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Identifying behaviour change techniques for sustainable food consumption: A systematic review using the BCTTv1

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ABSTRACT

Due to the significant impact of Western diets on the environment, interventions are being trialled in supermarkets, restaurants, and other settings to encourage sustainable food consumption (SFC). The Behaviour Change Technique Taxonomy (BCTTv1) lists and categorises Behaviour Change Techniques (BCTs), which facilitates the development and understanding of behaviour change interventions. However, its applicability to pro-environmental behaviour change has not been extensively explored. This systematic review uses the BCTTv1 to identify the BCTs that have been previously used to encourage SFC behaviours. Studies were retrieved from Scopus, PSYCInfo, GreenFILE, and the Web of Science Core Collection. Twenty-six interventions across 19 articles were reviewed, enabling the identification of 13 BCTs which were coded using the BCTTv1 and categorised according to their target behaviour and effect size. The most frequently applied BCTs were 12.1 'restructuring the physical environment', which was used in the most effective interventions; 6.2 'social comparison', which was used in interventions with smaller and more unpredictable effects; 5.3 'information about social and environmental consequences'; 5.2 'salience of consequences'; and 7.1 'prompts/cues'. Despite challenges in assessing the BCTs' effectiveness due to multicomponent interventions and varying effects across different contexts, this review offers recommendations on changing SFC behaviour as well as the applicability of the BCTTv1 for SFC interventions.

1. Introduction

Global environmental change is perhaps the most pressing issue of our time (IPCC, 2022). A significant contributor to greenhouse gas (GHG) emissions and ecological breakdown is human food consumption, most crucially our still-increasing consumption of animal products (Aiking & de Boer, 2020; Ritchie & Roser, 2019). Meat and dairy production alone accounts for 60 % of GHG emissions in agriculture (Poore & Nemecek, 2018). Indeed, one of the most impactful things that individuals in wealthier nations can do to minimise their contribution to environmental change is move towards a sustainable diet (Jarmul et al., 2020; Scarborough et al., 2023; Weibel et al., 2019). A 'sustainable diet' in simple terms is understood to be largely plant-based with few, if any, animal proteins (Fischer & Garnett, 2016; Hoolohan et al., 2013; Willett et al., 2019).

While there has been a rise in 'flexitarianism' - "a flexible eating style that emphasises the addition of plant or plant-based foods and encourages meat to be consumed less frequently and/or in smaller portions" (Bánáti, 2022, p. 4083) - the most sustainable diets remain relatively unpopular (Allenden et al., 2022; Bánáti, 2022). Indeed, studies examining how to accelerate the adoption of sustainable diets represent a growing body of research (Grundy et al., 2022). Scoping searches suggest that research on sustainable food consumption (hereafter abbreviated to SFC) has been primarily focused on the reduction of meat consumption, the uptake of lower-carbon options (e.g. choosing poultry instead of beef, buying 'eco-certified' products or plant-based milk), and increasing the consumption of plant-based foods overall (e.g. Coucke et al., 2019; Graça et al., 2019; Hoolohan et al., 2013; Nguyen et al., 2022; Taufik et al., 2019; Vanclay et al., 2011).

Adopting a sustainable diet will require many people to substantially

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alter their behaviour, as is the case for many of the changes needed to mitigate the climate crisis. A scientific report presented by the UK House of Lords (2022) estimated that two-thirds of the changes needed to achieve net zero emissions involve behaviour change, with one-third relating to solutions like low-carbon infrastructure and energy systems. However, such behaviour change is not easily achieved. Behaviours like food consumption are influenced by a highly complex network of factors both internal and external including motivation, cultural and peer norms, habits, availability of alternatives, the effort required, and information asymmetries (Sanchez-Sabaté and Sabaté, 2019; Vermeir et al., 2020; Vinnari & Vinnari, 2014). Any combination of these can make it difficult for even the most pro-environmentally minded individuals to choose the most sustainable options without external support. The complexity and importance of this challenge together mean that there is significant value in collating knowledge regarding the crucial influences on a given behaviour, and ways of targeting these, to inform the design of effective policies and interventions. That is why many behaviour change scientists and practitioners have studied, developed, and tested interventions to make the sustainable choice the easy, obvious choice when it comes to food consumption.

However, there has been limited progress so far in addressing the full range of influences on SFC behaviours, and interventions struggle to achieve more than small effects (Abrahamse, 2020). Past efforts to encourage SFC behaviours, such as reducing meat consumption or choosing more sustainable dishes and products, have often relied on the assumption that what holds people back is primarily a lack of knowledge or understanding, and that providing information about the negative environmental consequences of certain food choices should drive consumers to behave more sustainably (Graves & Roelich, 2021). Such interventions have tended to have very limited effects, which evidence indicates is because information alone has little power to change behaviour when other factors such as motivation play a large role (Abrahamse, 2020; Eker et al., 2019). It is not always obvious, however, whether knowledge, motivation, or other factors (e.g. in one's surroundings) play a bigger role.

Generating insights into what factors are truly driving a particular behaviour allows for the development of interventions that precisely target the most relevant factors, increasing the chance of success (Michie et al., 2011). For instance, if behavioural research indicates that sales of a particular climate-friendly food product are lagging not because consumers do not understand or appreciate its benefits but because they are put off by unattractive presentation or because it is easily overlooked in the supermarket, it stands to reason that the best solution is not to provide more information but to make the packaging and/or placement of the product more salient and attractive. Another way in which behavioural scientists can assist in the shift toward more sustainable diets is by identifying which interventions best target the relevant influences on a given behaviour once those have been identified, applying scientific rigour to developing and testing different interventions (Moore et al., 2015; Skivington et al., 2021).

As part of the process of changing behaviour, existing evidence should be examined to gain an overview of which behaviour change interventions are being used and which are most likely to be effective for which behaviours in which contexts (Godfray et al., 2018). This can reveal opportunities for improvement upon past attempts and avenues for intervention that can target the exact right lever to create a change in behaviour. Alongside learning which interventions show the most promise of changing certain target behaviours, there is value in understanding which interventions have been tested and showed *no* effect on behaviour, or even had a backlash effect. Knowing what has been tried before can prevent practitioners from having to 'reinvent the wheel' while freeing up resources to tailor the intervention to their context; knowing what to avoid could prevent failed investments in unsuitable interventions.

However, as behavioural science draws on and overlaps with a range of social science disciplines, it can be difficult to compare findings across existing studies that use vastly different language and frameworks and sometimes lack detail. To address this issue, tools have been developed to catalogue and compare such varied evidence in a unified way. Not only do these tools enable behavioural scientists to collate and analyse past research to inform their interventions, but using them (and finding their limitations) allows for the tools themselves to be refined further, increasing their accuracy and usefulness.

One such tool is a unified taxonomy (hierarchical classification) of methods to change behaviour that can be used to understand and classify the intervention components in (theoretically) any behaviour change study. The Behaviour Change Technique Taxonomy (BCTT) version 1 was developed by an international consensus of 32 behaviour change experts to reflect all the known 'building blocks' that could be used in behaviour change interventions, combining them into a single taxonomy with definitions and exemplars (Michie et al., 2013, 2015). Part of its purpose is to enable greater precision when reporting newly developed interventions, but this well-organised set of behaviour change techniques (BCTs) can also be used to analyse past interventions for their 'active ingredients' as well as to develop new interventions based on what each BCT is aimed at changing. The BCTTv1 consists of 93 techniques organised into 16 groups (e.g. BCT 1.9 'Commitment' in group 1 'Goals and planning'), which Armitage and colleagues (2021) compare to the periodic table (see Fig. 1). It was purposely labeled 'version 1' to allow for future improvements and updates based on new evidence and has since been cited over 5500 times.

However, applications of the BCTTv1 to interventions promoting SFC have been notably limited. A recently published review (Masciangelo et al., 2024) used the BCTTv1 to identify promising techniques to promote climate-friendly behaviour among people in upper-middle and high-income countries, but only for the domains of mobility, energy consumption, and water consumption. This leaves out sustainable food consumption, which is among the most impactful behaviour changes that members of the public in such countries can make (Jarmul et al., 2020; Scarborough et al., 2023; Weibel et al., 2019). Kwasny and colleagues (2022) did examine the effectiveness of different SFC interventions, but without categorising these into the BCTTv1; something that would make them more accessible and easier for practitioners to apply. Indeed, reviews using the BCTTv1 to categorise SFC interventions remain few and far between, the most prominent perhaps being Hedin and colleagues' (2019) review which is limited to digital interventions only and cannot account for research published since their search in early 2018.

This also means that there is limited evidence for the suitability of the BCTTv1 for the categorisation and understanding of behaviour change interventions in the domain of sustainable food consumption. Due to the nature of its development, it may lend itself better to some target behaviours than others. Crucially, the taxonomy was developed mainly in reference to literature on health behaviours and health psychology: two-thirds of sources cited in Michie and colleagues' (2015) reporting of their development of the BCTT were explicitly concerned with health behaviour, with most of the remaining articles relating to methodology rather than behaviour of any other kind. Very little is known about its ability to accurately categorise interventions in other domains such as pro-environmental behaviour (Armitage et al., 2021; Hedin et al., 2019). For instance, Hedin and colleagues (2019) note that the BCTTv1 mainly encompasses cognitive paths to behaviour change rather than techniques which induce emotional reactions (e.g. pride, hope, shame, fear). Meanwhile, recent research suggests that emotions can be powerful motivators for climate action and adopting more sustainable behaviours (Brosch & Steg, 2021; Gregersen et al., 2023), making this a potential area of improvement for future versions of the BCTT as it concerns pro-environmental behaviour change in particular.

To summarise, there is a need to accelerate the adoption of sustainable diets through behaviour change. To achieve significant behaviour change, interventions must target the most relevant influences on a behaviour. This requires two things: understanding the key

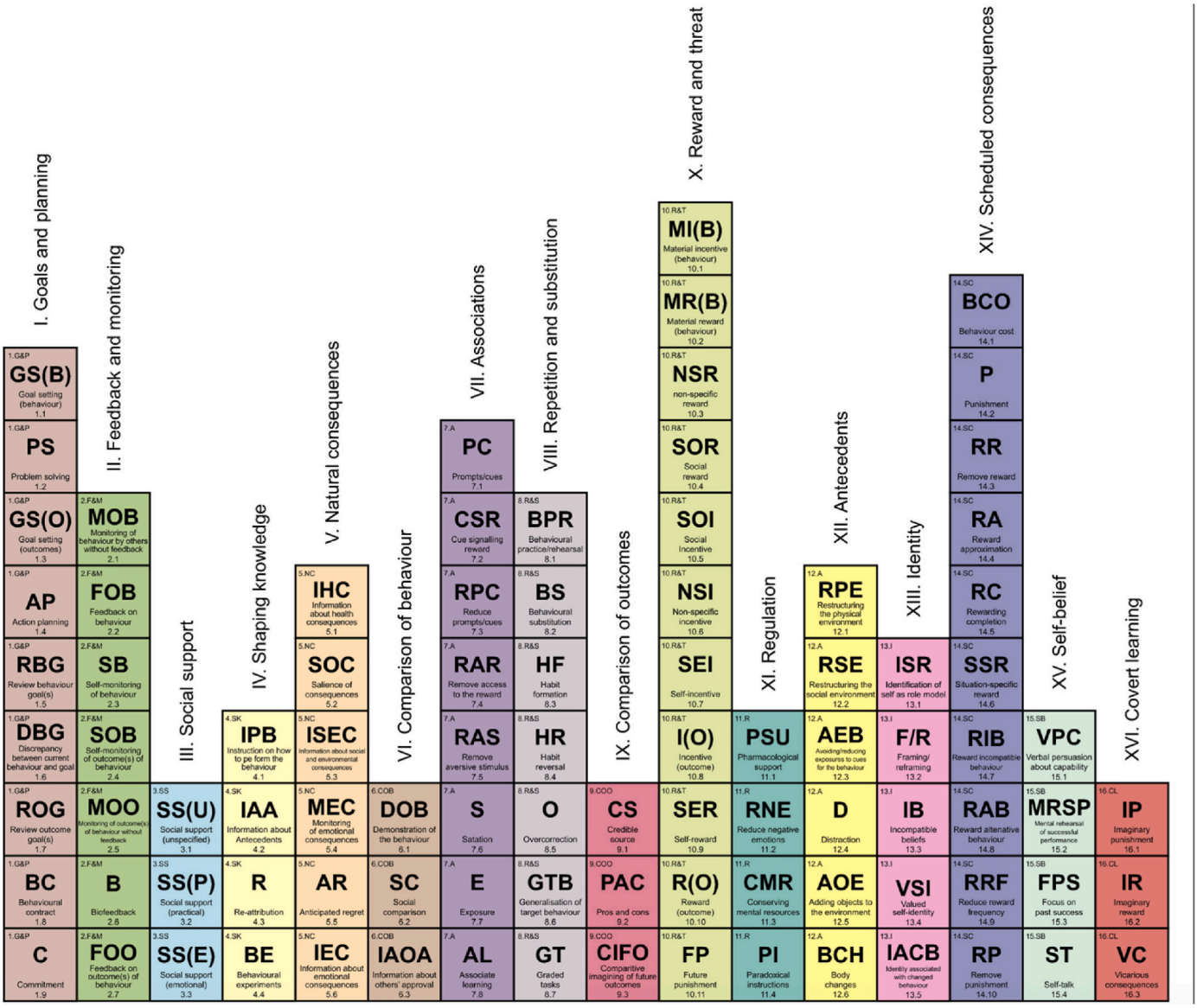

Fig. 1. The BCTTv1 as a 'periodic table' of Behaviour change elements (Armitage et al., 2021).

barriers and drivers of SFC behaviours, and understanding the 'active ingredients' of interventions in order to develop effective solutions that target those key barriers and drivers. To help create an overview of what 'active ingredients' work, where, and for whom, some tools have been developed in the behaviour change literature. The most ubiquitous of these to date, the BCTTv1, is a useful framework for collating existing knowledge and generating new insights about effective BCTs. However, while it can be applied to better understand interventions for SFC, its application in the domain of pro-environmental behaviour has been limited so far.

In response to this identified research gap, this systematic review will examine evidence obtained from behaviour change interventions aimed at increasing SFC as a type of pro-environmental behaviour, and code them according to the BCTs they contain. It will provide an overview of which BCTs have been previously used and which appear most effective at encouraging SFC behaviours, in order to serve as a resource for future intervention development and further the use of the BCTTv1 for comparing evidence across the literature in this particular context. This use of the taxonomy may also reveal gaps in the applicability of the BCTTv1 for categorising SFC interventions for which recommendations can be developed, although this is not the primary aim of this review.

The current review builds on existing work by including more recently published research on SFC - a topic which has seen much recent interest (Portugal-Nunes et al., 2023) and would certainly benefit from being better catalogued - and synthesising information about a wider range of past interventions into the BCTTv1.

To that end, the aims for this review are.

1. To identify which BCTs have been used in published behaviour change interventions to encourage sustainable food consumption (SFC).
2. To describe which BCTs seem to be most effective at encouraging SFC behaviour based on published intervention outcomes.

2. Methods

This systematic review is registered with PROSPERO (CRD42023442381). It was conducted following the steps set out in the PRISMA statement (Page et al., 2021). Due to the secondary nature of this research, no ethical approval was required.

2.1. Search strategy

The search strategy was developed in four facets as shown in Table 1, each containing relevant terms and synonyms found through scoping searches; for instance, the same component might be described as 'vegan', 'vegetarian', or 'plant-based' food by different authors. The databases searched were Scopus, PSYCInfo (via Ovid), GreenFILE (via EBSCOhost), and the Web of Science Core Collection; each chosen based on breadth and subject relevance.

Iterations of the search strategy were tested by entering terms into the various databases and checking whether the first page of results for each search contained a good proportion of seemingly relevant articles, whether it returned specific 'model' articles representative of the sort of articles that should be included (Coucke et al., 2019; Spaargaren et al., 2013), and whether a search inadvertently returned entirely irrelevant results based on some unforeseen combination of terms. Table 1 contains the syntax used for Scopus; the syntax used for other databases contained the same terms, with bracketing and Boolean operators adjusted as necessary for their search function. The final search took place on June 28, 2023.

2.2. Article screening and selection

Eligibility criteria (detailed in Table 2) were developed using the PICO (Population, Intervention, Comparator, Outcome) framework (e.g. Methley et al., 2014) with the addition of a 'publication' category. The criteria were based on considerations regarding the desired quality of evidence and practical constraints affecting the possible scope of the review. For instance, it was decided to exclude online and laboratory studies in favour of retaining a smaller number of only field studies, set in physical food purchasing settings. This is because, for behaviour taking place in 'real world' settings such as supermarkets and restaurants, field studies provide the most ecological validity regarding an intervention's effect on actual behaviour in those settings (Lunn & Ní Choisdealbha, 2018).[1] Search results were exported to Rayyan (Ouzzani et al., 2016) where automatically flagged duplicate files were manually checked and deleted. Where duplicates were found, the record with the

Table 1
Search terms used to find relevant records in scopus.

Facet	Syntax
Sustainable foods	(TITLE-ABS-KEY (((sustainab* OR low-carbon OR "low carbon" OR lower-carbon OR low-emissions OR "low emissions" OR veg*n OR flexitarian OR "reduce meat' OR "reducing meat" OR "reduction in meat" OR "sustainable meat" OR "animal product*" OR "animal protein' OR "alternative protein' OR "meat substitut*" OR "plant-based product'))
	AND
Consumption behaviour	((food AND (consum* OR choice OR buy OR select OR sales OR purchas* OR product OR meal OR dish)) OR "food consumption' OR ("sustainable food consumption' OR "low* carbon food consumption" OR "sustainable food choices"))
	AND
Evaluation	((evaluation OR test* OR rct OR "randomi*ed controlled trial' OR trial OR qed OR experiment OR measurement)
	AND
Intervention	(intervention OR program* OR regime OR nudg*))) AND PUBYEAR >2005)

[1] For interventions aiming to change *online* food purchasing behaviour, which fell outside the scope of this review, online study designs (e.g. as used by Lohmann et al., 2024; Katare & Zhao, 2024) can of course be highly suitable and deliver robust results, especially where the testing environment closely simulates the environment in which the behaviour would normally take place (e.g. an online supermarket or food delivery platform).

Table 2
Eligibility criteria for article screening.

	Inclusion criteria	Exclusion criteria
Population	Participants aged 18+ No specific population is selected beyond this, as the aim is to review interventions for SFC in a variety of contexts and settings. Settings may include retail, restaurants, cafeterias/ canteens, households, and so forth.	Studies focused on children and adolescents aged <18 were excluded because the same interventions might not have the same effects on children as on adults, so these populations would need to be separated for comparison of effects which is beyond the intended scope of this review. Children are also typically not in a position to make direct decisions regarding food choice at the point of purchase.
Intervention	Quantitative or mixed-methods descriptions and evaluations of behaviour change interventions.	Studies where the intervention was not actually implemented, or articles wherein the intervention is not described, were excluded because these do not provide any information on the use and effects of specific intervention components. Studies with only qualitative outcome measures were excluded because these would not allow for synthesising effect size information on the most promising BCTs.
Comparator	Articles to be reviewed must include some element of intervention evaluation, but this need not include a specific control group in an experimental setting.	Studies lacking any comparison/ evaluation were excluded, as this does not allow for valid conclusions to be drawn about the effects of an intervention.
Outcomes	Behavioural measures related to reducing meat consumption, increasing consumption of plant-based foods such as vegetables and pulses, substitution of high-carbon foods with lower-carbon alternatives, including but not limited to plant-based alternatives to meat and dairy or eco-certified products. Only objective measures of real-world food choice were accepted. Papers with other outcome measures related to food waste reduction were excluded as these are not directly related to food *choice* and therefore fall under a different domain than intended for this review.	Studies lacking a measure of behaviour (change) in terms of food choice were excluded as these do not meet the criteria of being an intervention test. Studies with attitudes, intentions, or 'willingness to pay' as their primary outcome were excluded as these are flawed predictors of behaviour and are not direct measures of choice (Bernardes et al., 2018; Fink et al., 2018; Terlau & Hirsch, 2015). Interventions to bridge this gap are the subject of their own category of behavioural research (Papies, 2017) and beyond the scope of this review. Online and laboratory studies were excluded as these cannot measure real-world food choice behaviour and so provide a lower quality of evidence regarding the real-world effectiveness of interventions. Studies with only self-reported measures of food consumption were excluded as they are not objective intervention outcomes and the reliability of self-reports can vary greatly between studies, impeding the comparability of different studies. Studies focused solely on health outcomes as relates to behaviour were excluded, as this review is concerning environmentally sustainable behaviour. Likewise,

(*continued on next page*)

Table 2 (*continued*)

	Inclusion criteria	Exclusion criteria
		studies aimed at increasing SFC behaviours such as fruit and vegetable consumption or reducing meat consumption for purely health-related reasons were excluded, as this was thought to potentially affect the intervention approach and render comparison inappropriate.
Publication	English-language full-text articles in peer-reviewed journals Published from 2006 onwards due to greater research focus in the social sciences on sustainable food consumption following a seminal UN report on the role of food systems in climate change (Steinfeld et al., 2006).	Non-peer-reviewed articles will be excluded in order to ensure a minimum level of research quality for included papers. Articles with no full text available will be excluded as these are insufficient for data extraction. Non-English language articles will be excluded as the author is not sufficiently proficient in other languages to conduct data extraction, and most peer-reviewed articles are published in English regardless of their country of origin. Review articles will be excluded due to a lack of primary data collection, but the bibliographies of relevant reviews may be used to manually add additional articles for screening.

most complete and up-to-date information was retained.

After deduplication, the primary reviewer screened all titles and abstracts against the eligibility criteria and recorded decisions in Rayyan. An informal hierarchy of exclusion criteria[2] was created so that exclusion decisions were tagged with the most 'problematic' reason why the article was unsuitable for this review. This meant records were organised based on a single exclusion reason for each paper as required for the PRISMA reporting method, even if a given abstract met multiple exclusion criteria.

The articles marked for potential inclusion were then screened against the eligibility criteria using their full text. To check reliability, a secondary reviewer from outside the author team independently screened 10 % of full texts and decisions were compared, resulting in 89 % agreement; discrepancies in inclusion decisions were resolved through discussion.

3. Data extraction

A data extraction form was created in Microsoft Excel to organise the information necessary to differentiate and compare studies at the level needed for this review. This was initially drafted by the first author and then refined and edited to add additional columns based on feedback from author DD. The final form included the following variables: author (s); publication year; country; target behaviour(s); study design; population; sample size; intervention description; analytical approach; intervention evaluation results; and effect size. An earlier iteration of the data extraction form combined effect size and results into one 'outcomes' column, but were later separated to distinguish between *whether* an intervention had been effective (in terms of statistical significance) and *how* effective it had been, so that BCTs could be compared in more detail.

3.1. Analysis/synthesis

3.1.1. Study characteristics

Study characteristics were analysed descriptively to gain an overview of the research to be reviewed.

3.1.2. Use of BCTs

The extracted intervention descriptions were deductively coded using the BCTTv1 to identify BCTs corresponding to the intervention components used. The primary reviewer was trained in using the taxonomy through a postgraduate degree in behavioural science, as well as following an additional specialised training provided by the taxonomy's creators (BCT Taxonomy, 2023). The BCTTv1 was used as a framework and coding manual using the descriptions and notes provided in the original document.

To check inter-rater reliability and refine the interventions' coding, several rounds of secondary coding took place. After primary coding of the full dataset, an external coder with experience using the taxonomy examined the BCT codes assigned by the primary coder for six studies (27 %) to check for (dis)agreements. This resulted in 78 % agreement; after discussion, two codes were added and one removed, with amendments made across the entire dataset where appropriate. An independent secondary coding of 22 % of the reviewed studies was performed by authors JT and RR, resulting in 71.4 % agreement. Two suggested changes were accepted and two rejected. Accepted changes in coding were applied to other similar instances across the articles for consistency. The resulting table (with 100 % of studies) underwent tertiary (confirmatory) coding by author DD, resulting in 84 % agreement. DD was not blinded to previously assigned codes, enabling them to explain their suggested changes and the primary coder AT to make informed final decisions. Twelve suggested changes were incorporated and one rejected, resulting in the final set of codes.

3.1.3. Effectiveness of BCTs

There is no definitive method yet for comparing the effectiveness of individual BCTs. A scoping review found that each of the various methods used to date (e.g. observational comparison studies, meta-analyses, meta-regressions) had inherent limitations, meaning only weak conclusions could be drawn (Michie et al., 2018). In the absence of an obvious best approach, it was decided to categorise effect sizes into a limited number of size categories and search for patterns of BCTs found in interventions with greater and smaller effects, an adaptation of one of the methods reviewed by Michie and colleagues (2018). Effect size indicates the magnitude of behaviour change an intervention seems to have caused, either compared to before its implementation (pre-post designs) or to a control condition which did not receive the intervention (experimental designs).

To synthesise the effectiveness of the reviewed interventions, the extracted measures of effect size were categorised into relatively small/moderate/large effects. Where effect size is expressed in odds ratios (ORs), Chen and colleagues (2010) argue that ± 1.68 = small, ± 3.47 = moderate, and ± 6.71 = large. Where an effect is expressed in percentage point (pp) change, Rosenthal (1996) argues that generally, ± 7 pp = small, ± 18 pp = moderate, ± 30 pp = large, and ± 45 pp = very large. Approximate 'very small' (<3 pp) and 'small to moderate' (10–15 pp) categories were added to distinguish slightly further between small effects. This simplified approach was used because different studies used different metrics of effect size and it is beyond the scope of this review to meta-analyse or recalculate these into a uniform metric which could be directly compared. The size categories were judged to allow for adequate indirect comparison and infer patterns in the apparent efficacy of different BCTs depending on their occurrence in more or less effective interventions. A 'heat map' table with intervention effects derived from

[2] Wrong population (no adult human participants) > Wrong outcome (not food choice behaviour) > Wrong aim (no sustainability focus) > Wrong study design (not testing an intervention) > Wrong publication type (not a scientific article).

Table 3
Study characteristics.

Study no.	Study	Country	Target Behaviour	Setting	Sample size
1	Pechey et al. (2022) study 1	UK	Reducing meat consumption	University cafeteria	12 cafeterias, 8 months of sales data
2	Pechey et al. (2022) study 2	UK	Choosing veg*n food	Workplace cafeteria	18 cafeterias, 16 weeks of sales data
3	Larner et al. (2021)	UK	Choosing lower-carbon foods	University cafeteria and café	2 food outlets, 3 weeks of sales data
4	Slapø and Karevold (2019)	Sweden	Reducing meat and fish consumption	University cafeteria	1 cafeteria, 228 observations
5	Andersson and Nelander (2021)	Sweden	Reducing meat consumption	University cafeteria	1 cafeteria, 7968 observations
6	Visschers and Siegrist (2015)	Switzerland	Choosing lower-carbon foods	University cafeteria	780 participants
7	Lohmann et al. (2022)	UK	Choosing lower-carbon foods	University cafeteria	5 cafeterias, 81,401 observations
8	Gavrieli et al. (2022)	Australia, USA, Singapore, Brazil	Choosing veg*n food	Workplace buffet restaurants	4 workplace buffets, 4 weeks of consumption data
9	Jalil et al. (2020)	USA	Reducing meat consumption	University cafeteria	215 participants, ±50,000 observations
10	Griesoph et al. (2021)	Germany	Choosing veg*n food	University cafeteria	2 cafeterias, 13,907 observations
11	Reinholdsson et al. (2022)	Sweden	Choosing veg*n food	Fast food restaurant	136 restaurants, 346,081 observations
12	Çoker et al. (2022)	UK	Reducing meat consumption	In-store restaurants	22 in-store restaurants, 4 weeks of sales data
13	Garnett et al. (2021)	UK	Reducing meat and fish consumption	University cafeteria	1 college dining hall, 13,840 observations
14	Gravert and Kurz (2021)	Sweden	Choosing veg*n food	Restaurant	1 restaurant, 8 weeks of sales data, ±4500 observations
15	Taufik et al. (2022)	The Netherlands	Choosing veg*n food	Restaurant	397 participants
16	Piernas et al. (2021)	UK	Reducing meat consumption, choosing veg*n food	Supermarket	108 supermarkets, 12 weeks of sales data
17	Bauer et al. (2022)	Denmark	Purchasing fruit and vegetables	Supermarket	2 supermarkets, 246,940 observations
18	Coucke et al. (2019)	Belgium	Choosing lower-carbon foods	Supermarket	2 supermarkets, 17,500 observations
19	Sparkman et al. (2020) study 1	USA	Choosing veg*n food	University cafeteria	23,103 observations
20	Sparkman et al. (2020) study 3	USA	Choosing veg*n food	Restaurant	12,636 observations
21	Sparkman et al. (2020) study 4	USA	Choosing veg*n food	Restaurant	7914 observations
22	Schwitzgebel et al. (2020)	USA	Reducing meat consumption	University cafeteria	495 participants, 13,642 observations

Note. The term 'veg*n' refers to vegetarian/vegan foods, which may or may not overlap but always denote the absence of meat.

Table 4 and color-coded by size was created to visually identify such patterns; for instance, if a particular BCT was repeatedly found in interventions with large effects.

4. Results

There were 3296 search results prior to deduplication. Of 1428 unique articles screened in Rayyan, 1346 were excluded based on title and abstract, leaving 82 for full-text screening. Of those 82 articles, 19 articles containing 22 relevant studies – testing a total of 26 interventions – were included for review. Fig. 2 reports these steps.

The results of the analyses are reported in two sections (3.4 and 3.5), corresponding with the study's two aims (1.11), and subdivided by the interventions' target behaviours. It should be noted that SFC behaviours often overlap, so an intervention targeting one behaviour may also affect another which was not explicitly targeted, for instance reducing meat consumption and increasing veg*n food consumption.

4.1. Study characteristics

Study characteristics are presented in Table 3. The included articles were all published since 2015, mainly between 2019 and 2022 (95 %). Most studies took place in the United Kingdom (32 %), the USA (27 %), or Sweden (18 %). Most studies tested a single intervention; only two studies compared the effects of multiple different interventions (Larner et al., 2021; Reinholdsson et al., 2022). Eight of the 26 interventions (31 %) aimed to reduce meat consumption. Ten interventions (38 %) had as (one of) their target behaviour(s) the consumption of veg*n (i.e. vegetarian and/or vegan) food, including plant-based meat alternatives. Four interventions (15 %) aimed to increase the consumption of foods with lower carbon footprints (e.g. oat milk instead of dairy). Only one intervention aimed to increase the purchasing of fruit and vegetables as a share of total supermarket shopping to encourage more sustainable diets. The most common measure of effect size was percentage point change, expressing the difference between two percentages. For instance, if veg*n orders increased from 3 % to 9 % of all orders, the change was 6 pp.

4.2. BCTs used for sustainable food consumption

4.2.1. Summary

Table 4 gives an overview of BCTs per intervention. Thirteen of the 93 BCTs in the BCTTv1 were identified across 26 interventions, featuring a total of 63 instances of BCTs (see coding table in Appendix A). The most frequently used BCTs overall were 5.3 'Information about social and environmental consequences' (12 instances), 5.2 'Salience of consequences' (9), 7.1 'Prompts/cues' (9), and 12.1 'Restructuring the physical environment' (10). Nine of the 26 interventions involved a single BCT, another nine used two BCTs, and the rest used at least three different BCTs.

To distinguish between the number of *different* BCTs coded for each intervention and the *total* number of BCTs used, we indicate in Table 4 how many total BCTs an intervention contained. For instance, an intervention that employed BCT 7.1 as well as two examples of BCT 5.3

Table 4
Results and effect sizes for each intervention, organised by target behaviour.

Study no.	Intervention	Target behaviour (s)	BCTs identified	no. of BCTs	Results	Effect size	Effect size category
1	Pechey et al. (2022) study 1	Reducing meat consumption	12.1 Restructuring the physical environment 12.5 Adding objects to the environment	2	Significant reduction in meat consumption	19.9 pp change	Moderate
4	Slapø and Karevold (2019)	Reducing meat and fish consumption	5.2 Salience of consequences 5.3 Info about social/ environmental cons. X2 7.1 Prompts/cues	3	No significant change in meat and fish consumption	N/A	Null
5	Andersson and Nelander (2021)	Reducing meat consumption	5.2 Salience of consequences 5.3 Info about social/ environmental cons.	2	Significant reduction in meat consumption	5.6 pp change in share of total sales	Small
9	Jalil et al. (2020)	Reducing meat consumption	5.1 Information about health consequences 5.3 Info about social/ environmental cons.	2	Significant reduction in meat consumption and increase in plant-based food consumption	4.6 pp change (meat) 4.2 pp change (plant-based)	Small
12	Çoker et al. (2022)	Reducing meat consumption	6.2 Social comparison 7.1 Prompts/cues	2	No significant change in meat consumption	N/A	Null
13	Garnett et al. (2021)	Reducing meat and fish consumption	12.1 Restructuring the physical environment 5.3 Info about social/ environmental cons.	2	No significant change in meat/fish consumption, but a significant increase in veg*n consumption	Odds ratio = 1.20	Very small
16	Piernas et al. (2021)	Reducing meat consumption	5.1 Information about health cons. 7.1 Prompts/cues 8.2 Behaviour substitution 12.1 Restructuring the physical environment 12.5 Adding objects to the environment 13.2 Framing/ reframing	6	Significant increase in meat alternative purchases, but no change in meat purchases	IRR 1.43	Moderate
22	Schwitzgebel et al. (2020)	Reducing meat consumption	5.3 Info about social/ environmental cons. 9.2 Pros and cons	2	Significant reduction in meat consumption	3.3 pp change (overall) 6.3 pp change (purchases $4.99+)	Small
2	Pechey et al. (2022) study 2	Choosing veg*n food	12.1 Restructuring the physical environment 12.5 Adding objects to the environment	2	Significant increase in veg*n food sales	5.4 pp change	Small
8	Gavrieli et al. (2022)	Choosing veg*n food	13.2 Framing/ reframing	1	Significant increase in veg*n food consumption in Anglophone sites	43.9 % change	Moderate
10	Griesoph et al. (2021)	Choosing veg*n food	6.2 Social comparison *x2*	2	Backfire; significant decrease in veg*n food choice	Odds ratio = .984	Very small
11a	Reinholdsson et al. (2022) intervention a	Choosing veg*n food	12.1 Restructuring the physical environment	1	Significant increase in veg*n food choice	2.96 % change	Very small
11 b	Reinholdsson et al. (2022) intervention b	Choosing veg*n food	6.2 Social comparison	1	No significant change in veg*n food choice	N/A	Null
11c	Reinholdsson et al. (2022) intervention c	Choosing veg*n food	5.2 Salience of consequences 5.6 Information about emotional consequences 13.2 Framing/ reframing	3	Significant increase in veg*n food choice	10 % change	Small
11 d	Reinholdsson et al. (2022) intervention d	Choosing veg*n food	5.2 Salience of consequences 5.6 Information about emotional consequences	2	No significant change in veg*n food choice	N/A	Null
14	Gravert and Kurz (2021)	Choosing veg*n food	12.1 Restructuring the physical environment	1	Significant increase in veg*n food choice and fish, and significant decrease in meat consumption	6 pp change (veg*n food) 8 pp change (fish) 13 pp change (meat)	Small to moderate
15	Taufik et al. (2022)	Choosing veg*n food	12.1 Restructuring the physical environment	1	Significant increase in veg*n orders replacing meat orders	71.4 pp change (bean wrap) 42.2 pp change (seaweed wrap)	Very large
19	Sparkman et al. (2020) study 1	Choosing veg*n food	6.2 Social comparison	1	Significant increase in veg*n purchases, disappearing when controlling for past purchasing	1.1–1.7 pp change	Very small

(*continued on next page*)

Table 4 (*continued*)

Study no.	Intervention	Target behaviour (s)	BCTs identified	no. of BCTs	Results	Effect size	Effect size category
20	Sparkman et al. (2020) study 3	Choosing veg*n food	6.2 Social comparison	1	Significant increase in veg*n purchases	2.2 pp change	Very small
21	Sparkman et al. (2020) study 4	Choosing veg*n food	6.2 Social comparison	1	Backfire; significant reduction in veg*n purchases	3.7 pp change	Small
3a	Larner et al. (2021) intervention a	Choosing lower-carbon foods	5.2 Salience of consequences *x*2 5.3 Info about social/ environmental cons. X2 7.1 Prompts/cues *x*3	7	Significant substitution of dairy milk with oat milk	9.3 pp change	Small
3 b	Larner et al. (2021) intervention b	Choosing lower-carbon foods	5.2 Salience of consequences 5.3 Info about social/ environmental cons. 12.1 Restructuring the physical environment	3	Significant substitution of beef burgers with chicken burgers; no change in veg*n burger sales	9 pp change	Small
6	Visschers and Siegrist (2015)	Choosing lower-carbon foods	5.2 Salience of consequences 5.3 Info about social/ environmental cons. X2	3	Significant substitution of higher-carbon foods with lower-carbon foods	9.7 pp change (low-carbon) 9.7 pp change (high-carbon)	Small
7	Lohmann et al. (2022)	Choosing lower-carbon foods	5.2 Salience of consequences 5.3 Info about social/ environmental cons. 7.1 Prompts/cues	3	Significant substitution of high-carbon foods with medium-carbon foods	2.7 pp change (high-carbon) 2.7 pp change (medium-carbon)	Very small
18	Coucke et al. (2019)	Choosing lower-carbon foods	12.1 Restructuring the physical environment *x*2 12.5 Adding objects to the environment	3	Significant increase in poultry purchases as a share of meat purchases	13 % change in relative share of total purchases	Small
17	Bauer et al. (2022)	Purchasing fruit and vegetables	4.1 Instructions on how to perform a behaviour 6.2 Social comparison 6.3 Information about others' approval 7.1 Prompts/cues *x*2	5	Significant increase in fruit and vegetable purchases	'% change in relative share of fruit and vegetables among total purchases	Very small

would be coded in Table 4 as using two *different* BCTs but three *total* BCTs.

Sections 3.4.2 - 3.4.5 discuss the BCTs identified per target behaviour.

4.2.2. BCTs used for reducing meat consumption (interventions 1, 4, 5, 9, 12, 13, 16, 22)

Interventions aimed at reducing meat consumption most often made use of BCTs 5.3 'Information about social and environmental consequences' (5 instances), 12.1 'Restructuring the physical environment' (3), 12.5 'Adding objects to the environment' (3), 5.2 'Salience of consequences' (2), and 7.1 'Prompts/cues' (2). BCTs used only once for this target behaviour included 6.2 'Social comparison', 6.3 'Information about others' approval', 8.2 'Behavioural substitution', 9.2 'Pros and cons', and 13.2 'Framing/reframing'.

*4.2.3. BCTs used for veg*n food choice (interventions 2, 3, 10, 11a, 11 b, 11c, 11 d, 14, 15, 19, 20, 21)*

Interventions to encourage veg*n food choices most commonly used BCT 12.1 'Restructuring the physical environment' (4 instances), 6.2 'Social comparison' (4), 5.2 'Salience of consequences' (2), and 13.2 'Framing/reframing' (2). BCTs 5.1 'Information about health consequences', 5.3 'Information about social and environmental consequences', and 5.6 'Information about emotional consequences' were used once.

4.2.4. BCTs used for lower-carbon food choice (interventions 3a, 3 b, 6, 7, 18)

Interventions to encourage consumption of lower-carbon foods over higher-carbon foods frequently used BCTs 5.3 'Information about social and environmental consequences' (6 instances) 5.2 'Salience of consequences' (5), 7.1 'Prompts/cues' (4), and 12.1 'Restructuring the physical environment' (3), and 12.5 'Adding objects to the environment' (1).

4.2.5. BCTs used for fruit and vegetable consumption (intervention 17)

Only one study aimed to increase fruit and vegetable consumption as an SFC behaviour. Bauer et al. (2022) intervention combined 3.2 'Social support (practical)', 6.2 'Social comparison', 6.3 'Information about others' approval', and two instances of 7.1 'Prompts/cues'.

4.3. Effectiveness of BCTs for sustainable food consumption

4.3.1. Summary

Most of the interventions had a significant effect on behaviour, although many of the observed effects were small. Some interventions using the same BCTs had widely different outcomes, but a few patterns in the effectiveness of interventions containing certain BCTs did emerge.

All interventions coded as using BCT 12.1 'Restructuring the physical environment' had a statistically significant positive effect, ranging from very small to very large. These interventions ranged from changes in the presentation of different options on a menu (Gravert & Kurz, 2021; Larner et al., 2021; Pechey et al., 2022; Reinholdsson et al., 2022; Taufik et al., 2022) to changes in what options were available and/or where

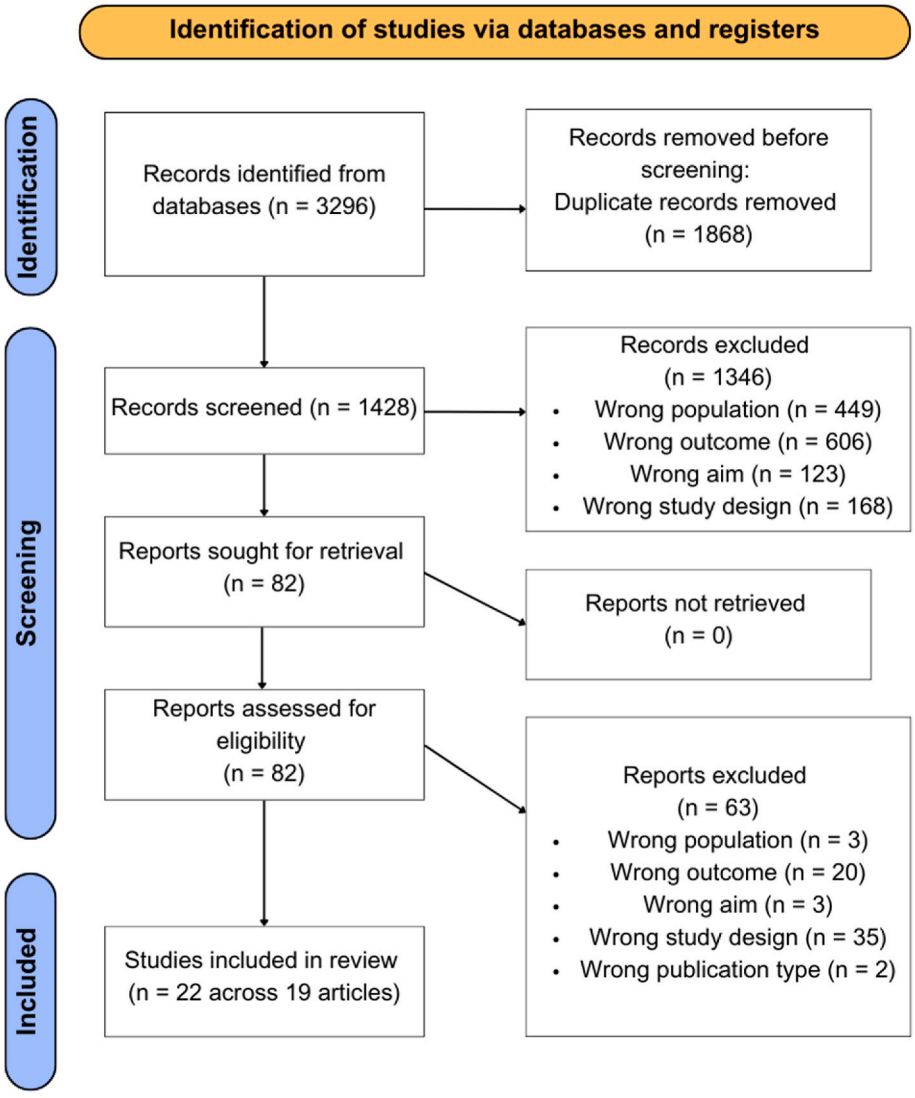

Fig. 2. Prisma Flow diagram.

they were placed (Coucke et al., 2019; Pechey et al., 2022; Piernas et al., 2021). BCT 12.1 was repeatedly used in combination with BCT 12.5 'Adding objects to the environment' in interventions that increased the number of sustainable food options.

BCT 12.5 appeared in combination with various other BCTs in interventions which all had a significant effect on behaviour (see Table 4), but was never used in isolation. The 'objects added' ranged from additional veg*n or low carbon food options (Coucke et al., 2019; Pechey et al., 2022) to extra menu cards (Larner et al., 2021) or promotional signs (Piernas et al., 2021).

Interventions exclusively using BCT 6.2 'Social comparison' tended to have very small or null effects, and even backfired in two cases. This BCT was coded for interventions including communicating a descriptive social norm reflecting the frequency of others' SFC behaviour (Griesoph et al., 2021; Reinholdsson et al., 2022), a dynamic norm suggesting an ongoing increase in the behaviour without mentioning statistics (Sparkman et al., 2020; Çoker et al., 2022), priming social norms by asking participants to have a guess (Griesoph et al., 2021), and suggesting an injunctive norm of approval for the target behaviour (Bauer et al., 2022).

There was no observable pattern in the effect sizes of interventions based on whether they used one or multiple BCTs.

4.3.2. Effectiveness of BCTs for reducing meat consumption (interventions 1, 4, 5, 9, 12, 13, 16, 22)

Interventions that effectively reduced meat consumption tended to use either BCT 5.3 'Information about social and environmental consequences' or 12.1 'Restructuring the physical environment', although this was often in combination with other BCTs. BCT 5.3 was twice combined with BCT 5.2 'Salience of consequences' by adding an emoji or logo as a salient visual representation of the relative environmental impact of different food options (Andersson & Nelander, 2021; Slapø & Karevold, 2019). Only one of these interventions (Andersson & Nelander, 2021) had a significant effect. However, BCT 5.3 was also present in two other successful interventions: a lecture on the health and environmental benefits of reduced meat consumption (Jalil et al., 2020) and the distribution of mandatory reading material on the ethics of meat consumption prior to a philosophy class (Schwitzgebel et al., 2020), with a live debate bringing in BCTs 6.3 'Information about others' approval' and 9.2 'Pros and cons'.

Three interventions solely used BCT 12.1 'Restructuring the physical environment'. Two of these – changing the ratio of available meat-based/veg*n options (Study 1 b y Pechey et al., 2022) and listing only veg*n options on a menu by default (Gravert & Kurz, 2021) – had a small-to-moderate and moderate effect respectively, while the third – changing the prices of meat-based/veg*n options – had a null effect on

meat consumption (Garnett et al., 2021), but did effectively increase veg*n food consumption.

BCT 7.1 'Prompts/cues' appeared in two ineffective interventions. Slapø and Karevold (2019) aimed to reduce meat consumption by placing informational posters (5.3 'Information about social and environmental consequences') at the point of sale (7.1). Çoker and colleagues (2022) presented a dynamic norm ("More and more [store name] customers are choosing our veggie options") (6.2 'Social comparison') alongside a prompt showing a veg*n meal (7.1).

4.3.3. Effectiveness of BCTs for veg*n food choice (interventions 2, 3, 10, 11a, 11 b, 11c, 11 d, 14, 15, 19, 20, 21)

The most effective interventions to encourage veg*n food choice used BCT 12.1 'Restructuring the physical environment' by making vegetarian dishes the default option on restaurant menus (Gravert & Kurz, 2021; Taufik et al., 2022). These interventions led to a significant increase in orders of veg*n dishes as well as a significant reduction in meat consumption. Similarly, Reinholdsson and colleagues (2022) placed veg*n options at the top of a menu (intervention a), resulting in a very small significant increase in veg*n orders. BCT 12.1 was also used by Garnett and colleagues (2021) who changed the pricing of veg*n and meat-based dishes and saw a very small significant increase in veg*n food consumption, though meat consumption was unaffected.

BCT 6.2 'Social comparison' was used in two interventions with a small but significant effect on veg*n food consumption (Study 1 and 3 b y Sparkman et al., 2020). Both used a dynamic norm message ("We've noticed customers are starting to order our meatless dishes for lunch more often"). However, BCT 6.2 was also found in the least successful interventions when it came to increasing veg*n food consumption. Sparkman and colleagues' (2020) dynamic norm message, when applied to a dinner menu instead of a lunch menu, backfired and led to a small significant reduction in veg*n orders. Reinholdsson and colleagues' (2022) descriptive norm message had no significant effect on veg*n food consumption. Griesoph and colleagues (2021) tested the effect of 'guessed norms' on veg*n food consumption and discovered that the more common participants guessed veg*n orders to be, the less likely they themselves were to order a veg*n dish.

BCT 13.2 'Framing/reframing' was used in two interventions to reframe veg*n dishes as particularly tasty either through changing their names (Gavrieli et al., 2022) or assuring customers that "The green option tastes good!" (Reinholdsson et al., 2022), the latter in combination with a salient emoticon (BCT 5.2 'Salience of consequences'). Reinholdsson and colleagues' (2022) message had no effect, and Gavrieli and colleagues' (2022) name changes only had a significant effect in the study sites where participants spoke native English.

Reinholdsson and colleagues (2022) again used BCT 5.2 'Salience of consequences' when making salient the emotional consequences (BCT 5.6 'Information about emotional consequences') of choosing veg*n food ("The green option feels good!" with an emoticon), but this intervention was also ineffective.

BCTs 5.1 'Information about health consequences' and 5.3 'Information about social and environmental consequences' were used by Jalil and colleagues (2020) in the form of a university lecture targeted at reducing meat consumption, which also led to a small increase in veg*n food consumption replacing meat consumption.

4.3.4. Effectiveness of BCTs for lower-carbon food choice (interventions 3a, 3 b, 6, 7, 18)

All interventions aimed at promoting lower-carbon food choice had a significant effect on behaviour, ranging from very small to moderate. Among them, there were multiple successful instances of 'carbon labelling'. Carbon labels were coded as corresponding with BCT 5.3 'Information about social and environmental consequences' and 5.2 'Salience of consequences' because they provide information about the consequences of different food choices in a salient way, with colours or symbols. The most effective of these interventions was created and tested by Visschers and Siegrist (2015), who used a positive labelling approach (only marking the most environmentally friendly options; BCT 5.2; 5.3) as well as hanging informative posters explaining the climate consequences of food choices (BCT 5.3; 12.5 'Adding objects to the environment'). Lohmann and colleagues (2022) used a 'traffic light' labelling approach with a smaller effect, combining BCT 5.2 and 5.3 b y labelling all food options in a university cafeteria with their CO^2 per 100 g and color-coding these as green (low carbon), yellow (medium carbon), or red (high carbon). The placement of these labels on cards above each dish at the point of sale was coded as a cue to perform the more environmentally friendly behaviour (BCT 7.1 'Prompts/cues'; 12.5).

Larner and colleagues' (2021) first intervention labeled the lowest-carbon food options in a university food outlet as 'low impact foods' alongside a symbolic representation of their carbon footprint (BCT 5.2; 5.3) and displayed a poster at the till explaining what the logo meant (BCT 7.1 'Prompts/cues'; 12.5 'Adding objects to the environment'). An additional food menu was produced and placed at the front of the menu stack (BCT 12.1 'Restructuring the physical environment'; 12.5) which showed only the 'low impact' options from the other menus, all marked with the logo (BCT 5.2; 5.3). This led to a significant substitution of beef burgers with chicken burgers. BCTs 5.2 and 5.3 were also effectively combined in Larner and colleagues' (2021) second intervention: in a university café, a 'milk guide' was placed by the till (BCT 12.5; 7.1) providing information about the environmental benefits of plant-based milk with the 'low impact' logo printed onto it (BCT 5.2; 5.3). This intervention had a small-to-moderate substitution effect with oat milk replacing dairy milk.

Piernas and colleagues' (2021) multicomponent supermarket intervention included BCT 12.1 'Restructuring the physical environment' - moving lower-carbon meat alternatives to the meat aisle - and had a moderately sized effect on sales of lower-carbon meat alternatives but did not affect the target behaviour (meat consumption). BCTs 8.2 'Behaviour substitution' and 13.2 'Framing/reframing' were used to guide customers to the meat alternatives, framing them as 'easy switches' to suggest substituting them as a protein source. Coucke et al. (2019) applied BCT 12.1 in a similar way and setting by increasing the space allotted to poultry products at an in-supermarket butchers' counter and reducing the space and number of other, more environmentally harmful meat products. This resulted in a small but significant increase in the sale of poultry as a share of total meat sales, without increasing the overall amount of meat sold.

4.3.5. Effectiveness of BCTs for fruit and vegetable consumption (intervention 17)

Bauer and colleagues (2022), as the one example in this review of an intervention to increase fruit and vegetable consumption, placed brightly coloured signs in a supermarket's shopping baskets and carts which read "In [our store], we are proud that most people choose fruit and vegetables" (BCT 6.2 'Social comparison'; 6.3 'Information about others' approval'). They also placed signs with three vegetable-based recipe ideas in the carts/baskets and in the produce section of the supermarket to help customers think of ways to incorporate vegetables (BCT 3.2 'Social support (practical)') and prompt their purchasing of the vegetables shown in the recipe ideas (BCT 7.1). This intervention resulted in a very small significant increase in the sale of vegetables as a share of total supermarket purchases.

Table 4 provides an overview for each study of which BCTs were used and with what results.

5. Discussion

The aims of this systematic review were, firstly, to identify which BCTs have been used in past interventions to encourage sustainable food consumption (SFC), and secondly, to make some inference regarding which of those BCTs show the most promise for successfully changing SFC behaviours when used in interventions.

5.1. Findings and implications

Through a methodical examination of existing literature, this review provides a clear overview of how different techniques have been used in past interventions, now categorised into the BCTTv1 for better intelligibility and comparability across domains (Michie et al., 2013). We identified 13 different BCTs used in 26 interventions, tested in 22 field studies published since 2015 concerning the encouragement of sustainable food consumption (SFC) behaviours.

This review builds upon previous work by analysing more recently published research from a variety of settings without restrictions on the type of intervention that would be considered. For instance, the range of BCTs we identified differed substantially from that found by Hedin and colleagues (2019) in digital SFC interventions; only six BCTs overlapped, suggesting that intervention setting (i.e. online vs. in-person) affects which BCTs are used.

The fact that only 13 of 93 BCTs appeared at all suggests a somewhat narrow range of behaviour change techniques used in SFC interventions so far. However, this review only examined a subset of existing research so it is unlikely to capture all previously used BCTs; the reality may be more expansive. Furthermore, not all BCTs may be applicable or appropriate in this domain, limiting the number of different techniques that are likely to be used. Examples include BCTs that are primarily oriented toward health outcomes (e.g. 2.6 'Biofeedback', 11.1 'Pharmacological support', 12.6 'Body changes') or those that may raise ethical concerns when applied to SFC (e.g. 10.11 'Future punishment').

Only a few patterns in BCT effectiveness were discernible. Most clearly, the results of this review suggest that BCT 12.1 'Restructuring the physical environment' has particular potential for encouraging SFC. This is in line with Kwasny and colleagues' (2022) review finding that increasing the visibility and variety of veg*n options effectively encourages SFC. BCT 6.2 'Social comparison' might need to be used more cautiously: outcomes of interventions using this technique ranged from very small positive effects to significant backfire effects. A potential explanation comes from De Groot and colleagues (2021), who find that the outcomes of social norm interventions for pro-environmental behaviour change greatly depend on participants' personal norms. This underscores the importance of using behavioural science to understand how to change behaviour in its context (Michie et al., 2011), rather than pursuing universal principles or a 'one-size-fits-all' approach to intervention design.

BCTs 12.1 and 6.2 were repeatedly used in single-BCT interventions so that (lack of) success appears to be directly attributable to the use of those BCTs, assuming well-controlled study designs. For interventions using multiple BCTs, it is difficult to infer which BCTs did the 'heavy lifting' and caused the measured effect, which were redundant, and which may have even been counterproductive. For instance, BCT 12.5 'Adding objects to the environment', used in various combinations, could be speculated to improve interventions by making them more tangible and was indeed associated with significant behaviour change (Larner et al., 2021; Piernas et al., 2021), but the relative success of those interventions could have more to do with the other BCTs involved than with 12.5. For another example, several interventions communicated the environmental consequences of certain food choices (BCT 5.3) along with some visual element to make those consequences more salient (BCT 5.2) (Andersson & Nelander, 2021; Visschers & Siegrist, 2015), and some strategically placed these at the point of decision-making to prompt sustainable choices (BCT 7.1) (Lohmann et al., 2022; Slapø & Karevold, 2019). While it was not possible to determine how effective BCT 5.2 *or* 5.3 *or* 7.1 was in these cases, it was possible to look for patterns in the success of their combination since it was repeatedly used. However, the variety of outcomes was such that combining BCT 5.2 with 5.3 (and sometimes 7.1) was not obviously linked with stronger or weaker effects, although there were some small positive effects which might be promising. Still, the use of multicomponent interventions means that very few BCTs could be concluded to be singly (in)effective at encouraging SFC behaviour.

The operationalisation of BCTs varied widely, making it somewhat surprising that any patterns of effectiveness appeared at all. To illustrate, BCT 6.2 was variously operationalised by communicating a descriptive norm (Griesoph et al., 2021; Reinholdsson et al., 2022), a dynamic norm (Sparkman et al., 2020; Çoker et al., 2022), suggesting an injunctive norm (Bauer et al., 2022), and asking participants for a 'guessed norm' (Griesoph et al., 2021). Categorising these all as 'BCT 6.2' and drawing generalised conclusions ignores the differences in how social comparison was incorporated in those interventions. Reviews of social norm interventions for pro-environmental behaviour change indicate that descriptive, dynamic, and injunctive norm messages can all have different effects (Abrahamse & Steg, 2013; Farrow et al., 2017). Indeed, it is possible that among the interventions reviewed here, operationalisation was a major factor influencing the differing effectiveness of interventions using the same BCTs. Some differences in intervention outcomes could also be due to the setting in which they were tested. For instance, Pechey and colleagues (2022) tested their intervention twice, and its effect was much larger in a university cafeteria than a workplace one. This review lacks the depth of scope to account for such factors and isolate the pure effect of the BCTs used, and so is limited to making cautious inferences.

Overall, this review has the potential to serve as a resource for future intervention design by demonstrating which (combinations of) BCTs have been used before and how, and by tentatively indicating which BCTs might be most effective at encouraging SFC.

Beyond examining past interventions for the most common and seemingly effective techniques, this review also generated some insight regarding the chosen tool: the BCTTv1 itself. Applying the BCTTv1 to a subdomain of behaviour change with which it has not previously seen much interaction has demonstrated that the taxonomy is useful for categorising many different interventions, but not without exception. In some cases, it proved difficult to accurately categorise (this subset of) pro-environmental behaviour change interventions. This is discussed in more detail in Section 5.3 'Critique of the BCTTv1'.

5.2. Strengths and limitations

Despite searching for articles published anytime since 2006, the earliest publication date among the reviewed articles was 2015, with the other 18 all published since 2019. As a result, this review is weighted towards some of the most recent findings from what is still a small, but growing area of behaviour change research.

Additionally, this review's use of the BCTTv1 framework enabled a systematic examination of the reviewed interventions by splitting them into components based on predetermined definitions. The standardisation of BCTs means that the results of this review are comparable with past and future research using the BCTTv1, increasing the validity and future value of the findings. The approach used in this review is made highly replicable by including detailed tables, descriptions, and appendices. Furthermore, this review used reliability checks for both screening and coding to ensure higher quality results. More than just demonstrating inter-rater reliability, these checks were used as opportunities for improvement along the way by discussing and resolving any points of disagreement based on shared assessments of what was best.

However, there are some limitations to consider. Firstly, although the scope and size of this review already extend past that of similar reviews like Hedin and colleagues' (2019) and proved sufficient for its

aims of cataloguing and comparing BCTs, the volume of material reviewed would need to be greater to generate certain further insights; for example, to enable comparisons among different target groups and settings.

The comparison of different BCTs' effectiveness was partly made difficult by a lack of uniformity in reported effect size metrics, which led to the use of a simplified categorisation as an indirect means of comparison, and by many interventions' use of multiple BCTs at once. While this lack of direct comparability is a limitation more so of the reviewed research than this review, the method chosen under these circumstances was an imperfect way of comparing which BCTs are most effective. Michie and colleagues (2018) point out that such a method is likely to identify effective BCTs if they are often used (as seen with BCT 12.1) but could make less-used BCTs seem ineffective if the rare intervention using them happens to be unsuccessful. For successful multicomponent interventions, this method also risks lumping in ineffective BCTs with those that caused the actual effect. This limitation unfortunately means that only tentative conclusions can be drawn from the results of this review.

The size classifications of effect sizes in this review are also not derived from behavioural science literature, due to a lack of available references, so these may not be entirely appropriate. What counts as a small effect in one field might be a moderate effect in the context of another field where the maximum attainable effect size would realistically be smaller. Within the confines of this review, the effects are considered comparable as they all concern changes in SFC behaviours in a limited number of settings, so that the relative effectiveness of the interventions can be inferred. However, in comparing their relative size, labelling certain effects as 'small' or 'very small' might suggest they are negligible or unimportant when this is not necessarily the case. Behaviour change interventions often have small effects (e.g. Mertens et al., 2021; Nisa et al., 2019) but when implemented on a large scale to target an important behaviour, their impact can be large in real terms (e.g. a few percentage points of behaviour change preventing thousands of tonnes of GHG emissions). Therefore, 'small' effects are not inherently undesirable and should not be dismissed entirely.

Independently of the suitability of any framework or tool for categorising and understanding SFC interventions specifically or even pro-environmental interventions more broadly, this review suffers from the limitation of relying on the reporting quality of previous interventions. This has been notably poor in the past and presents a problem for the field of behaviour change (Lorencatto et al., 2013), although recent reporting shows improvement (Johnston, 2021). The articles reviewed here all described their interventions in such a way that it allowed for coding at least one BCT, but some descriptions are so brief (e.g. "a 50-min lecture about how food choices affect climate change, along with information on the health benefits of reduced meat consumption") that questions remain about how exactly the intervention was implemented. This not only limits what conclusions can be drawn from reviewing their findings, but also limits the ability of future research to replicate or apply those findings. Even a simple intervention like "communicating a descriptive norm", when described in so few words, is not fully replicable or comparable with another without further information about how, where, and by whom the message was communicated. For instance, if the message came from a relevant authoritative figure or entity, that might present an additional BCT (9.1 'Credible source') which could not be coded without that explicit information being present in the intervention description. As such, there might have been more BCTs actually present in the interventions than this review was able to account for based on incomplete or ambiguous reporting, which would skew the apparent popularity and effectiveness of different BCTs.

We note here that a risk of bias assessment was not conducted for this review. This is because our primary aim was to catalogue the content of interventions aside from their quality. The comparison of effect sizes was of a tentative and more descriptive nature, limited as it was by the methodological constraints noted above. If a meta-analysis of these interventions were to be conducted to more robustly compare effect sizes, a risk of bias assessment would indicate whether an intervention's effect might have been over- or underestimated, for instance due to inadequate reporting of what an intervention actually contained.

Speaking more broadly, vague reporting hinders the field of behavioural science in its efforts to establish what works to change behaviour, for whom, and under what circumstances. That is why clear reporting of intervention components by those developing and/or delivering the intervention, whether as BCTs or using other standardised terms, would benefit both science and practice.

5.3. Critique of the BCTTv1

The BCTTv1, being relatively widely used and containing standardised definitions, is a valuable tool for categorising and comparing interventions across the body of behavioural science literature, as well as non-academic reports on intervention testing. It offers a unified method of constructing and deconstructing interventions based on their 'active ingredients' that can be replicated for validity. Generally, the intervention components described in these studies could be adequately coded as BCTs, allowing for comparison within this dataset as well as with any other publications, past and future, that apply the BCTTv1.

That said, there were some challenges in categorising these SFC interventions using the BCTTv1. BCT 12.1, for instance, seems to have a particularly wide range of operationalisations among SFC interventions. For one thing, interventions coded under this BCT vary in their level of actual physicality. For another, many different interventions that could be called 'nudges' (e.g. changing the default option on a menu) and which do not fit the definition of any other BCTs are also coded under BCT 12.1. The distinction between BCT 12.1. And 12.5 'Adding objects to the environment' can also be unclear: increasing the quantities of vegetarian meals could be a form of environmental restructuring but might also be referred to as adding objects. For these reasons, it might be misleading to conclude anything too strongly about the effectiveness of BCT 12.1 alone when used in SFC interventions. Many of the differences between interventions coded as using the same BCTs are differences of operationalisation, but some of these 'differences of operationalisation' might also be considered candidates for additional BCTs which are not currently represented in the BCTT.

We note here that newer and more complex tools have since been published that aim to make systematically developing, reporting, and categorising interventions as accurate as possible. Chief among these is the BCT Ontology (Marques et al., 2024a), published as part of the larger Behaviour Change Intervention Ontology (BCIO; Human Behaviour Change Project, 2024). The BCTO (available to download from Marques et al., 2024b) breaks down the original 93 BCTs into further parent and child classes across 5 levels and is significantly more complex, consisting of 20 top-level groupings, 97 BCTs at the same level as the original 93 (some of which are new and/or reformulated), and a further three levels of more specific sub-BCTs, totalling 281 techniques in all.

Interestingly, the few recommendations we might have made to enable greater differentiation within the BCTT are found to be present in the BCTO. To illustrate: using the BCTTv1, a number of different intervention components could only be categorised as BCT 12.1 'Restructuring the environment', which cannot be broken down into any more specific techniques. In the BCTO, 'Restructure the environment' is a level 1 grouping, divided into 'restructure the social environment' and

restructure the physical environment' (level 2), with the latter being split into five BCTs (level 3) one of which has a further two subcategories (level 4) - some other BCTs have a level 5. By specifying additional levels, the BCTO could enable a more exact categorisation of some SFC interventions which restructure the physical environment in different ways: for instance, whether they add objects to the environment, making this a subcategory rather than an alternative. This could help prevent BCT 12.1 from becoming something of a 'catch-all' for a range of different SFC interventions.

The BCTO offers a potential alternative to the BCTTv1 in the form of a more fine-grained tool - if also more complex and perhaps less accessible to use. What the BCTTv1 lacks in detail, it makes up for in practical useability. Bearing in mind the historic underreporting of intervention details (e.g. Lorencatto et al., 2013) and calls within the behavioural science community for greater uptake of frameworks that enable systematic intervention design and testing, we suggest a simpler framework may be easier to apply by a wider audience and to more general intervention descriptions. This is because such descriptions may lack the level of detail required to accurately categorise BCTs according to the BCTO. As such, we argue that the BCTO is not a like-for-like replacement to the BCTTv1; rather, a more detailed alternative that may be preferable to some users, while the BCTT presents a lower threshold to encourage widespread reporting and comparison of intervention components.

5.4. Future research

There were some challenges to applying the BCTTv1 in this review relating to the more precise differentiation of techniques which future researchers may wish to consider, although it still proves a valuable and accessible framework for forward and backward comparison of techniques to change behaviour. Elements of the more recently published BCTO (Marques et al., 2024a, Marques et al., 2024b) seem promising for areas where the simpler BCTTv1 lacks detail, although it may require a correspondingly greater level of detail in intervention descriptions to be used to its full advantage. As such, we recommend that future research consider applying both tools as appropriate to understand, compare, or develop interventions for sustainable food consumption. As the original 93 BCTs are largely represented within the BCTO, it may also be possible and helpful, where sufficient detail exists, to use the BCTO to extend existing work that categorises interventions into the BCTTv1.

As to where future research is most needed, it should be noted that only one study in this review was (partly) conducted in non-WEIRD (Western, Educated, Industrialised, Rich, Democratic) countries (Gavrieli et al., 2022). Systematic reviews can only analyse what already exists, so a lack of intervention tests in non-WEIRD countries hinders the field of behavioural science in generating and collating insights into what works, where, and for whom. Currently, the adoption of sustainable diets is a more pressing behavioural issue in WEIRD countries than the rest of the world, where diets low in meat and other animal products are already somewhat more common (Chaudhary & Krishna, 2019). As such, this is not necessarily a limitation for this review, but it is notable that the non-WEIRD settings in which Gavrieli and colleagues' (2022) intervention was tested (Brazil and Singapore) returned a null result whereas the study arms conducted in Australia and the USA showed a significant effect. In this case, the intervention was purely language-based (making veg*n dish names more appealing) so it is not overly surprising that subtle linguistic changes in English would have little effect on non-native English speakers. However, this finding does underline the importance of future research testing behaviour change interventions in a wider variety of cultural contexts to determine under what circumstances they do (not) work and why.

Future research should also investigate the overall impact of interventions promoting SFC. Some interventions indeed increase veg*n consumption but without decreasing meat consumption (e.g. Garnett et al., 2021), leading to an overall increase in consumption and reducing the potential positive impact of interventions. This mirrors a similar trend in the energy sector, known as Jevons' Paradox (Alcott, 2005) where the introduction of more efficient technology (such as renewable energy) tends to result in increased total consumption instead of reducing it.

The scope of this review was limited to extracting the techniques actively included in the design of SFC interventions. Going forward, there is a need for larger reviews with access to much greater (human) resources to develop a more complete overview of which BCTs have been used in SFC interventions and which ones, in which combinations and settings, operationalised in what ways, seem to be most effective. Reviews such as this one contribute to the development of a tailored evidence base to support individual pro-environmental behaviour change, but to benefit maximally from what has come before, intervention designers will require details about past interventions that go beyond the techniques used. Notably, the Human Behaviour Change Project (Human Behaviour Change Project, 2024; Michie et al., 2017) aims to do exactly that, synthesising behaviour change evidence through training machine learning and AI tools to extract and interpret intervention information from published studies on an unprecedented scale. Of course, this relies on reports and articles providing as much information as possible on the other factors that could influence intervention success such as setting, operationalisation, and intervention fidelity (how closely actual implementation matched the intervention's design).

5.5. Conclusion

In conclusion, this systematic review has provided a structured overview of BCTs found in past SFC interventions and some indication of which BCTs show promise for effectively changing SFC behaviour. It goes some way to expanding the limited body of work analysing behaviour change techniques in this domain, and adds to the understanding of how individual behaviour might be changed as part of efforts to combat global environmental change.

Practically speaking, we hope this review can serve as a valuable resource for behavioural science practitioners in the sustainable food domain, offering them a comprehensive understanding of previously used BCTs and enabling them to leverage the most promising ones for promoting various dietary behaviours and fostering SFC. Practitioners are advised, however, to be mindful that the effectiveness of these BCTs may vary based on contextual and cultural differences. The review also underscores the importance of grasping the full spectrum of influences on SFC before designing interventions, and highlights the need to go beyond mere awareness and knowledge raising to make sustainable dietary changes easier. The strategic application of effective BCTs can play a vital role in encouraging the broader adoption of sustainable diets and, ultimately, contribute to reducing the environmental impact of diets to achieve net zero.

It is hoped that this review can serve as a resource to support future intervention design in this area and encourage the trend of reporting new interventions in a replicable way by breaking down the techniques used - whether those are BCTs or derived from a different tool. This would make behaviour change research more accessible and more easily applicable for practitioners in the field, ultimately leading to higher-quality, more effective interventions to support an important part of the behaviour change needed to mitigate the climate crisis.

CRediT authorship contribution statement

Anna S.C. Tirion: Writing – review & editing, Writing – original draft, Visualization, Project administration, Investigation, Formal analysis, Data curation, Conceptualization. **Danielle D'Lima:** Writing – review & editing, Validation, Supervision, Conceptualization. **Julia Terlet:** Writing – review & editing, Validation, Conceptualization. **Ramya Rao:** Writing – review & editing, Validation, Conceptualization. **Leslie M. Gutman:** Writing – review & editing, Supervision,

Conceptualization.

Ethical statement

As this was a secondary piece of research and no primary data was collected, ethical approval from a registered body was not required.

Declaration of Competing interest

none'.

Appendix A. Intervention descriptions and BCT coding table

Study no.	Paper	Intervention components	BCTs	BCT descriptions
1 + 2	Pechey et al. (2022)	**Study 1:** "**ratio** was shifted to one meat meal and two meat-free meals each day" from "two meat meals and one meat-free option" ($^1/_3$ vegetarian to $^2/_3$ vegetarian)	Increasing ratio of meat-free meals = **12.1** Restructuring the physical environment + **12.5** Adding objects to the environment	**12.1** Change, or advise to change the physical environment in order to facilitate performance of the wanted behavior or create barriers to the unwanted behavior (other than prompts/cues, rewards and punishments)
		Study 2: "changed their menus to (1) introduce **meat-free Mondays**; (2) **increase their range of meat-free meals**." NOTE: "mean percentage of meat-free meal options offered in the 8 weeks prior to the menu change was 21.0 % (s.d. 12.7), rising to 23.8 % (s.d. 12.4) in the 8 weeks after." (i.e. proportion of meat-free options barely increased) - analysing just for settings where the proportion of meat-free options actually increased: "The mean **difference in percentage of meat-free meals offered** in these 10 sites was −6.7″	**12.1** Restructuring the physical environment + **12.5** Adding objects to the environment	**12.5** Add objects to the environment in order to facilitate performance of the behavior
3	Larner et al. (2021)	**3a:** **New Leaf outlet:** "The logo was designed with the carbon footprint iconography in mind with additional text to signify the items' low GHGE impact" - "A magnet stating '**low impact foods** below' accompanied by the **logo** (Fig. 1) was used" - "an A4 **informational poster** was displayed by the till to help customers **recognise and understand the logo**"	Logo placement on menu = **5.2** Salience of consequences + **5.3** Information about social and environmental consequences Informational poster = **7.1** Prompts/cues	**5.2** Use methods specifically designed to emphasise the consequences of performing the behaviour with the aim of making them more memorable (goes beyond informing about consequences)
		Coffee revolution outlet: "An A4 '**milk guide**' was produced containing **information on the environmental benefits of plant milk** alongside the **low impact logo** (Fig. 1)"	Milk guide with logo = **5.3** Information about social and environmental consequences + **5.2** Salience of consequences	**5.3** Provide information (e.g. written, verbal, visual) about social and environmental consequences of performing the behavior Note: consequences can be for any target, not just the recipient(s) of the intervention
		Interval outlet: "the **milk guide** was also implemented and placed alongside coffee stirrers and sugar on a table by the till" "the **low impact logo** (Fig. 1) was placed alongside low impact food items on the A4 main food menu"	Multiple placements of guide = **7.1** Prompts/cues Multiple placements of logo = **7.1** Prompts/cues	**7.1** Introduce or define environmental or social stimulus with the purpose of prompting or cueing the behavior. The prompt or cue would normally occur at the time or place of performance
		3b: **Bar One outlet**: "An **additional menu section** was produced called the '**Low carbon impact** menu' which featured the **low impact logo** (Fig. 1) alongside six existing low impact menu items" "This menu (…) was **placed at the front of the clipboard** menu"	**12.1** Restructuring the physical environment + **5.3** Information about social and environmental consequences + **5.2** Salience of consequences	**12.1** Change, or advise to change the physical environment in order to facilitate performance of the wanted behavior or create barriers to the unwanted behavior (other than prompts/cues, rewards and punishments)
4	Slapø & Karevold (2019)	3 different labelling systems: 1. "the **traffic-light system** labeled all three warm dishes" 2. "For the single-green labeling format only **the vegetarian dish was labeled with the "Low CO2" sign**" 3. "the single-red labeling format exclusively **marked the meat dish with a "High CO2" label**" "all meat dishes were labeled as "High CO2" dishes, all fish dishes as "Medium CO2" and all vegetarian as "Low CO2" dishes"	Carbon labelling with relative CO2 & colours = **5.3** Information about social and environmental consequences + **5.2** Salience of consequences	**5.2** Use methods specifically designed to emphasise the consequences of performing the behaviour with the aim of making them more memorable (goes beyond informing about consequences) **5.3** Provide information (e.g. written, verbal, visual) about social and environmental consequences of performing the behavior Note: consequences can be for any target, not just the recipient(s) of the intervention

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Study no.	Paper	Intervention components	BCTs	BCT descriptions
		"The labels used a simple **color-coded scheme** in combination with words inside the labels to **visualize the environmental impact** of the dish"		**5.3** Provide information (e.g. written, verbal, visual) about social and environmental consequences of performing the behavior Note: consequences can be for any target, not just the recipient(s) of the intervention
		"In addition to labels, **posters** were placed in the cafeteria, **explaining the labeling system and the climate impact** of the different food categories"	Informational posters placed in multiple locations including point of sale = **5.3** Information about social and environmental consequences + **7.1** Prompts and cues	**7.1** Introduce or define environmental or social stimulus with the purpose of prompting or cueing the behavior. The prompt or cue would normally occur at the time or place of performance
		- "posters were placed both at the entrance of the cafeteria and on a shelf next to the warm dishes. Besides, table cards with the same design as the posters were placed on the tables in the cafeteria."		
5	Andersson & Nelander (2021)	"Accompanied with the name and description of each option on the menu, the amount of carbon dioxide equivalents (CO2e) emissions for each option were displayed. **The num- ber of kilograms CO2e** per each standard portion was shown along with a **coloured bar of different length and color** depending on how large the emission was."	Carbon labelling with amount of CO2 & coloured bars = **5.3** Information about social and environmental consequences + **5.2** Salience of consequences	**5.2** Use methods specifically designed to emphasise the consequences of performing the behaviour with the aim of making them more memorable (goes beyond informing about consequences) **5.3** Provide information (e.g. written, verbal, visual) about social and environmental consequences of performing the behavior Note: consequences can be for any target, not just the recipient(s) of the intervention
6	Visschers & Siegrist (2015)	"the **[climate-friendly] label was presented on the two climate-friendlier meals** of the four hot meals offered each day"	**5.3** Information about social and environmental consequences + **5.2** Salience of consequences	**5.2** Use methods specifically designed to emphasise the consequences of performing the behaviour with the aim of making them more memorable (goes beyond informing about consequences)
		"**posters informed** the guests about the relationship between food production and the **consequences for the climate**, such as the fact that the production of meat and dairy products results in much higher kg CO2-eq than vegetables and that products transported by air are associated with a much higher kg CO2-eq than products transported by car or boat"	**5.3** Information about social and environmental consequences	**5.3** Provide information (e.g. written, verbal, visual) about social and environmental consequences of performing the behavior Note: consequences can be for any target, not just the recipient(s) of the intervention
7	Lohmann et al. (2022)	"The label depicts the **carbon footprint** (CO2 equivalent) per 100 g serving of each meal, combined with a **traffic-light** coloured scheme and a **numerical scale**"	Carbon labelling with amount of CO2 & coloured bars = **5.3** Information about social and environmental consequences + **5.2** Salience of consequences	**5.2** Use methods specifically designed to emphasise the consequences of performing the behaviour with the aim of making them more memorable (goes beyond informing about consequences)
		"labels were displayed in the servery directly above the cafeteria meals during lunch and dinner"	Placement at point of sale = **7.1** Prompts/cues	**5.3** Provide information (e.g. written, verbal, visual) about social and environmental consequences of performing the behavior Note: consequences can be for any target, not just the recipient(s) of the intervention **7.1** Introduce or define environmental or social stimulus with the purpose of prompting or cueing the behavior. The prompt or cue would normally occur at the time or place of performance
8	Gavrieli et al. (2022)	"the plant-rich dishes were shown with their **basic names** two times (three in Chicago) and with their **appealing names** another two (three in Chicago). No changes to the dish preparation were made across dish repetitions and **the only thing that changed during the study period was the dish title**." "All dishes were presented on the menu with their basic name the very first time (baseline) and then the plant-rich test dishes were presented **alternating between basic and appealing names** in a random order."	Appealing names = **13.2** Framing/reframing (as indulgent, tasty dishes)	**13.2** Suggest the deliberate adoption of a perspective or new perspective on behavior (e.g. its purpose) in order to change cognitions or emotions about performing the behavior
9	Jalil et al. (2020)	"the intervention: a 50-min lecture about **how food choices affect climate change**, along with information on the **health benefits** of reduced meat consumption"	**5.1** Information about health consequences + **5.3** Information about social and environmental consequences	**5.1** Provide information (e.g. written, verbal, visual) about health consequences of performing the behavior Note: consequences can be for any target, not just the recipient(s) of the intervention **5.3** Provide information (e.g. written, verbal, visual) about social and environmental consequences of performing the behavior Note: consequences can be for any target, not just the recipient(s) of the intervention

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Study no.	Paper	Intervention components	BCTs	BCT descriptions
10	Griesoph et al. (2021)	"Guessed norms were tested in canteen 1, descriptive norms in canteen 2" "Before entering the canteen, they **filled in the questionnaire**, then they bought their lunch." **Descriptive norms:** • "Did you know? On average, 44 % of our canteen customers chose a vegan or vegetarian main dish during the last winter term." • "Did you know? On average, 56 % of our canteen customers chose a main dish containing meat or fish during the last winter term."	**6.2** Social comparison (The descriptive norm condition is used instead of a control condition to measure the comparative effect of guessed norms, so this arm is not counted as its own intervention)	**6.2** Draw attention to others' performance to allow comparison with the person's own performance
		Guessed norms: • "What do you think was the proportion of vegan or vegetarian main dishes sold in our canteen last winter term? __% of the main dishes sold during the last winter term were vegan or vegetarian." • "What do you think was the proportion of meat and fish main dishes sold in our canteen last winter term? __% of the main dishes sold during the last winter term contained meat, sausage or fish."	**6.2** Social comparison	
11	Reinholdsson et al. (2022)	The nudges involved (1) normative goal-nudging ("the **descriptive norm** nudge"), (2) hedonic goal-nudging ("the **hedonic** nudge"), (3) a combination of normative and hedonic goal-nudging ("the **warm-glow** nudge"), and (4) **positional** nudging ("the position nudge").		**12.1** Change, or advise to change the physical environment in order to facilitate performance of the wanted behavior or create barriers to the unwanted behavior (other than prompts/cues, rewards and punishments)
		11a: "The **position** nudge involved moving the icon representing the 'green' category from the sixth position in the grid of icons in the menu (out of 10) to the first position."	Changing menu positions: **12.1** Restructuring the physical environment	**6.2** Draw attention to others' performance to allow comparison with the person's own performance
		11b: "the **descriptive norm** message read (translated from the original phrase in Swedish) "Many here choose green!", which was accompanied by a minimalistic illustration of three people"	**6.2** Social comparison	**13.2** Suggest the deliberate adoption of a perspective or new perspective on behavior (e.g. its purpose) in order to change cognitions or emotions about performing the behavior
		11c: "The **hedonic** message read (translated from Swedish) "The green option tastes good!" and was accompanied by an emoji with its tongue on one side of its mouth, conveying a sense of tastiness and fun"	**13.2** Framing/reframing (as tasty rather than just responsible) + **5.6** Information about emotional consequences + **5.2** Salience of consequences (emoji)	**5.2** Use methods specifically designed to emphasise the consequences of performing the behaviour with the aim of making them more memorable (goes beyond informing about consequences)
		11d: "the **warm-glow** message read (translated from Swedish) "The green option feels good!" and was accompanied by a happy emoji with a halo, conveying a sense of feeling good by doing good."		
		"All four nudges were applied to the "Green" food category, which contains the restaurants' vegetarian and vegan food"	**5.6** Information about emotional consequences + **5.2** Salience of consequences (emoji)	**5.6** Provide information (e.g. written, verbal, visual) about emotional consequences of performing the behavior
12	Çoker et al. (2022)	"**dynamic social norm message** displayed on the digital menu and information screen boards in the cafeteria and other locations in the store that are normally used to advertise meals."		
		"A social norm message ("**More and more [retail store name] customers are choosing our veggie options**") appeared in a green circle on the top right corner of the image displayed on the digital boards, covering 1/8th of the screen, and was **animated with a small stretching and wobbling effect to draw customers' attention further**"	**6.2** Social comparison	**6.2** Draw attention to others' performance to allow comparison with the person's own performance
		"The message was dis- played **alongside a picture of the vegetarian breakfast** option during the breakfast service hours, and a vegetarian main meal during the remaining trading hours on digital screens"	**7.1** Prompts/cues	**7.1** Introduce or define environmental or social stimulus with the purpose of prompting or cueing the behavior. The prompt or cue would normally occur at the time or place of performance
13	Garnett et al. (2021)	"**decreased the price of the vegetarian option** by 20p (from £2.05 to £1.85, a 9.8 % decrease) and **increased the price of meat options** by 20p (from £2.52 to £2.72, a 7.9 %	Price changes = **12.1** Restructuring the physical environment + **5.3** Information about social and environmental consequences (financial)	**12.1** Change, or advise to change the physical environment in order to facilitate performance of the wanted behavior or create barriers to the unwanted behavior

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Study no.	Paper	Intervention components	BCTs	BCT descriptions
		increase, Table 1). The price of the vegan option (£2.39) and the fish option(s) (£2.85) were not changed. The price difference between the meat and vegetarian option increased from 47p to 87p (85 % increase)"		(other than prompts/cues, rewards and punishments)
		"The **price changes were advertised** (…) The notification was worded: "As of Monday 29th October, the meal prices are changing a small amount **to reflect the cost of ingredients**" (…) The price change did result in the meal option prices better reflecting the cost of ingredients."		**5.3** Provide information (e.g. written, verbal, visual) about social and environmental consequences of performing the behavior Note: consequences can be for any target, not just the recipient(s) of the intervention
14	Gravert & Kurz (2019)	"the waiters handed out **two different menus** at the restaurant. One menu contained, as before, the **daily meat and fish options for the whole week**, but it had an additional sentence stating, "A vegetarian option is available on request.""		
		"The menu distributed to customers seated in the front differed by **listing the daily vegetarian and fish dishes but not the meat dish.** Comparably to the menu distributed in the back, we added a sentence stating, "An option containing meat is available on request.""	Default nudge = **12.1** Restructuring the physical environment	**12.1** Change, or advise to change the physical environment in order to facilitate performance of the wanted behavior or create barriers to the unwanted behavior (other than prompts/cues, rewards and punishments)
15	Taufik et al. (2022)	"we tweaked the main dish (a wrap) of the 'menu of the month', which is one of the items on the restaurants' menu, by **changing the default** (meat vs. plant-based) and by **changing the type of plant-based meat alternative** (beans vs. seaweed)"	Default nudge = **12.1** Restructuring the physical environment	**12.1** Change, or advise to change the physical environment in order to facilitate performance of the wanted behavior or create barriers to the unwanted behavior (other than prompts/cues, rewards and punishments)
16	Piernas et al. (2021)	"**moved** a selection of 26 meat-free products into a newly created **meat-free bay within the meat aisle**" … "from their usual section"	**12.1** Restructuring the physical environment	**12.1** Change, or advise to change the physical environment in order to facilitate performance of the wanted behavior or create barriers to the unwanted behavior (other than prompts/cues, rewards and punishments)
		"Additionally, the meat-free bay had a **promotional header board** above it in most stores (with the words "Meat Alternatives" and a **meat-free burger image**) and 2 point of sale displays (aisle fins) that included the following text, developed by the retail partner:	**7.1** Prompts/cues	**7.1** Introduce or define environmental or social stimulus with the purpose of prompting or cueing the behavior. The prompt or cue would normally occur at the time or place of performance
		• **Simple swaps**—More **delicious** meat alternatives can be found across the store • Plant power—**Easy switches** for an alternative source of **protein.**"	**13.2** Framing/reframing (as easy) + **8.2** Behaviour substitution (suggestion of switching to meat-free alternative) + **5.1** Information about health consequences	**13.2** Suggest the deliberate adoption of a perspective or new perspective on behavior (e.g. its purpose) in order to change cognitions or emotions about performing the behavior
		Phase 2: "8 of the 20 stores enhanced the intervention from August 2019 onwards (Phase II intervention) by **adding a second bay of meat-free products into the meat aisle**" "This second bay of meat-free products included **additional meat-free products** (e.g., falafels, sausage rolls, tofu, and slices), which were stocked alongside the previous 26 products included in the Phase I intervention."	Additional meat-free products = **12.5** Adding objects to the environment	**8.2** Prompt substitution of the unwanted behavior with a wanted or neutral behavior
17	Bauer et al. (2022)	"multi- layered intervention, increasing the salience, leveraging descriptive social norms, and reducing cognitive effort to increase the sales of fruit and vegetables."		
		"Two distinct linguistic elements made up the **descriptive-norm** message. The central element was a sign placed in all shopping carts and baskets saying that "most people choose fruit and vegetables". Based on the research find- ings of Goldstein et al. (2008), the second linguistic element specified a proximal social group to whom the social norm applied. Therefore, our message started with "In [our store] we are proud that …" -> "**In [our store] , we are proud that most people choose fruit and vegetables**" "To increase **salience**, the signs used bright colours and were hard to overlook for customers using a shopping cart or basket"	Message = **6.2** Social comparison + **6.3** Information about others' approval ("We are proud")	**6.2** Draw attention to others' performance to allow comparison with the person's own performance **6.3** Provide information about what other people think about the behavior. The information clarifies whether others will like, approve or disapprove of what the person is doing or will do

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Study no.	Paper	Intervention components	BCTs	BCT descriptions
		"Cognitive effort was reduced for customers who did not come with a clear shopping list and needed inspiration. We specifically **highlighted five different vegetables**, namely tomatoes, cucumbers, peppers, carrots, and broccoli, in each of **three recipe ideas** that were presented in the bottom of the shopping cart"		
		"we added **signs prompting the same recipe ideas** at the locations of the target vegetables in the supermarket."	Recipe ideas = **7.1** Prompts/cues + **4.1** Instruction on how to perform a behaviour	**7.1** Introduce or define environmental or social stimulus with the purpose of prompting or cueing the behavior. The prompt or cue would normally occur at the time or place of performance **4.1** Advise or agree on how to perform the behavior
			Repeated recipe idea signs = **7.1** Prompts/cues	
18	Coucke et al. (2019)	"the **display area size** for poultry products was horizontally **enlarged**, going from 1.3 m to 1.85 m in length (an increase of 42 %). The **number of poultry products offered in the display area was also increased** to 27 instead of 19 plates (an increase of 42 %). The variety of poultry products was kept the same, but the quantity of the specific products increased."	**12.1** Restructuring the physical environment Increased no. of poultry products = **12.5** Adding objects to the environment	**12.1** Change, or advise to change the physical environment in order to facilitate performance of the wanted behavior or create barriers to the unwanted behavior (other than prompts/cues, rewards and punishments)
		"We **reduced the display area size** for veal, beef, lamb, and prepared meat dishes. The display area size of veal, beef, and lamb was reduced from 80 cm to 55 cm in length (a decrease of 31 %). The **display area size** for the prepared meat was decreased from 1.3 m to 1 m (a decrease of 27 %)."	**12.1** Restructuring the physical environment	**12.5** Add objects to the environment in order to facilitate performance of the behavior
19 + 20 + 21	Sparkman et al. (2020)	1: - "**dynamic norm message** added to the menu": "Our Meatless Burgers Are on the Rise From Lunch to Late Night, we offer a variety of options for you to enjoy." - In both control and treatment conditions "**A leaf symbol was placed** next to vegetarian items on the menu board and the menu tablets, and a key at the bottom of the primary section on the menu board indicated that the leaf marked dishes that were vegetarian or vegan" - "also included **a similar note** to the top of the tablet that customers used to place their orders on intervention days" "We've noticed customers are starting to choose more meatless dishes. From Lunch to Late night, we make sure to offer you a variety of dishes to choose from."	Message = **6.2** Social comparison (Leaf symbol was added in both control and treatment, so not coded as part of intervention)	**6.2** Draw attention to others' performance to allow comparison with the person's own performance
		2 (3 in paper): - "**dynamic norm message** added to the menu" - "Those assigned to the intervention condition saw a menu with a note at the top right of the menu. It read: *We've noticed that our customers are starting to order our meatless dishes for lunch more often. We delight in bringing you the best of Italian food inspired by California's bounty: all of our dishes feature carefully sourced ingredients and fresh produce.*"	Message = **6.2** Social comparison	
		3 (4 in paper): - "similar materials as Study 3, except that the **dynamic norm note** added to the dinner menu referred to choosing dishes for **dinner** instead of lunch."	Message = **6.2** Social comparison	
22	Schwitzgebel et al. (2020)	"In a week selected by the instructor, half of the course **discussion sections** covered the ethics of charity and **half covered the ethics of eating meat**." "The Tas **emailed the relevant reading materials** to their students, readings either on meat or charity ethics. The email also		

(*continued on next page*)

(*continued*)

Study no.	Paper	Intervention components	BCTs	BCT descriptions
		contained a **link to an optional related video**. Students were encouraged to complete the reading before attending section."		
		"Students in the meat ethics condition were **required to read James Rachels' article "The Basic Argument for Vegetarianism"** (Rachels, 2004), an introductory-level ten-page philosophy article arguing that it is unethical to eat meat. Students were also **encouraged to view on their own outside of class an optional 11-min vegetarianism advocacy video** "What Came Before" (http://whatcamebefore.com)."	**5.3** Information about social and environmental consequences	**5.3** Provide information (e.g. written, verbal, visual) about social and environmental consequences of performing the behavior
		"**TAs presented both the pro and con considerations in their discussion sections**, **encouraging debate** among the students, as is typical instructional procedure in philosophy discussion sections in the U.S."	**9.2** Pros and cons	**9.2** Advise the person to identify and compare reasons for wanting (pros) and not wanting to (cons) change the behavior

Data availability

No data was used for the research described in the article.

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