental components. The bodily process that are experienced will usually involve some mental process.	Feeling calm; hunger; pain	

Label	Comment	Example	Non-hierarchical relationships with other classes
	Bodily sensation and the experiences of emotions (e.g., feeling calm) would both qualify as examples of 'subjective affective feeling'. As a subclass of 'affective process', subjective affective feelings have valence. Valence refers to the 'the subjective value of an event, object, person, or other entity in the life space of the individual' (https://dictionary.apa.org/valence). Valence ranges from negative to positive.		
Feeling an urge	An urge is felt when an impulse is frustrated.		
Feeling nervous	Note that 'feeling nervous' is related to 'anxiety' but is not identical with it. Feeling nervous is the subjective experience of nervousness, while anxiety is a full-blown emotion process. Affective feelings are process parts of emotion processes.		
Impulse	An impulse is not felt or consciously processed. If an impulse if frustrated, a person or other organism feels an urge.		
Decision-making	The output of decision-making is a decision.		
Learning	The class 'learning' from the Gene Ontology was not reused but adapted for the Mechanism of Action (MoA) Ontology, as the Gene Ontology only focuses on learning adaptive behaviours in order to be relevant to all organisms.		
Associative learning	While associative learning is often defined as learning an association between a stimulus and response, the stimulus has to be perceived. Therefore, associative learning is between perceiving or processing information about a stimulus (a mental process) and one or more other mental processes. The label 'associative learning' is also used for a behaviour change technique (BCT) in the BCT Taxonomy v1 (Michie et al., 2013). The definition for this BCT reads as follows: 'Present a neutral stimulus jointly with a stimulus that already elicits the behavior repeatedly until the neutral stimulus elicits that behavior.' As indicated by the definition, the BCT is the deliberate presentation of a stimulus, whereas the MoA is a learning process that occurs in the brain.		
Extinction in classical conditioning	An unconditioned stimulus is "a stimulus that elicits a reflexive or innate response (the unconditioned response) without prior learning." (p., 280, Holt, N., Bremner, A., Sutherland, E., Vliek, M., Passer, M., & Smith, R. (2019). EBOOK: Psychology: The Science of Mind and Behaviour, 4e. McGraw Hill.) A conditioned stimulus is a stimulus that, through association with an unconditioned stimulus, comes to elicit a conditioned response similar to the original unconditioned response (Holt, N., Bremner, A., Sutherland, E., Vliek, M., Passer, M., & Smith, R. (2019). EBOOK: Psychology: The Science of Mind and Behaviour, 4e. McGraw Hill.)		

Label	Comment	Example	Non-hierarchical relationships with other classes
Extinction in operant learning	Discriminative stimulus is "a signal that a particular response will produce certain consequences." (p. 291; Holt, N., Bremner, A., Sutherland, E., Vliek, M., Passer, M., & Smith, R. (2019). EBOOK: Psychology: The Science of Mind and Behaviour, 4e. McGraw Hill.)		
Generalisation in learning	The label 'Generalisation of target behavior' is used for a behaviour change technique (BCT) in the BCT Taxonomy v1 (Michie et al., 2013). The definition for this BCT reads as follows: 'Advise to perform the wanted behaviour, which is already performed in a particular situation, in another situation.' Therefore, the BCT is the advice to perform the behaviour, whereas the MoA is a learning process that occurs in the brain.		
Mentally comparing against a standard	The term 'condition' may refer to the characteristics of an object, event and person.		
Intrinsic motivation	The phrase 'benefits to oneself' includes the reduction of unpleasant internal states.		
Perception	Examples for 'causal processes involving a part of the environment of an organism' that can be perceived are light rays and air vibrations.

'Perception' is about perceiving stimuli in one's environment in the MoA Ontology. However, the term 'perception' is sometimes used to refer to things defined as 'belief' in the MoA Ontology. | | |
| **Planning** | The outcome of this mental process is a mental plan which has the potential to be followed to bring about the desired outcome* | | |
| **Self-monitoring** | There are behaviour change techniques labelled 'Self-monitoring of behaviour' and 'Self-monitoring of outcome of behaviour'. These are about establishing a method for monitoring states. In contrast, the MoA is the mental process of monitoring.

'Self-monitoring of behaviour' is defined as 'Instruct self recording of specified behaviour/s (with or without associated thoughts, emotions, situations) as part of a behaviour change strategy ' (Michie et al., 2013).
'Self-monitoring of outcome of behaviour' is defined "Establish a method for the person to monitor and record their behavior(s) as part of a behavior change strategy" (Michie et al., 2013). | | |
| **Linguistic communication behaviour** | | Written language, spoken language and sign-language communication | |

Label	Comment	Example	Non-hierarchical relationships with other classes
Non-linguistic communication behaviour		Communicating through bodily gestures, through pictograms and through sound (e.g., a siren going off communicates information about the presence of danger without the use of language)	
Social influence behaviour		Social support from social network*	

Notes. *The comments, relationships and examples that were not added to the MoA Ontology in Chapter 7

Appendix 8-1. Instructions on using EPPI-Reviewer added to the annotation manual

What will I be doing on this project?

You will be using the EPPI Reviewer programme to identify pieces of text in scientific papers that represent aspects of Mechanisms of Action (MoAs) Ontology. This process is called *annotation*.

You will allocate *codes* to pieces of text within these papers. These codes provide a label to describe what is of interest in an article e.g., 'motivation' as an MoA.

To ensure inter-rater reliability, you will be paired with another coder to annotate the same papers for MoAs. As we will be testing the inter-rater reliability, you will not be in contact with this person during the annotations.
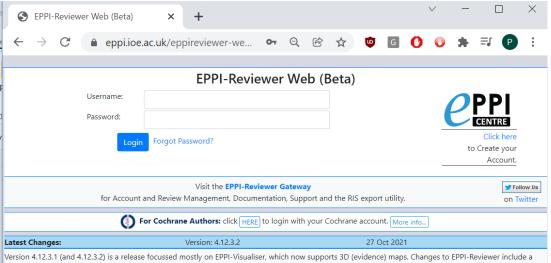
How to annotate using EPPI reviewer
What is EPPI Reviewer?
EPPI Reviewer is a programme to help manage systematic reviews. It is developed and maintained by the EPPI-Centre at UCL. In Human Behaviour-Change Project, we are using EPPI-Reviewer to annotate published behaviour change interventions reports.

A. Accessing EPPI Reviewer
- https://eppi.ioe.ac.uk/EPPIReviewer-Web/ Enter your username and password. Note: EPPI is currently not accessible using Internet Explorer.
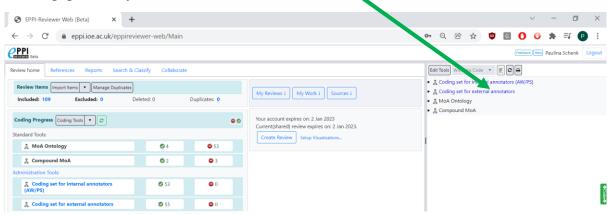
B. How to locate the papers you'll need

Step 1: Find a document to annotate

You can find the documents assigned to you clicking on the Codes panel.

1) On the Codes panel, under "Coding set for external annotators" find the sets of papers that you need to code.

2) Right click the set of papers you need (e.g., 'Pilot annotations' or 'Set 1') and click 'With this Code'. The papers in this set will then populate in the main window.

3) Find your chosen PDF and Click 'Go'

4) Click 'View PDF' (eye symbol) at the bottom right of the Files window.

C. General Annotation Guidance

Note: Before annotating, you must have read the abstract, part of Introduction listing study's hypotheses (usually the last 1 or 2 paragraphs), Method and Results of the paper.
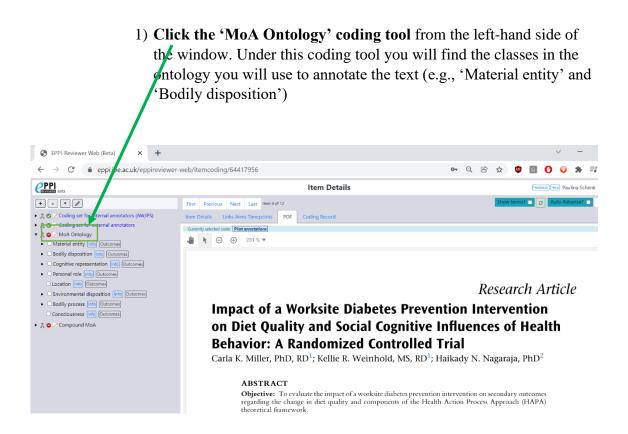
(For details on where to look for MoAs in an intervention report, see Section D)

Reminder: What is Annotation?

Annotation is the process of identifying pieces of text in scientific papers that represent aspects of the MoA Ontology. This involves highlighting a word or phrase in a paper and saying it is relevant to a code in the MoA Ontology.

Step 1: Adding an annotation

Important: You must also refer to the 'Mechanism of action annotation guidance' (Section D) to give you information on how to code mechanisms of action (MoAs).

1) **Click the 'MoA Ontology' coding tool** from the left-hand side of the window. Under this coding tool you will find the classes in the ontology you will use to annotate the text (e.g., 'Material entity' and 'Bodily disposition')

2) By **right clicking the arrows next to the classes** (e.g., 'Bodily disposition'), you can open more detailed classes that you might need to code with (e.g., 'Behavioural intention').

3) When you have identified an MoA in the intervention report and the class that applied to this MoA (e.g., 'Behavioural intention'), then **select the relevant code by clicking the box** on the left next to it.

4) Once you selected the relevant code (e.g., 'Behavioural intention'), you need to **highlight** the relevant text (e.g., 'behavior intention') that made you select this class and **right click the 'A' symbol (Highlight).**

5) You can remove a code by unchecking the box next to the relevant code (e.g., Behavioural intention').

6) To reset comments or coding, click Reset.

ANNOTATING TIPS

- **Scan through the WHOLE PAPER.**

- **Preference for annotations and evidence is *always for in-text words/sentences*, rather than tables. This is because tables are harder for the system to interpret than text.**

- **If you remove a code and it is not relevant to the paper, ensure you uncheck the tickbox associated with it.**

Step 2: Adding evidence to each code

All codes must have '*evidence*' to show where the text is located in the paper. This evidence provides the context of where the coded information was found: the words before and after it.

Evidence can be:

1. If evidence is found in-text:

The full sentence that the word(s) is found in:

> Example*: "Two items assessed **behavioral intention**; 1 item assessed intention for a healthy food plan and 1 assessed intention for performing regular exercise"* (Miller, Weinhold, & Nagaraja, 2016).
>
> (Provides evidence for the code *'behavioral intention'* (coded word in bold, evidence in italics)

2. If evidence is ONLY found in tables:
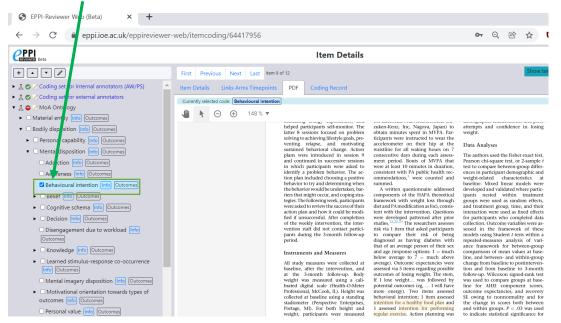
The line before, during and after the coded word(s)/number(s),

> Example: "*Motivation 47.5 48.0 **Behaviour intention** 41.4 38.5 Outcome expectation 7.4 7.4*" (MoA: Behaviour intention – information taken across 3 rows of a table)
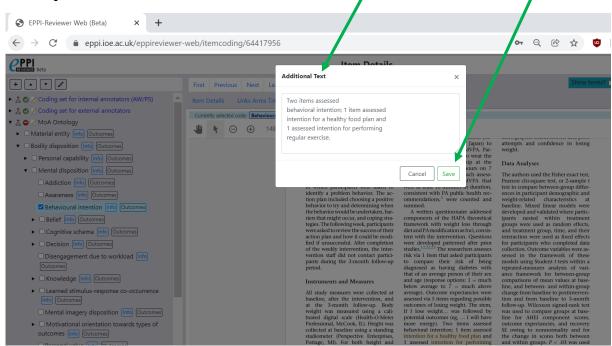
If you cannot copy the line before, during and after the coded word(s), then copy the table's title and use it as evidence.

To add evidence to a code you have selected:

1) First, **copy the sentence or Table lines** would like to add as evidence. Then, **click 'Info' box** next to relevant code when a paper is open.

2) Once you have clicked the 'Info' box, **a small window labelled 'Additional Text'** will pop-up. **Paste the evidence into the 'Additional Text' window and press 'Save'.**

3) If you add find evidence for coding a class in more than one sentence, you can take both the sentences as evidence. To add multiple sources of evidence, please add a ';;;' between each source of evidence.

4) If you think a piece of text is relevant but there is no code for it, code it as the next highest level of the MoA Ontology

e.g., If you are unsure if an MoA is 'intrinsic motivation' or 'extrinsic motivation', then code the text as the upper-level code 'motivation'

ANNOTATING TIPS

- **Preference for annotations and evidence is** *the clearest first mention of an MoA in the Methods or Results Sections.*

- **Do not worry about the formatting of copied table information in the Info box. It does not need to represent the visual appearance in the text.**

Step 3: Checking your coding

Once you have finished coding a paper, it is important that you check your coding. This helps to improve reliability between annotators.

Checking the Coding Record
1) Go out of the paper record and re-enter it (via 'View) for your codes to be visible.
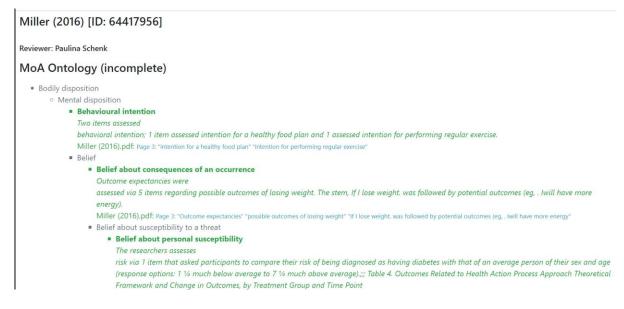
2) Click on the 'Coding record' tab of paper

3) Click 'View' next to your coding.

4) Check your codes - check that all the codes you have identified are present in the Coding record

5) Check your evidence in the coding record and that each code has at least one source of evidence (see Step 2). The evidence is shown in italics.

Note: **Only the code that you clicked should be in bold** – this reflects the codes that have been selected in annotations.

For example, in the screenshot above, only 'Behavioural intention', 'Belief about consequences of an occurrence' and 'Belief about personal susceptibility' codes and evidences are in bold and/or green. The respective higher levels of 'Mental disposition', 'Belief' and 'Belief about susceptibility to a threat' are not in bold.

Next step: Accessing the next of your allocated papers

Once you're happy with your annotations, you can easily move to the next of your allocated papers by clicking 'Next'.

Appendix 8-2. The number of reports in which researchers familiar with the MoA Ontology agreed or disagreed on a class's presence, and the Krippendorff's alpha value for each annotated class

No	Class label	No of reports in which researchers agreed on a class's presence	No of reports in which researchers disagreed on a class's presence	Krippendorff's alpha	> 0.67 Krippendorff's alpha*
1	Emotional self-regulation capability	1	0	1	✓
2	Belief about need satisfaction	1	0	1	✓
3	Belief about sufficient time for a behaviour	1	0	1	✓
4	Normative belief	3	0	1	✓
5	Belief about responsibility to act	1	0	1	✓
6	Social embeddedness	1	0	1	✓
7	Self-identity	1	0	1	✓
8	Physical behavioural opportunity	1	0	1	✓
9	Pleasure associated with behaviour	1	0	1	✓
10	Feeling at ease	1	0	1	✓
11	Feeling energetic	1	0	1	✓
12	Feeling sadness	1	0	1	✓
13	Feeling exhausted	1	0	1	✓
14	Goal setting process	2	0	1	✓
15	Intrinsic motivation	4	0	1	✓
16	Fundamental need-based motivation	1	0	1	✓
17	Approval-based motivation	3	0	1	✓
18	Non-judgemental acknowledgement	1	0	1	✓
19	Belief about severity of an outcome	4	1	0.879	✓
20	Knowledge regarding a behaviour	4	1	0.879	✓
21	Extrinsic motivation	4	1	0.879	✓
22	Belief about emotional consequences of a behaviour	3	1	0.848	✓
23	Perceived descriptive norm	3	1	0.848	✓
24	Self-efficacy belief for a behaviour	15	4	0.824	✓
25	Behavioural intention	14	4	0.818	✓
26	Motivation	5	2	0.813	✓
27	Autonomous motivation	5	2	0.815	✓
28	Situational self-efficacy belief for a behaviour	12	4	0.804	✓
29	Mental capability	2	1	0.792	✓

No	Class label	No of reports in which researchers agreed on a class's presence	No of reports in which researchers disagreed on a class's presence	Krippendorff's alpha	> 0.67 Krippendorff's alpha*
30	Belief about personal susceptibility	3	2	0.731	✓
31	Social influence behaviour	6	4	0.705	✓
32	Belief about consequences of behaviour	12	7	0.676	✓
33	Belief about barriers	1	1	0.66	
34	Belief about message	1	1	0.66	
35	Belief about message trustworthiness	1	1	0.66	
36	Belief about one's social environment	1	1	0.66	
37	Perceived injunctive norm	1	1	0.66	
38	Belief about control over behaviour	1	1	0.66	
39	Learned stimulus-behaviour co-occurrence	1	1	0.66	
40	Linguistic communication behaviour	1	1	0.66	
41	Fear	1	1	0.66	
42	Belief about health consequences of behaviour	2	2	0.649	
43	Evaluative belief about behaviour	2	2	0.649	
44	Knowledge	2	2	0.649	
45	Individual human behaviour	2	2	0.649	
46	Planning	2	2	0.649	
47	Mental disposition	3	3	0.637	
48	Mental plan for a behaviour	2	3	0.544	
49	Belief about consequences of an occurrence	1	2	0.484	
50	Belief about social consequences of behaviour	1	2	0.484	
51	Belief about likelihood of health consequences of behaviour	1	2	0.484	
52	Behavioural self-regulation of behaviour	1	2	0.484	
53	Subjective affective feeling	1	2	0.484	
54	Feeling nervous	1	2	0.484	

No	Class label	No of reports in which researchers agreed on a class's presence	No of reports in which researchers disagreed on a class's presence	Krippendorff's alpha	> 0.67 Krippendorff's alpha*
55	Belief about social support	1	3	0.375	
56	Perceived norm	1	3	0.375	
57	Belief about susceptibility to a threat	1	3	0.375	
58	Knowledge regarding a threat	1	3	0.375	
59	Mental process	1	3	0.375	
60	Belief	1	4	0.298	
61	Bodily disposition	0	1	0	
62	Mental skill	0	1	0	
63	Behavioural self-regulation capability	0	1	0	
64	Behavioural capability	0	1	0	
65	Physical behavioural capability	0	1	0	
66	Belief about conformity to behavioural norms	0	1	0	
67	Belief about likelihood of consequences of an occurrence	0	1	0	
68	Belief about one's physical environment	0	1	0	
69	Belief about threat	0	1	0	
70	Evaluative belief	0	1	0	
71	Evaluation of self	0	1	0	
72	Evaluative belief about behavioural outcomes	0	1	0	
73	Belief about the personal desirability of consequences of a behaviour	0	1	0	
74	Self-efficacy belief for a behaviour and its associated outcomes	0	1	0	
75	Cognitive schema	0	1	0	
76	Learned stimulus-thought co-occurrence	0	1	0	
77	Mental plan	0	1	0	
78	Social identity	0	1	0	
79	Normative behaviour	0	1	0	
80	Anxiety	0	1	0	
81	Happiness	0	1	0	
82	Arousal	0	1	0	
83	Attending	0	1	0	
84	Associative learning	0	1	0	
85	Automatic motivation	0	1	0	
86	Self-monitoring	0	1	0	

No	Class label	No of reports in which researchers agreed on a class's presence	No of reports in which researchers disagreed on a class's presence	Krippendorff's alpha	> 0.67 Krippendorff's alpha*
87	Environmental system	0	2	-0.01	
88	Social environmental system	0	2	-0.01	
89	Personal capability	0	2	-0.01	
90	Belief about anticipated emotion	0	2	-0.01	
91	Habitual behaviour	0	2	-0.01	
92	Communication behaviour	0	2	-0.01	
93	Self-regulation of behaviour	0	2	-0.01	
94	Bodily process	0	3	-0.021	
95	Inter-personal behaviour	0	3	-0.021	
96	Cognitive process	0	3	-0.021	
97	Emotion process	0	4	-0.031	

Notes. *A Krippendorff's alpha value above 0.67 indicated 'acceptable' inter-rater reliability

Appendix 8-3. The number of reports in which researchers unfamiliar with the MoA Ontology agreed or disagreed on a class's presence, and the Krippendorff's alpha value for each annotated class

No	Class label	No of reports in which researchers agreed on a class's presence	No of reports in which researchers disagreed on a class's presence	Krippendorff's alpha	> 0.67 Krippendorff's alpha*
1	Belief about health consequences of behaviour	2	0	1	✓
2	Belief about sufficient time for a behaviour	1	0	1	✓
3	Belief about others' susceptibility	2	0	1	✓
4	Personal value	1	0	1	✓
5	Physical behavioural opportunity	1	0	1	✓
6	Fear	1	0	1	✓
7	Guilt	1	0	1	✓
8	Pleasure associated with behaviour	1	0	1	✓
9	Memory	1	0	1	✓
10	Iconic memory	1	0	1	✓
11	Planning	1	0	1	✓
12	Non-judgemental acknowledgement	1	0	1	✓
13	Belief about severity of an outcome	3	1	0.848	✓
14	Knowledge	4	2	0.78	✓
15	Knowledge regarding a behaviour	4	2	0.78	✓
16	Perceived norm	3	2	0.731	✓
17	Perceived descriptive norm	3	2	0.731	✓
18	Mental plan for a behaviour	3	2	0.731	✓
19	Self-efficacy belief for a behaviour	18	8	0.679	✓
20	Friendship network	1	1	0.66	

No	Class label	No of reports in which researchers agreed on a class's presence	No of reports in which researchers disagreed on a class's presence	Krippendorff's alpha	> 0.67 Krippendorff's alpha*
21	Belief about social consequences of behaviour	1	1	0.66	
22	Belief about susceptibility to a threat	1	1	0.66	
23	Social behavioural opportunity	1	1	0.66	
24	Hunger	1	1	0.66	
25	Intrinsic motivation	1	1	0.66	
26	Self-monitoring	1	1	0.66	
27	Belief about personal susceptibility	2	2	0.649	
28	Social influence behaviour	6	6	0.598	
29	Belief about social support	2	3	0.544	
30	Normative belief	2	3	0.544	
31	Situational self-efficacy belief for a behaviour	6	8	0.505	
32	Belief about control over behaviour	1	2	0.484	
33	Emotion process	1	2	0.484	
34	Anger	1	2	0.484	
35	Craving	1	2	0.484	
36	Feeling an urge	1	2	0.484	
37	Behavioural intention	6	9	0.463	
38	Motivation	2	5	0.396	
39	Belief about consequences of behaviour	3	9	0.301	
40	Inter-personal behaviour	1	4	0.298	
41	Evaluative belief about behavioural outcomes	1	5	0.24	
42	Belief	1	6	0.193	
43	Mental disposition	1	8	0.12	

No	Class label	No of reports in which researchers agreed on a class's presence	No of reports in which researchers disagreed on a class's presence	Krippendorff's alpha	> 0.67 Krippendorff's alpha*
44	Bodily disposition	0	1	0	
45	Personal capability	0	1	0	
46	Mental skill	0	1	0	
47	Attentional self-regulation capability	0	1	0	
48	Behavioural self-regulation capability	0	1	0	
49	Cognitive self-regulation capability	0	1	0	
50	Emotional self-regulation capability	0	1	0	
51	Social behavioural capability	0	1	0	
52	Social skill	0	1	0	
53	Addiction	0	1	0	
54	Belief about emotional consequences of behaviour	0	1	0	
55	Belief about likelihood of consequences of an occurrence	0	1	0	
56	Belief about likelihood of health consequences of behaviour	0	1	0	
57	Belief about gain	0	1	0	
58	Belief about need satisfaction	0	1	0	
59	Belief about one's environment	0	1	0	
60	Perceived injunctive norm	0	1	0	
61	Evaluative belief about others	0	1	0	
62	Mental plan	0	1	0	
63	Self-identity	0	1	0	

No	Class label	No of reports in which researchers agreed on a class's presence	No of reports in which researchers disagreed on a class's presence	Krippendorff's alpha	> 0.67 Krippendorff's alpha*
64	Personal role	0	1	0	
65	Communication behaviour	0	1	0	
66	Linguistic communication behaviour	0	1	0	
67	Goal pursuit process	0	1	0	
68	Plan enactment	0	1	0	
69	Mental process	0	1	0	
70	Anxiety	0	1	0	
71	Feeling sadness	0	1	0	
72	Subjective need	0	1	0	
73	Avoidance mental process	0	1	0	
74	Learning	0	1	0	
75	Autonomous motivation	0	1	0	
76	Behavioural importance-based motivation	0	1	0	
77	Wanting	0	1	0	
78	Mental capability	0	2	-0.01	
79	Evaluative belief	0	2	-0.01	
80	Evaluation of self	0	2	-0.01	
81	Belief about voluntariness of behaviour	0	2	-0.01	
82	Knowledge regarding a threat	0	2	-0.01	
83	Social embeddedness	0	2	-0.01	
84	Emotional action tendency	0	2	-0.01	
85	Appraisal	0	2	-0.01	
86	Behavioural opportunity	0	2	-0.01	
87	Affective process	0	2	-0.01	
88	Decision-making	0	2	-0.01	

No	Class label	No of reports in which researchers agreed on a class's presence	No of reports in which researchers disagreed on a class's presence	Krippendorff's alpha	> 0.67 Krippendorff's alpha*
89	Extrinsic motivation	0	2	-0.01	
90	Self-regulation capability	0	3	-0.021	
91	Belief about barriers	0	3	-0.021	
92	Belief about one's social environment	0	3	-0.021	
93	Evaluative belief about behaviour	0	3	-0.021	
94	Mental plan for coping with barriers	0	3	-0.021	
95	Impulse	0	3	-0.021	
96	Social comparison process	0	3	-0.021	
97	Belief about consequences of an occurrence	0	4	-0.031	
98	Individual human behaviour	0	4	-0.031	
99	Self-regulation of behaviour	0	5	-0.042	
100	Subjective affective feeling	0	7	-0.065	
101	Bodily process	0	8	-0.076	

Notes. *A Krippendorff's alpha value above 0.67 indicated 'acceptable' inter-rater reliability