HABITUAL BEHAVIOUR AND WEIGHT CONTROL

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DECLARATION

I, Phillippa Jane Lally, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

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ABSTRACT

With obesity rates rising steadily in most parts of the world, there is considerable interest in novel weight loss interventions. This thesis tests the utility of habit formation theory for designing behaviour change advice for weight loss. Central to models of habit operation is the idea that habits develop through repetition of the behaviour in consistent contexts (Context Dependent Repetition; CDR), but the process itself has attracted little research attention, and it has never been used as a basis for interventions. This thesis used CDR as the basis of a weight loss intervention and also examined the process of habit development for diet and activity behaviours. Study 1 was an eight week pilot study with ten participants who were given simple advice on developing diet and exercise habits associated with weight loss. Post-intervention interviews found evidence that some behaviours had acquired 'automaticity' – the hallmark of habits - and weight data showed an average 3kg weight loss. Study 2 extended the evaluation of the intervention in a randomised controlled trial of the habit-based advice compared with a no-treatment control group, incorporating standardised measures of automaticity. The results showed significantly greater weight loss in the intervention group, which was maintained over follow up. The recommended behaviours also became increasingly automatic. Study 3 tracked changes in automaticity over three months as volunteers repeated one eating or activity behaviour in a consistent context on a daily basis. The results showed that advice on CDR is sufficient to promote habit formation and supported the prediction that an asymptotic curve of increasing automaticity reflects a generalised habit-formation process. The average length of time to reach an asymptote was 70 days. This research has contributed to the understanding of habit formation and shown that it may be a useful foundation for simple, easily disseminable, weight loss interventions.

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CHAPTER 1
HABITUAL BEHAVIOUR

THE HABIT CONSTRUCT

Though widely used in everyday speech, definitions of the word 'habit' vary. Behaviours are often deemed habitual if they are performed frequently, but more specifically this term is used to refer to behaviours that are performed automatically; once initiated they progress without conscious input (Bargh, 1992). Alternative definitions will be discussed but as a starting point the term habitual is used to refer to behaviours which are performed automatically, where the automatic performance of the behaviour is the result of repetition. Although, in this chapter, the term 'a habit' is often used, habit strength is conceptualised as a continuum. Understanding the process through which behaviours become habitual could inform the design of interventions that aim to promote long-term performance of healthy behaviours and reduce performance of unhealthy behaviours. This chapter therefore presents a review of the growing body of research on habitual behaviour, albeit defined and assessed in different ways, emerging within social psychology. To situate this research in the appropriate context I firstly discuss how habits have traditionally been conceptualised and measured.

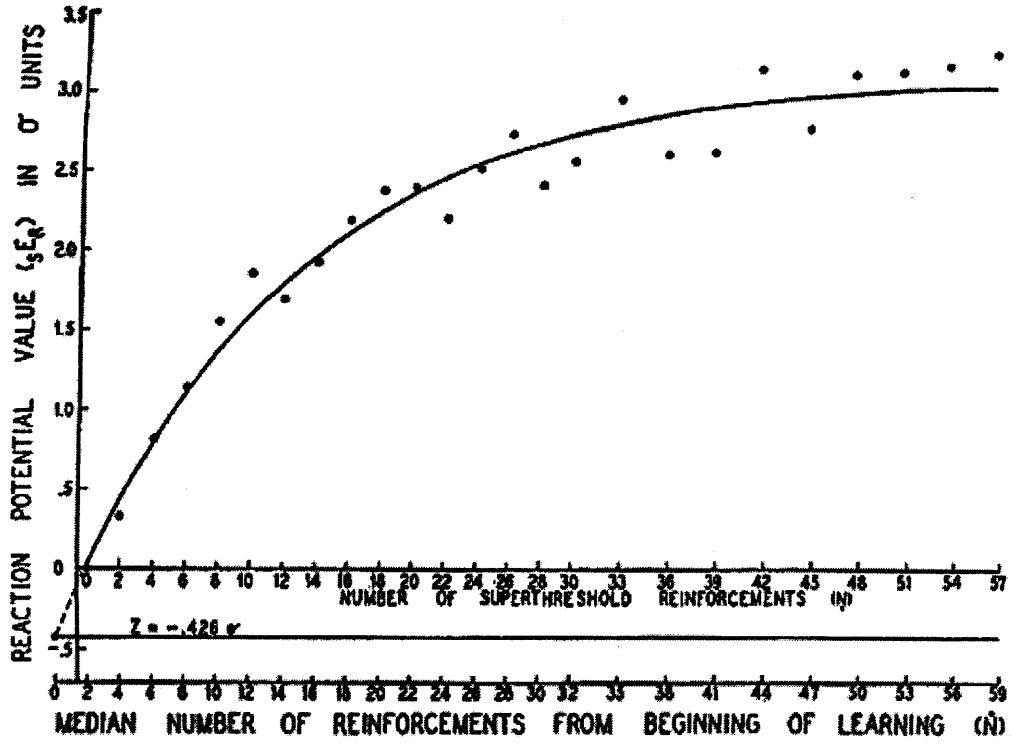
Behaviourism

The concept of 'habit' was central to the behaviourist tradition (e.g. James, 1890) which held that behavioural responses were determined by learned associations between situations and rewards. The more often a behavioural response to a cue (situation) had been rewarded in the past, the stronger the situation-behaviour link was assumed to be. Habit strength was therefore seen as proportional to the number of successful prior performances (the number of reinforcements) (Skinner, 1938). As William James put it, "a tendency to act only becomes effectively ingrained in us in proportion to the uninterrupted frequency with which the actions actually occur, and the brain 'grows' to their use " (James, 1890, p129).

It is unlikely that repetition continues to have the same impact on habit strength indefinitely. At some point habit strength must get so high that more repetition can no longer increase it. Hull (1943; 1951) recognised this, and using data from trials with

rats and physical responses in humans (e.g. to electric shock) developed a formula for the relationship between reinforcement and habit strength which plotted a curve (Habit $= a\,(1 - 10^{-bN})$), where N is the number of repetitions and a and b are constants. In this research, habit strength was inferred from measures of behaviour (e.g. drops of saliva secreted in response to a cue) and data were pooled across participants (average responses at each number of repetitions). The curve (see Figure 1.1) shows that the impact of each reinforcement results in a smaller increase in habit strength as the number of reinforcements increases.

Figure 1.1: Hull's habit development curve*



*reprinted from Hull, C.L. (1951). *Essentials of Behavior.* Westport, Connecticut: Greenwood Press.

Since Hull's studies, no research has focused on the habit formation process per-se. Nevertheless, recently a number of authors have proposed models of how habits operate that incorporate, either implicitly or explicitly, assumptions about the process of habit acquisition. These ideas will be discussed towards the end of this chapter.

Social Cognition Models

Many social cognition models of behaviour used in research today, for example the Theory of Planned Behaviour (Ajzen, 1991), do not incorporate the habit concept, although some mention it as a complication. However, two authors have incorporated

the habit concept in their models and elaborated the concept. Triandis (1977; 1980) defined habits as "situation-behaviour sequences that are or have become automatic" (p204). He viewed reinforcement as central to habit development, but reasoned that the specific nature of the reinforcement is difficult to define and may relate to expectations. He saw some behaviours as being under habitual control and others under intentional control, and in his model weighted the influence of habit and intention inversely so that the influence of intention on behaviour was highest when habit strength was low. Through repetition, automaticity increased and the influence of intention decreased.

Ronis et al (1988) defined a habit as "an action that has been done many times and has become automatic" (p218). In their model, attitudes are seen as important in the initiation of behaviours whereas habits control behaviours that have been repeated. Ronis et al made the claim that the special characteristics of repeated behaviour (presumably their habitual characteristics) only occur when a behaviour has been "performed frequently (at least twice a month) and extensively (at least 10 times)" (p213). This is an interesting attempt to quantify the amount of repetition required, although the numbers appear to be entirely arbitrary.

Past Behaviour as a measure of habit strength

In studies testing the predictions of social cognition models, past behaviour is consistently found to be the strongest predictor of future behaviour, over and above attitudes, beliefs and most importantly intentions (Sutton, 1994). These findings are often attributed to the role of habits, although this is problematic because the past behaviour–future behaviour relationship only tells us that behaviour is consistent over time and tells us nothing about the mechanisms guiding behaviour. For example, people may engage in reasoned decision-making each time they perform a behaviour and if the factors influencing this remain stable the behaviour will also be stable. Alternatively people may consciously decide to repeat the behaviour because of its previous success. In addition, the finding may be due to shared method variance, i.e. measures of past and future behaviour are likely to be more similar than measures of intention and future behaviour, and intention measures may be unreliable (Sutton, 1994).

Another important issue is the ability of past behaviour measures to capture important features of habit strength. Using past behaviour as a measure implies that habit strength

continues to increase with repetition. As Hull's (1943; 1951) equation suggests, this is unlikely to be the case beyond a certain number of repetitions. Also, estimates of past behaviour are prone to bias. For frequently performed behaviours, subjective ease of retrieval - which can be influenced by factors such as how many instances of the behaviour a person is asked to recall or how important an event is to them - affects frequency estimates of past behaviour (Aarts & Dijksterhuis, 1999). However, in an experiment where participants were asked to remember instances of past bicycle use, these effects were minimised when participants were motivated to be accurate (Aarts & Dijksterhuis, 1999).

There is an important debate about people who rarely or never perform the behaviour of interest. Ajzen (2002) argues that this should be considered as a strong habit of *not* performing the behaviour and so proposes a U-shaped relationship between repetition and habit strength. However both Sheeran (2002) and Sutton (1994) have argued that non-behaviour cannot be considered a habit, and therefore the past behaviour-future behaviour link overestimates the impact of habits. The difference could be that Ajzen is focusing on choices between two alternatives, while Sheeran and Sutton focus on situations with multiple choices. Wood and Neal (2007) have argued that in most cases non-responses are not habits because they do not reflect a learned association between a situation and a response. However, when people break a habit by forming a link between the cue for an established habit and non-performance of the behaviour, this non-performance can be considered a habit. This is a helpful resolution to the debate.

Overestimation of relationships between predictors and behaviour is an issue for many different types of prediction research, not just habits. For example, in research on intention-behaviour consistency, people who do not intend to perform a behaviour and then carry through this intention by not doing the behaviour will give an (undeserved) boost to the extent of intention-behaviour consistency. This needs to be considered when interpreting results of all behavioural prediction studies, but is a particular challenge for conclusions based on past behaviour because of the stronger similarity between the measures of past and present behaviour.

Past behaviour is often added to predictive models after intention to test if it has an impact beyond repeated decision-making. However it is important to note that when a behaviour is habitual, intentions are also likely to remain constant and be strongly held.

Indeed intentions are more closely linked with past behaviour for behaviours that are performed frequently in consistent contexts (likely to be habits) rather than infrequently in inconsistent contexts (less likely to be habits) (Ouellette & Wood, 1998). So in situations when habits and intentions correspond and "people intend to do what comes habitually" (Wood & Quinn, 2004, p60), it is difficult to determine which is guiding behaviour.

Overall, using past behaviour as a measure of habit strength leads to little clarification of the potential role of habits in controlling behaviour, and cannot solve the disagreements between researchers on this topic. Both Triandis and Ronis et al. acknowledged that it is difficult to test their models without an adequate measure of habitual behaviour. Similarly, Eagly and Chaiken (1993) noted that "the role of habit *per se* remains indeterminate in this research because of the difficulty of designing adequate measures of habit" (p181). Recently a number of different measures have been developed. In this chapter I will describe these alternative measures and the results obtained using these. I will then discuss the models of habitual behaviour which have been proposed, and relate these to the measures described. Finally I will assess how this literature informs our understanding of how to create and break habits, and how this might be applied in behaviour change interventions.

MEASURES

Repeated behaviour within a stable context (The Context Habit Measure)

A meta-analysis

In 1998 Ouellette and Wood conducted a meta-analysis of studies that had measured both intention and past behaviour to predict a range of behaviours. They defined habits as "behavioural tendencies to repeat responses given a stable supporting context" (Ouellette & Wood, 1998) and argued that in situations where behaviours can be performed in this way, past behaviour will reflect habit strength. They classified studies based on whether the behaviour of interest was likely to support the development of habits (ie. could be performed daily or weekly in a consistent context). For behaviours conducive of habit formation (for example coffee drinking), past behaviour directly predicted future performance and intention was a weaker predictor. For behaviours not conducive to habit formation (for example blood donation), intentions were a strong

predictor and past behaviour weaker. They concluded that habits and intentions alternate as predictors of future acts.

Ouellette and Wood (1998) tested their conclusion from the meta-analysis in a study of TV-viewing and recycling behaviour. Participant reports on the situations in which they performed these behaviours were classified as stable or unstable. Again past behaviour was more predictive in situations conducive to habit formation (stable contexts).

The Context Habit Measure

Building on the results of the meta-analysis Wood and colleagues have now conducted a number of studies where habit strength is assessed by measuring past behaviour and stability of the performance context and multiplying these together (measure shown in Appendix 1.1) (Wood, Quinn, & Kashy, 2002; Wood, Tam, & Witt, 2005; Ji & Wood, 2007). Measurement of context has varied, from the physical location to mood when the behaviour is performed. I refer to this measure as the Context Habit Measure (CHM). Although this measure is based on an assessment of past behaviour, it is not subject to all the criticisms outlined above. Firstly, the explanation that the past-future behaviour relationship is attributable to shared method variance is undermined by the differential prediction of past on future behaviour for behaviours which are performed in stable compared to unstable contexts. Ajzen (2002) argued that past-future behaviour relationships are due to weak intentions, but it has been shown that when habits are particularly strong, and therefore past behaviour is a strong predictor of future behaviour, intentions are also likely to be strong (Ouellette & Wood, 1998; Ji & Wood, 2007). Ji and Wood (2007) provide evidence that issues with poor recall of past behaviour are unlikely to impact scores on the CHM. They found that when asked to give a number for how often in a week they perform a behaviour, participants typically use a 'rate estimation strategy' to estimate past performance frequency rather than recalling specific episodes (which is where the criticism of poor recall was founded), and the approach used did not impact the relationship between the CHM score and behaviour.

The CHM avoids the problem of assuming that habit strength increases indefinitely each time a behaviour is repeated because the response scale asks for an estimation of the amount a behaviour is performed. This is either (as shown in Appendix 1.1) with four response options of never, monthly or less, at least one a week and just about every

day (Wood et al., 2002), or an estimate of an amount per week (Ji & Wood, 2007). This gives an upper limit for the estimate of how often the behaviour is performed, and therefore does not assume that performing a behaviour 101 times results in stronger habit strength than performing it 100 times. However, this measure can only be used to assess habit strength at one time point and not for tracking small changes over time, because rating the general level of behavioural performance would only be appropriate once performance becomes regular. The CHM does not directly assess how habitual a behaviour is, but rather assesses the probability that it is habitual based on its history of repetition in a stable context.

Findings using the context habit measure

Habits in everyday life

Diary studies are able to assess habits in everyday life, and with compliant participants can also investigate the thoughts people have when performing habits. In two studies Wood et al (2002) asked participants to provide hourly reports of their ongoing experiences, behaviours and thoughts. The CHM was used to define behaviours as habits when participants reported performing them just about every day and usually in the same location. A third to a half of all behaviours reported were classified as habits. Results showed that participants were less likely to think about their behaviour when performing habits than non-habits: thoughts wandered from behaviour 50-60% of the time when performing habits, compared to 30-35% when performing non-habits. This study may overestimate how much people thought about their behaviour because completing a diary may result in participants thinking more than usual about their behaviour. The results also indicated that habits were associated with lesser emotional intensity, and that when performing habits participants were more likely to identify their thoughts as the source of their emotions rather than their behaviour. Habits were not judged to be self-relevant, and participants reported negative self-evaluations (participants reported how each behaviour made them feel about themselves, from positive to negative) and less pride in relation to habits. These results serve as an additional validation of the CHM by showing that behaviours classified as habits are associated with a lack of awareness, a central feature of the habit concept.

The same study also examined the complexity of the behaviours reported in the diaries. They were rated as complex (requiring responses tailored to new information) and less complex (can be performed with little modification to new information). Participants

thought more about the behaviour they were performing when the behaviours were complex, but within the set of complex behaviours they had fewer thoughts about those that were performed frequently. This suggests that complex behaviours may become less automatic than simple behaviours but that complex behaviours can become somewhat automatic.

Changing circumstances

The CHM has also been used to investigate the impact of changes in life circumstances on habits, in a study conducted with students who were transferring to a new university (Wood et al., 2005). Participants completed measures of their habits, intentions and aspects of the performance environment for exercising, reading newspapers and watching TV, before and after the move. Changes in the context (location, roommate's behaviour and the presence of others) disrupted habits. Habits remained stable when the performance context did not change, for example when students continued to read the paper with friends. Context change was associated with changes in intention, but equally for habits and non-habits, suggesting that it is not the change in intention that results in the change in behaviour but the change in context. When habits were disrupted behaviour was often then in line with intentions. This study provided evidence for the common assumption that if the cues which trigger habitual responses are removed habits will no longer be performed.

Habits and self-control

The CHM has been used to consider the effect of habits when self-control is depleted. Neal and Wood (2007)[1] conducted a four day diary study where for two days participants' self-control resources were reduced by asking them to do everyday activities with their non-dominant hand. In these situations participants were less likely to perform non-habitual behaviours but continued to perform habitual behaviour (defined as above using the CHM). This was the case for both healthy and unhealthy behaviours highlighting that habits can have both a positive and negative influence when viewed from the perspective of promoting healthy behaviours.

Habit vs intention

Ji and Wood (2007) used a moderator analysis to examine the relationship between habit, intention and behaviour. They found that for TV viewing, fast food purchases

[1] Cited in Neal et al (2006) and Wood and Neal (2007) as an unpublished manuscript.

and taking the bus, intentions predicted behaviour when habits were weak or moderate, but when habits were strong, past behaviour was repeated irrespective of intentions. Here the CHM was used with four different features of the performance context; location, mood, time of day and the presence of 'the same' other people. For fast food purchase, only location and mood were predictive, for TV viewing all four were predictive, and for taking the bus all except mood were predictive. This suggests that different aspects of the performance context may be important for different behaviours. It may also be the case that different aspects of the context are relevant for different people depending on how their habits have developed. One person may always have fast food on a Friday night, whoever they are with, and another may always have fast food when a particular friend visits but this happens on different days of the week. This means that within any group of people, behaviours may appear more or less habitual depending on which features of performance context are assessed. This is a limitation of this measure.

Ji and Wood (2007) also found that people with stronger habits had stronger intentions in relation to this behaviour, indicating that the moderating effect of habits on intention was not due to an association between strong habits and weaker intentions. It is possible that the level of abstraction at which intentions are represented may change as behaviours become habitual and this could inflate the apparent habit-by-intention interaction. In this study the results were replicated when participants specified their intentions for themselves suggesting that the level of abstraction did not impact the results.

Conclusion

The CHM is a useful tool to assess the probability that a behaviour is habitual at one point in time although, as discussed above, it is limited by potential differences in the type of cues relevant for different behaviours in different people. The results using this measure are informative and have shown that habits are common in everyday life, occur with little thought, and are independent of intention in determining behaviour such that when habits are strong they can override intentions. These studies have also shown that when self-control capacity is reduced, habits continue to be performed but when the supporting context alters, behaviour comes again under conscious control. These findings indicate that habits persist as long as the performance context remains stable.

The Response Frequency Measure

The measure

A series of experiments have been carried out, developing and using a measure referred to as the Response Frequency Measure (RFM) (Verplanken, Aarts, van Knippenberg, & van Knippenberg, 1994; Verplanken & Aarts, 1999) in the specific field of travel mode choice. This is based on a definition of habits as "learned sequences of acts that have become automatic responses to specific cues, and are functional in obtaining certain goals or end-states" (Verplanken & Aarts, 1999, p104). Verplanken and Aarts (1999) argue that habits can operate at various levels of specificity, from behaviours that occur in only one context to behaviours that occur in a variety of settings by virtue of the cue for behaviour occurring across a number of settings. They refer to the latter as generalised habits, and the RFM assesses habits at this level.

The RFM is administered by giving participants a number of travel goals and asking them to respond as quickly as possible with the travel mode option that comes to mind (e.g. bicycle, car, walking). The number of times each travel mode is selected is taken as a measure of the strength of the habit of using that mode of transport. Participants are asked to respond quickly so that responses tap mental representations (schema elements linking cues and action) rather than being based on conscious deliberation (Verplanken, Myrbakk, & Rudi, 2005). The measure has been shown to correlate highly with car use among commuters who live close to work, even when controlling for their attitude towards car use. It also showed good test-retest reliability over 4 months (Aarts, 1996).[2]

Findings using the Response Frequency Measure

Habits and attitudes

In the initial study using this measure, Verplanken et al (1994) used a slightly different approach. They did not require participants to answer quickly but gave vague descriptions of the travel situations (for example going to the beach with some friends) so that participants could not engage in deliberation such as weighing up the pros and cons of different options. In their study of car use habit, they found that when habit was weak, attitude was a good predictor of behaviour; but that when habit was strong, attitudes were much weaker predictors.

[2] Cited in Verplanken and Aarts (1999) as an unpublished dissertation.

Aarts et al. (1994)[3] examined the relationship between habit strength (RFM) of bicycle use and attitude accessibility (response time when responding to travel mode attitude objects and answering if they were favourable or unfavourable). They found that individuals with a strong bicycle use habit were faster at responding to the object bicycle than to other travel mode words, but habit strength was unrelated to whether they chose favourable or unfavourable as their response. It is logical that attitudes towards a habitual behaviour would be more easily accessible as participants have had more experience with these behaviours. It is less obvious that these attitudes would not be favourable towards the behaviour. The relationship between habits and views of oneself will be discussed later.

Habits and information processing

A series of studies using the RFM have investigated how information is accessed and used in relation to travel mode choices. Verplanken et al (1994) found (using a decisional-balance questionnaire) that people who were motivated to engage in making a decision were those with a weak habit, while participants with a strong habit had low motivation to engage in decision-making. Using an information-display-board where participants could choose the level of information they accessed before making a decision, it was found that habitual bicycle users accessed less information about the choice options and about the travel situation than those without this habit (Verplanken, Aarts, & van Knippenberg, 1997). The information that was accessed related to their habitual choice rather than other options (Verplanken et al., 1997). Participants also used the information accessed less in making decisions when a habit was present (Aarts, Verplanken, & van Knippenberg, 1997). In all these studies the researchers tried to manipulate the impact of habit on decisions. When participants with a strong habit were told they would have to justify their choice they accessed more information but there was no interaction between this justification effect and that of habit (Verplanken et al., 1997; Aarts et al., 1997). When participants with a strong habit had their attention drawn to the importance of the information, they initially accessed more information than those without the manipulation but over 27 trials the levels of information accessed reduced and the group difference disappeared (Verplanken et al., 1997).

[3] Because this chapter is in Dutch I have used the information regarding it from Verplanken and Aarts (1999).

Habits vs intention

The RFM has also been used to examine the independent prediction of habit and intention on behaviour. Verplanken et al (1998) found that intention, perceived behavioural control, RFM and past behaviour were significantly related to car use behaviour, but habit assessed either with the RFM or past behaviour, was the strongest predictor. A significant habit by intention interaction was also found such that intention predicted behaviour when habit was weak but not when habit was strong. Participants with strong habits acted in accordance with these, irrespective of intentions. This gives strong evidence for the importance of habits as it replicates previous findings using a measure which does not rely on an assessment of past behaviour.

Conclusion

One recent study has cast doubt on the validity of the RFM, finding that car use habit, assessed using the RFM, was not a significant predictor of public transport use (Bamberg, 2006). It is difficult to identify the reason for this negative finding but it could be partly due to the fact that the RFM used various trips, some of which were rare, whereas the behaviour measure was used for only one day. Ajzen (2002) criticises the RFM arguing it is more a measure of generalised intention to perform the behaviour than of habit strength. Despite these issues the finding that there is an interaction between the RFM and intention in predicting behaviour is strong support that the RFM does assess habit strength.

One area of uncertainty is whether asking participants to respond quickly means that their responses tap the mental associations underlying habits. If this is not the case, then the response may be more directly related to past behaviour and can be seen as similar to the CHM i.e. a measure of the probability that a behaviour is habitual. The major limitation of this work is that it has only been applied to travel mode choices. Although extending these findings to other behaviours would require developing new measures, the results appear to reflect aspects of habitual behaviours which should be applicable across different behavioural domains. This is again supported by the finding that habits measured using the RFM and intentions alternate as predictors of behaviour, because this has also been shown using other measures. The findings relating to attitudes and information processing add to our understanding of how habitual behaviours can impact views of one's own behaviour, and how people interact with their environment once habits are established.

The Self Report Habit Index (SRHI)

The measure

Verplanken and Orbell (2003) argued that habit is a psychological construct that can be accessed via self report of relevant features. They chose the following features of habits as the basis of a measure: a history of repetition of behaviour, difficulty in controlling behaviour, lack of awareness, efficiency and incorporation into self-identity. These were used to create a 12 item, Self Report Habit Index (SRHI) (Appendix 1.2). These features were used to guide the development of items, although not all items are directly linked to one of the listed features. To administer the SRHI, the behaviour of interest is stated and followed with the words 'is something' and respondents are asked to agree or disagree (on a Likert scale) to the items (e.g. 'I do frequently'). Therefore the measure can be used for both specific and general habits (e.g. 'eating an apple after lunch' vs 'taking the bus').

Features of habits, used to develop the SRHI

Three of the features (difficulty in controlling behaviour, lack of awareness, and efficiency) are derived from Bargh's conceptualisation of automaticity (Bargh, 1992; 1994). He identified four features of behaviour considered to be relevant to automaticity; efficient, outside of awareness, unintentional and uncontrollable. He argued these are relatively independent qualities and can occur in any combination in different types of automatic behaviour. Therefore Verplanken and Orbell used the combination of features which they consider represent habitual behaviour (a subclass of automatic behaviour). They argued that "habits can be characterised as behaviour that is intentional in its origin, is controllable to a limited extent, is executed without awareness, and is efficient" (p1317). The basis for arguing that habits are intentional was that they are goal-directed. The issue of intentionality is difficult in this area, mostly because of different uses of the word. When Bargh uses the term 'unintentional' he is referring to the fact that conscious intention is not always used to initiate the action in response to a cue. However it is not clear that Verplanken and Orbell are using the term in the same way. They did not use the intention component in their measure, but took the other three aspects of automaticity as central components.

Verplanken and Orbell argue that behavioural repetition is a necessity for behaviour to be habitual and therefore included it as a feature in the SRHI. It is agreed that repetition is required for behaviour to become habitual, but the amount of repetition necessary has

not been investigated. The identity component of the SRHI was based on the idea that behaviours performed frequently "might" (Verplanken & Orbell, 2003, p1317) reflect personal identity and items that appear to be related to this are; 'that's typically me' and 'it makes me feel weird not to do it'. The relationship between habits and identity is a point of debate within the habit literature and will be discussed later in this chapter.

Validation

Verplaken and Orbell (2003) validated the SRHI in the area of travel mode choice. They found it measured a single construct (principle components analysis), had good test-retest reliability, correlated well with the RFM and past behaviour measures, and could differentiate between behaviours usually performed with different frequencies (daily and weekly habits; assumed to be more and less likely to be habitual). They also replicated the results having removed the behavioural frequency items, to avoid the potential criticism that the SRHI is merely another measure of past behaviour.

Verplanken (2006) has specifically tested whether the SRHI has discriminant validity over past frequency of behaviour. In a study of unhealthy snacking, he found that SRHI scores contributed to the prediction of behaviour over and above both the Theory of Planned Behaviour variables and past behaviour. SRHI scores were also shown to mediate the effect of past on later behaviour, indicating that the ubiquitous finding that past behaviour predicts future behaviour is at least in part due to these behaviours being habitual. Again the analysis was repeated removing the items referring to past frequency and the results remained significant. In another study Verplanken (2006) also used an experimental design to manipulate habit development while keeping behavioural frequency constant. This involved a word processing task where participants either had to underline each time the word she appeared in a text (simple condition), or underline all the words that indicated 'a mammal or an object that could be moved', in the same text (complex condition). All participants completed the same number of trials. The hypothesis was that habits are more likely to develop for simple than complicated rules. The SRHI was adapted to be appropriate to answering questions about this task. It was found that participants in the simple rule condition had higher SRHI scores than those in the complex rule condition, indicating that there is a clear distinction between frequency of occurrence and habit strength.

To compare different measures of habit directly, Verplanken et al (2005) conducted a study in the field of travel mode choice. They used the RFM measure, SRHI and past behaviour to assess habit strength for car and bus use. The measures were highly correlated. It would be expected that habit strength for each of these two travel options would be inversely related, as having a strong car use habit precludes also having a strong bus use habit. This was found most convincingly by the SRHI. The RFM found a high correlation because the same measure was used to measure both behaviours, with participants choosing between options, so this is a methodological artefact rather than a validation of the measure.

Findings using the Self Report Habit Index

The SRHI has been used in a number of studies showing that habit strength predicts behaviour. As discussed above Verplanken (2006) found that SRHI scores contributed to the prediction of future behaviour over and above the Theory of Planned Behaviour variables and past behaviour in a study of unhealthy snacking. In cross-sectional studies habit strength has been associated with consumption of sugar sweetened beverage consumption among adolescents (Kremers, van der Horst, & Brug, 2007; van der Horst et al., 2007), and habits for 'doing all that is needed to produce clean and uncontaminated turkey products' was significantly associated with food safety behaviours (Hinsz, Nickell, & Park, 2007). Two prospective studies predicting future behaviour have used the SRHI to measure habit strength. Chatzisarantis & Hagger (2007) used the SRHI to show that habits are predictive of leisure time physical activity. They also found the anticipated habit by intention interaction such that non-habitual exercisers were more likely to act based on their intentions than habitual exercisers. De Bruijn et al (2007) showed that intention was only a significant predictor of future fruit consumption among those with small or medium habit strength and not among those with a strong habit (categorised based on scores on the SRHI, with groups differentiated using half a standard deviation from the mean).

Some researchers have chosen to use a selection of items from the SRHI. Using only two of the items, habits were shown to be predictive of condom use with steady sex partners among 14-16 year old adolescents (van Empelen & Kok, 2006). Using three items completed by parents about their children, habit was found to be the strongest predictor of fruit and vegetable consumption in 4-12 year old children, over and above parental fruit and vegetable consumption, availability and accessibility, exposure to fruit

and vegetables, as well as psychosocial factors (e.g. attitudes and norms) (Reinaerts, de Nooijer, Candel, & de Vries, 2007). It is interesting that significant results have been found using only a sample of the SRHI items and future work will need to assess the relative predictive power of the measure using different combinations of items.

Brug et al (2006) found that adding habit strength (SRHI for fruit intake) to a model including variables from the Theory of Planned Behaviour and the Attitude, Social Influence and Self-Efficacy model to predict fruit consumption, explained additional variance in behaviour. After controlling for habit strength, perceived behavioural control, attitudes and subjective norms were no longer significant predictors. They found that habit strength predicted intention, such that those with stronger habit strength also had stronger intentions. A second study has also found a relationship between habit and intention. Honkanen et al. (2005) used the SRHI for consumption of seafood. They found that both past behaviour and SRHI scores had a strong influence on intention, much larger than that of attitudes.

The results of these two studies using the SRHI fit with previous work showing that people often have strong intentions to perform behaviours that are habitual (Ouellette & Wood, 1998; Ji & Wood, 2007). It is worth noting that the habit by intention interaction found when predicting behaviour, and the finding that intentions are predicted by habits, are not in opposition. These two findings together tell us that people are more likely to intend to perform a behaviour that they already perform habitually, but that whether they do or do not intend to perform the behaviour, if it is habitual they are likely to do so irrespective of this intention. In contrast when a behaviour is not habitual, the probability of an individual performing the behaviour is, to a significant extent, dependent on whether or not they intend to do so.

Conclusion

The SRHI is a useful measure of habit because it focuses on features of habitual behaviour to assess habit strength rather than on assumptions about the underlying processes guiding habitual responding. So far, habit strength as measured using the SRHI has been shown to be an independent predictor of behaviour over and above attitudes, intentions, and past behaviour, and it can detect the expected inverse relationship between habits on two alternative choices. It has also been used to show a habit by intention interaction in predicting behaviour, and that intentions are stronger

when habits are also strong. Both these findings have also been found using the CHM, and the first has been demonstrated using the RFM. The studies using this measure help to provide evidence that habit is a useful construct and is predictive of behaviour. There is scope for this questionnaire to add significantly to the field because it could be used to investigate many aspects of habitual responding (for example the findings relating to information use could be replicated measuring habit strength using the SRHI) as well as to track changes in habit strength over time.

MODELS OF HABITUAL BEHAVIOUR

The three measures discussed above are based on different conceptualisations of how habits develop and control action. Nevertheless all three view habitual behaviour as a subclass of automatic behaviours. Therefore it is useful to consider cognitive theories of automaticity before examining different models of how habitual behaviour operates.

Cognitive theories of automaticity

In cognitive psychology automaticity is viewed as present when attention is not required to perform the behaviour. Historically an "all-or-none" view of automaticity has been used, with a list of features that an automatic behaviour must have. Different authors have provided lists of the features (e.g. Logan, 1985; Shriffin & Schneider, 1977) which are rarely in agreement.

As discussed, Bargh (1992; 1994) identified four features which have been considered to define automaticity: efficiency, outside of awareness, unintentional and uncontrollable. He argues that no process is exclusively automatic but that many behaviours have some features of automaticity and can therefore be considered somewhat automatic. He argues that these different types of automatic behaviours evidence different combinations of the features, and that these features are relatively independent. Moors and De Houwer (2006) reviewed the automaticity literature and also concluded that to assess automaticity it is necessary to examine the features of a behaviour and infer from these the automatic nature of the underlying processes (Logan's (1985) gradual view). They argued that individual features should be considered as separate continua and proposed as relevant: unintentional, autonomous, purely stimulus driven, unconscious, efficient and fast. These are not very different

from Bargh's. It is important to highlight that in both these analyses, 'unintentional' refers to the behaviour being initiated without a conscious intention guiding it. It does not mean that an individual would not endorse the behaviour if they were asked in advance if they intended to perform the action. As I have discussed, it is often the case that people report strong intentions to perform their habits.

The argument that different automatic behaviours show different features allows for the examination of different subclasses of automatic behaviours which display different combinations. Bargh (1992; 1994) identified three types of automaticity: preconscious, postconscious and goal-dependent. Preconscious automaticity requires only the triggering stimuli to be present. Postconscious automaticity requires a recent conscious experience in the same stimulus domain for the stimulus-response association to occur, or in other words the cue is a thought. Finally goal-dependent automaticity occurs only when a goal is in place and the triggering stimulus is encountered. Bargh believes that all three forms occur in the natural environment, but argues that it is important to be clear about which is being referred to at any time.

Everyone appears to agree that habitual behaviours are the subclass of automatic behaviours in which automaticity has developed through repetition, in contrast to those where it is developed through planning, for example.[4] However within the category of automatic behaviours where automaticity is developed through repetition, there may be further sub-divisions. A number of models have been proposed to explain how habits operate and I now discuss four alternative models derived from an examination of the literature.

Four habit models

The four models are presented in Table 1.1 and are then discussed in turn.

Table1.1: Four alternative models of habitual behaviour

Name	Model	Goals	Rewards
Direct Cuing	cue-response	Not goal-dependent	Rewards not required
Motivational Contexts	cue-response-reward	Not goal-dependent	Rewards required
Goal Mediated	cue-goal-response	Goal-dependent	Achieving goals considered reinforcing
Goal Reliant	cue-response in the presence of an activated goal	Goal-dependent	Rewards not required

[4] Automaticity developed through planning will be discussed later under implementation intentions.

The Direct Cuing Model (habits as cue-response associations)

Wood and colleagues (Neal, Wood, & Quinn, 2006; Wood & Neal, 2007) argue that the subclass of automatic behaviours which are habitual are those which are *not* goal-dependent. They argue for two different mechanisms underlying habitual responses (Direct Cuing and Motivational Contexts). These are discussed in turn.

The Direct Cuing Model proposes that memory traces are laid down when a cue and response are repeatedly co-activated and this forms a link in procedural memory. This link is then activated when the situation is encountered, and it triggers the response. This gives a plausible explanation for how the perception of a cue activates a mental representation of a previously repeated response, but there is currently no evidence that this heightened cognitive accessibility can cause the initiation of a behaviour, although mental activation of a response has been shown to influence the way in which intended behaviours are enacted (e.g. priming of an elderly stereotype can result in elderly behaviours (Bargh, Chen, & Burrows, 1996)).

The Motivational Contexts Model (habits as cue-response-reward associations)

The second mechanism Wood and colleagues (Neal et al., 2006; Wood & Neal, 2007) discuss, they term Motivational Contexts and is based strongly on research on operant conditioning (e.g. Staddon & Cerutti, 2003). They argue that when environmental cues are associated with a reward received after a specific response to the cue, the motivating properties of the reward can be transferred onto the cues. Cues are then argued to motivate the response because they signal the opportunity to perform a response which will be rewarded. A neurological basis to cue-responsiveness is shown in studies in monkeys where a reward is repeatedly given after a particular action is performed in response to a cue. A dopamine response which initially occurs after the reward, over time begins to occur in response to the cue (Schultz, Dayan, & Montague, 1997). Wood and colleagues argue that the motivational power of the cue is created from the cumulative residue of previous rewarded responding. So reward predicting environments cue the value (established from prior reward) of an action rather than signalling a desired outcome (a goal) which could be achieved in a number of ways. Wood and Neal (2007) argue that the value of reward outlined in this model may enhance direct cuing rather than being an alternative mechanism, and suggest future research may combine these two approaches.

The Goal Mediated Model (habits as cue-goal-response associations)

In criticising the habit concept Ajzen (2002) argued that when behaviour is repeatedly performed in consistent contexts it can become routine, but not habitual. He argued that when attitudes and intentions are well-established they are activated automatically by situations, and guide behaviour without attention being given to this. Other authors have argued that this mechanism can be defined as a habit. Bargh and Ferguson proposed an "auto-motive model of environmentally driven, goal-directed behaviour" (p933) (Bargh & Ferguson, 2000), as one subclass of automaticity. This proposes that a situation activates a goal and the goal then directs behaviour, unconsciously. This type of behaviour was not termed habitual by these authors (Bargh & Ferguson, 2000), but has since become the basis of one model of habits. I refer to this model as the Goal Mediated Model.

Two papers take an approach to understanding habits based on the auto-motive model, and focus on the link between goals and actions. Firstly, Aarts and Dijksterhuis (2000b) primed participants (they read sentences containing the relevant goals) with five travel goals (e.g. go shopping) and they were then asked to respond to the word bicycle as being a realistic (or unrealistic) mode of transport to get to various locations presented immediately prior to the word bicycle (5 of these were the locations relevant to the primed goals e.g. the shops). Time taken to respond 'yes' to the word bicycle was the outcome of interest. Participants with a habit, defined using a median split based on past frequency of bicycle use, and primed with travel goals showed faster responses than non-habitual users, and those who were not primed. In a second study Aarts and Dijkerhuis (2000b) replicated this finding using a verb verification task and also showed no difference in response times when just before responding to the word 'cycling' participants were presented with a travel location vs a non-location word.

The authors interpret these findings as support for the argument that habits operate through a goal-behaviour link; arguing that this link was activated when the goal was primed and this made the word bicycle easily accessible. However what they have shown is simply that those who have more experience of using a bicycle for a particular journey are quicker to respond to the word bicycle when they are primed with the goal of making that journey. This does not prove that the goal triggers the behaviour.

The second paper testing this model focused on drinking habits (Sheeran et al., 2005). Based on previous research Sheeran et al (2005) used the goal of socialising as relevant to drinking. In two studies they used a similar design to that of Aarts and Dijkerhuis (2000b); participants indicated as fast as possible whether drinking (along with other words) was an action or not, and their response latencies to the word drink were taken as a measure of their readiness to drink. Some participants were primed with the goal of socialising (either by asking participants questions about socialising, or using a scrambled sentence task). Habit strength was measured using a detailed questionnaire of past frequency, and a median split was used to designate habitual and non-habitual drinkers. When comparing the four conditions (habit and goal activated, habit and no goal activated, no habit and goal activated and no habit and no goal activated) they showed that those in the habit and goal activated condition were significantly faster than the other three groups.

In a further study Sheeran et al (2005) used uptake of a £1 discount voucher, which was valid from a week after the study, as a behavioural outcome. Participants chose between a voucher for alcohol or for coffee/tea at a café bar. In this experiment the goal to socialise was activated using a questionnaire about cities for a good social life. Differences between the four groups were significant with habitual drinkers more likely to choose the alcohol voucher than non-habitual drinkers but only in the goal activated group.

Sheeran et al (2005) argue these results show that for strong habits, activating the goal automatically elicits the behaviour, but the results do not conclusively prove this. They show that for those who are frequent drinkers there is a mental association between socialising and drinking, but not that the goal of socialising triggers the behaviour. The attempt to measure behaviour fails to do so because choosing a voucher is a novel behaviour which requires conscious decision making and relates to enabling behaviour at a later date. To show that activating the goal of socialising leads to drinking the experiment would have needed to show that these participants were more likely to have a drink directly after the experiment.

A central issue in models of habits that include goals is whether the goal is considered to be equivalent to the intention to perform the behavioural response. If the goals were considered to be at this level then the model is immediately challenged by the

observation that people often perform habitual behaviours which are in opposition to their intentions. In the two studies discussed here the goals were to travel and to socialise, not to use a bicycle or to drink. Therefore it appears that the goals in this model are not specifically the goal to perform the behaviour and are therefore not equivalent to the intention to perform the response.

A strong argument against this model, put forward by Wood and colleagues (Neal et al., 2006; Wood & Neal, 2007), is that habitual responding is rigid, i.e. one response to one cue, whereas striving for goal attainment is flexible (Bargh, Gollwitzer, Lee-Chai, Barndollar, & Trotschel, 2001). In relation to the studies above, it is easy to imagine that it is only in certain situations that the goal of going shopping leads to an individual using a bicycle and that the goal of socialising leads to drinking. Although this model does include cues as the trigger for the goal this is seen as separate from the link between the goal and the action. This leads me to an alternative model where cues, goals, and responses are linked that does not include the proposal that a goal triggers behaviour irrespective of the situation.

The Goal Reliant Model (habits as cue-response associations in the presence of an activated goal)

Bargh (1992; 1994) defined goal-dependent automaticity as occurring only when a goal is in place and the triggering stimulus is encountered. Moors and De Houwer (2006) discussed goal-dependent acts and define them as acts that are dependent on a goal for them to occur. They argue this can be the goal to perform the act or a more remote goal which takes away the need for the proximal goal. When a proximal goal is present they define the behaviour as an intentional goal-dependent act, whereas when a remote goal is present, they define this as an unintentional goal-dependent act. Intentional here refers to the intention to perform the behaviour, but does not mean that it guides the behaviour consciously. However, if the intention is directly relevant to the behaviour in question, then this model does not fit with the finding that people often continue to perform habits even when intentions relevant to the specific behaviour are no longer held, therefore intentional goal-dependent acts can *not* be considered habits. As discussed above, the term intentional is problematic. Verplanken and Orbell (2003) argued that habits are intentional because they are goal dependent. However Moors and De Houwer have highlighted the fact that intentional and goal dependent are not wholly

overlapping constructs and therefore it is not possible to simply infer one from the other.

An alternative model of habit operation, which I have termed the Goal Reliant Model, is that habits are cue-response associations, which have developed and are only subsequently triggered, in the presence of an activated goal. This allows habits to be conceptualised as goal dependent but can also explain the rigidity of habitual responses, and fits with both Bargh's view of goal-dependent automaticity and Moors and De Houwer's (2006) unintentional goal-dependent acts. As in the Goal Mediated Model, the goals considered relevant are not the proximal goals to perform the behavioural response but are more distal. This model is also similar to two additional models of behaviour from separate literatures. In the cognitive literature it has been argued that two opposing models of routine sequential action; the 'Interactive Activation Network' and the 'Simple Recurrent Network' (in simpler terms a 'schema' model and a 'connectionist' model) can both be interpreted as viewing goals as gating mechanisms that allow links between cues and action to be activated (Botvinick & Plaut, 2006). This is consistent with the model of habits as requiring goal activation for their operation. The second theory of interest is that of occasion setting in the animal learning literature. An occasion-setter (e.g. a certain environment) signals the conditioned association, in Pavlovian terms between the unconditioned stimulus and the conditioned stimulus (Davidson, 2000). In operant learning the occasion-setter would signal the association between cue and response. Therefore a distal goal could be considered as an occasion-setter that activates the cue-response association.

Implementation Intentions and models of habit

Although research on habitual behaviours is still in the early stages, an associated literature, namely that of implementation intentions, is well established. Implementation intentions spell out when, where, and how an intention to perform a behaviour will be enacted (Gollwitzer, 1993) and are worded "if situation Y is encountered, then I will initiate goal-directed behaviour X". Across 94 studies implementation intentions have been shown to have a medium-to-large association with goal attainment (Gollwitzer & Sheeran, 2006). Gollwitzer, who first proposed the concept of implementation intentions, asserted that these plans operate through passing control of behaviour to the environment, such that the specified cues automatically trigger action (Gollwitzer, 1993; Gollwitzer, 1999). However it is only recently that

evidence has begun to accumulate, suggesting that behaviours performed as a result of implementation intentions are indeed performed automatically, i.e. they are characterised by immediacy, efficiency and redundancy of conscious intent (Gollwitzer & Sheeran, 2006).

There have been three studies focusing on the mechanisms through which implementation intentions operate. They have shown that implementation intentions operate through increasing the accessibility of the cue and the strength of the relationship between the cue and the response (Aarts, Dijksterhuis, & Midden, 1999; Webb & Sheeran, 2007a; Webb & Sheeran, 2007b). The three are similar in design, but the most recent is the best example. Webb and Sheeran (2007b) told participants that their study started in the laboratory and ended in the cafeteria and that they needed to collect a coupon from the cognition lab on their way to the cafeteria. Participants were given directions to the cognition lab and half (implementation intention condition) planned when, where and how they would collect the coupon. They then completed a filler task and subsequently the accessibility of the cue and the strength of the cue-response link were assessed using a lexical decision task. This involved responding as quickly as possible to whether words presented on a screen were verbs or not. Prime words were presented quickly prior to the target words, so participants were not aware they had seen them. Among the primes were three different cue words associated with the plan of collecting the coupon, based on the directions participants had been given, and the target word 'collect'. The response times of interest were, when the cue was presented after a neutral prime (cue accessibility) and when the target word was presented after a cue prime (cue-response strength). After this task, participants were asked to remember 5 food items and to go to the cafeteria where the experimenter would be waiting. Those who formed implementation intentions were more likely to collect the coupon, on the way to the cafeteria, than those who did not (64% vs 39%). Participants in the implementation intention group also showed faster response times for cue trials and cue-response trials in the lexical decision task. Mediational analyses showed that the cue accessibility and strength of the cue-response link, fully and simultaneously mediated the impact of implementation intentions on behaviour.

Another feature of implementation intentions is that they only operate when goal intentions are activated and strong. Sheeran et al (2005) found that implementation intentions did not significantly impact behaviour when the strength of the goal intention,

operationalised as the number of hours participants intended to study in a week, was low. The impact of implementation intentions on behaviour increased as goal intentions became stronger. In a second study they showed that when participants in a puzzle task, who were consciously trying to be accurate, had formed implementation intentions relating to responding quickly, participants who were then primed with the goal of responding quickly achieved this. This did not occur when the goal was not primed. Implementation intentions are formed based on proximal goal intentions, therefore behaviours performed as a consequence of implementation intentions can be considered to be intentional goal-dependent acts (Moors & De Houwer, 2006). Combining the two separate findings relating to the operation of implementation intentions shows that implementation intentions operate based on a cue-response link that automatically triggers behaviour when a proximal goal is activated.

A potential criticism of the Goal-Reliant Model is that, as with the Direct Cuing Model, there is a lack of evidence that simply activating a cue-response association can trigger behaviour. However the work on implementation intentions helps to support this model of habits. It is not a big step to move from evidence that cue-response links can trigger behaviour when proximal goals are activated, to the idea that they can also do this when more distal goals are activated.

Models and measurement

How do these models relate to the measures of habitual behaviour and their appropriateness for their task? Are some measures only appropriate to a particular model? All models agree that habits develop with repetition in constant contexts. As this assumption is the basis of the CHM, this measure can be used for all models. The SRHI focuses on the features of automaticity considered relevant to habits. The summing of the scale means that a higher score represents more of the features related to habitual behaviour. Given that the features included do not address the contentious aspects such as intentionality and goal-dependency, high scores would be considered to indicate a strong habit whichever model of habits is applied.

The RFM is based on the assumption that when a goal-related cue is activated the mental link/association to the action is activated, and that asking participants to respond quickly with a behavioural response option means they use this link. As discussed, the particular field of travel mode choice limits this research. Here the cue is a travel

destination which appears to be more similar to a goal than in other situations. A cue is usually a feature of the current environment rather than a situation someone intends to find themselves in. Therefore it is possible to interpret the outcome of this measure as operating either through a cue-response link or a goal-response link. People are either cued by the situation of needing to go to a particular place or they consider the goal of needing to get to this place. As discussed above, this measure may not tap the mental associations between a cue and a response, and therefore reflects more an assessment of past behaviour. Therefore this measure does not appear to be model-specific.

In these terms any of the measures can fit with any of the models, which is encouraging as it suggests that the three separate literatures can be integrated. However one difference which remains is the level of generalisation that each implies. The RFM can only be used for habits which are generalised across situations i.e. where the cue occurs across many situations, whereas the SRHI can be used at different levels from the specific (eating an apple after lunch) to general. The CHM uses different features of the context to determine habit strength, for example location, time of day, the presence of particular people, and mood (Ji & Wood, 2007). These could relate to either specific situations or a number of different situations, reflecting a more generalised habit. These differences do not preclude consideration of the literature as a whole because they all remain focused on cue-response links. Which measure is used in research will depend on the nature of the specific study design, including how specific the habit of interest is likely to be.

Conclusions

It is possible that the four models represent different types of automatic behaviours, or some of the models may be inaccurate descriptions of any automatic behaviours. Alternatively, it may be possible to combine some of the models. One interesting combination is between the Motivational Contexts Model and the Goal Reliant Model. This would then view habits as associations between situations and actions which operate due to the motivating properties of a reward being transferred onto the cue, but only in the presence of a particular goal. This would occur when a behavioural response to a cue was only performed (and was rewarded) or was only rewarded when a particular goal was active.[5] A significant amount of research will be required to discover which models provide accurate descriptions of automatic behaviours that

[5] Note this would be the closest model to that of occasion setters mentioned above.

develop through repetition, and if a number of models are supported for subgroups of these behaviours, a consensus will need to be reached about which of these is termed habitual.

The aim of reviewing these models was to try to understand how they represent habit formation, and whether they can inform the design of an intervention aimed at creating habits. What is central to all models is that habits are automatic (which implies a lack of thought and conscious intent at the moment of performance) and that they develop through repetition in consistent contexts. I refer to this as the theory of Context Dependent Repetition (CDR). However there are three issues on which they differ: the roles of goals, the importance of rewards, and how habits are related to identity. These three areas will be discussed in the next section, before I focus on how the models help in understanding how to create and break habits.

Debates in the habit literature

Goals

In discussing the models above it was clear that the role of goals is a central difference between them. This has already been described but there is one point which warrants further consideration: how habits develop around a distal goal. When a behaviour is novel, performance must be guided by a conscious proximal goal to perform that specific behaviour (a conscious intention). However the goals considered in the habit models above have been conceptualised as distal to the behaviour. Can these two ideas be reconciled? Although this is not the focus of this thesis, I describe a possible mechanism through which this could occur, for completeness. I describe this in terms of the Goal Reliant Model, but a similar idea could be applied to the Goal Mediated Model.

It is assumed that as a behaviour is repeated a cue-response link is forged. Initially both the proximal and more distal goals are activated on each occasion the behaviour is performed. However with repetition the individual begins to represent the behaviour at a higher level and the proximal goal is no longer activated. Because every time the behaviour was performed the relevant distal goal would have been activated this ultimately becomes a gating mechanism for the cue-response link. This idea fits with the idea that behaviours are conceptualised at different levels when they are repeated. Vallacher and Wegner (1987) argued that when an action is repeated there is potential

for it to become incorporated into a higher order identity than that upon which it was first performed. Although Ji and Wood (2007) found that describing intentions at an abstract level did not change the predictive value of habits on behaviour when intentions were also included in the model, this could be due to a failure to correctly identify the relevant abstract intentions. More work will be required to establish if the proposed model is accurate, whether there is a different explanation for how habits become based on associations with distal goals, or whether models which do not include goals provide a better explanation for how habits operate.

The role of goals in the operation of habits, and the level of these goals, remain unclear. However, even researchers who argue for a non goal-dependent model of habits, agree that goals are relevant to the formation of habits (Wood & Neal, 2007). Goals provide the initial impetus for behaviour until responses have become habitual. However none of the models propose that goals need to be explicitly identified by an individual trying to form a habit, and a behaviour which is repeated in the same situation is likely to be in service of the same goal each time it is performed. Therefore although the role of goals is central to the debate on habit operation it may be less central to a debate on habit formation.

Reward

The role of reinforcement/rewards in both habit development and maintenance of a habit association is unclear. In the behaviourist tradition, habit strength was considered to be a function of repetition only when rewards were received for performing the behaviour upon encountering a cue (Hull, 1943; Hull, 1951); without reinforcement there could be no habits. A number of authors have implied that rewards may only be needed during habit development, to encourage enough repetition of the behaviour until it becomes automatic (Ouellette & Wood, 1998). Similarly, Verplanken and Aarts (1999) argued that because health behaviours often have long-term rather than immediate rewards, self-control may be required in order for sufficient repetition to occur. These arguments suggest habit formation and maintenance can occur without immediate rewards for behaviour, although they may be useful in promoting repetition.

The four models outlined above place different emphasis on the role of rewards. The Direct Cuing Model (cue-response) does not include rewards or reinforcement and habit is viewed as based on repetition alone. The only model that requires discrete rewards to

occur directly after each repetition of a behaviour is the Motivational Contexts Model, which is largely based on animal learning literature. Experiments with animals suggest that rewards are necessary, not only during habit acquisition, but also for continued performance of the behaviour. Although studies have shown that after enough practice a behavioural response to a cue will occur even when the reward is devalued (Dickinson & Balleine, 2002), numerous extinction experiments make it clear that with a sufficient number of trials where a previously conditioned (rewarded) response is no longer rewarded, animals will stop acting in response to the cue (Rescorla, 1993; 1997). Wood and Neal (2007) propose that cues are motivating because of 'a cumulative residue of consistently rewarding responding'.[6] This suggests that the reward for the behaviour does not need to always be the same as long as the behaviour continues to be rewarded in some way.

The Goal Mediated Model (cue-goal-response) considers achieving the goal to be reinforcing. Sheeran et al (2005) specifically made this argument in their discussion of drinking habits and the goal of socialising, suggesting that achieving a goal is reinforcing even when the goal is distal to the behaviour. The Goal Reliant Model is not based on the idea of reinforcement. The evidence that implementation intentions operate through enhanced accessibility of the cue and the strength of the cue-response association shows that a cue-response link can automatically trigger behaviour and therefore suggests that this model does not need to incorporate the concept of reward.

Within the Motivational Contexts Model rewards need to be immediately received after the behaviour is performed. What these rewards may be for free-living humans is unclear, but for the model to operate, they need to be immediate and specific. The Motivated Contexts Model would fit with the idea that it could help someone create a habit to provide them with explicit rewards every time they perform the behaviour. However, even within this model, this is not necessary for behaviours that are inherently rewarding, nor would it be practical to continue to provide the reward in perpetuity for habits to be maintained. In contrast, the other models do not require rewards to be received directly after performance in order for habits either to form or persist. However, in order for the behaviour to be performed sufficiently for it to become habitual it needs to be valued, and this could be due to a variety of reinforcers, e.g. living up to one's own values and beliefs (Verplanken & Wood, 2006).

[6] No page numbers are available for this quote as the paper is currently in press.

Identity

Although not central to the topic of habit formation, it is interesting to note that two directly opposing associations between habits and identity have been proposed. Namely that habits *are* and *are not* associated with identity. Verplanken and Orbell (2003) identified 'incorporation into one's identity' as a feature of habits and included items related to this in the SRHI (e.g. 'that's typically me'). However other studies have suggested that habits are less associated with identity than non-habitual behaviours. Aarts et al. (1997) found that habit was only weakly related to favourability of the behaviour, and Wood et al (2002) showed that people did not think habits were particularly self-relevant, and felt less pride and more negative self-evaluations in relation to habitual behaviours.

Knowledge of the self is often considered to be based on autobiographical episodic memory developed through self-reflection, self-agency, self-ownership and an understanding of oneself as progressing through time (Klein & German, 2004). This fits with the view that habits are not related to identity, because self-knowledge is deemed to be built on conscious thoughts whereas habits occur without thought. However there may be different types of self-knowledge and identity, one related to habitual behaviours and one to non-habitual behaviour. This is supported by findings from functional magnetic resonance imaging. When making self-descriptive judgements, people with high levels of experience in a domain activate neural structures that are associated with automatic social cognition (including the ventromedial prefrontal cortex, basal ganglia, and amygdala) whereas those with low levels of experience activate areas involved in effortful social cognition (including the lateral prefrontal cortex, posterior parietal cortex, and the hippocampus) (Lieberman, Jarcho, & Satpute, 2004). The first has been labelled intuition-based self-knowledge and may be considered distinct from the effortful self-knowledge based on episodic memory.

CREATING AND BREAKING HABITS

Creating Habits

Context Dependent Repetition

I now turn to evaluating how the literature reviewed in this chapter contributes to understanding how to help people to create habits. No research since Hull (1943; 1951)

has specifically examined the habit formation process, despite the potential for doing so provided by the development of the SRHI. Of particular interest, both to individuals wanting to acquire healthy habits and behavioural researchers wanting to promote behaviour change, is how long it takes to form a habit. We do not know the answer to this question for real-life habits in everyday situations.

The models all make assumptions, either explicitly or implicitly, about how habits form. As discussed, the only consistent component of all models is that habits develop through repetition of behaviour in constant contexts (CDR) and that this results in them becoming automatically triggered when the cue is encountered. The models disagree on the role of goals and rewards in the development and operation of habits. From a viewpoint of goal-dependent automaticity, it is assumed that during habit formation the behaviour is repeatedly performed in response to a cue in order to achieve a goal (that was either triggered by the cue or already active) and that this results in the mental associations between these factors. However, it is unlikely that it is necessary for individuals to explicitly identify their own goals when they wish to make a behaviour habitual. Only one model proposes that immediate discrete rewards are required each time the behaviour is performed, and it may be possible that behaviours people want to perform are inherently rewarding. Whether it is possible to promote habit formation without providing explicit rewards is unknown, but the models can be seen to fit with this proposal.

There are a number of other questions relating to how to create habits. One is whether some types of cue are better than others. Prospective memory research indicates that situation cues permit external cueing of an intended action, whereas time of day cues require monitoring to identify the time to act. Ji and Wood (2007) have used 'time of day' as the context in one version of the CHM and found that this was predictive of behaviour. This can be considered evidence that some habits do naturally develop for particular times in the day, however there may be additional cues which trigger the behaviour at that time and the time may be vaguely specified. Therefore although some habits may be time-cued, situations are likely to be easier cues upon which to build a habit.

A second unanswered question is whether when trying to form a habit it is necessary to perform the behaviour every time the cue is encountered. James (1890) argued that

development of habits requires uninterrupted performance, and no exceptions must occur while the habit is developing. In the real world it is unlikely that this occurs and yet people report having many habits (Wood et al., 2002). This suggests that uninterrupted performance is not required, but no research has examined this.

A third question is whether the habit formation process is different for more complex behaviours. Verplanken (2006) has suggested that more complex behaviours achieve lower levels of automaticity. However in his study the number of repetitions was restricted and it is therefore possible that the complex task would have become as habitual as the simple task with more repetitions. Nevertheless, Wood et al (2002) found that complex tasks were associated with more thoughts during their performance than less complex tasks, suggesting they may be less automatic. It has also been suggested that the complexity of a task can determine the 'type' of automaticity which can develop. Wood and Neal (2007) proposed that complex tasks are more likely to be goal directed and therefore do not fall under their definition of habits. Again this remains unresolved.

Although this review highlights the need for research investigating the habit formation process and asking the questions outlined, it also gives a starting point. It provides the hypothesis that recommending Context Dependent Repetition (i.e. that people try to perform the same behaviour in the same situations frequently) could be enough to result in habit formation for behaviours that individuals want to perform.

Creating habits using implementation intentions

It is possible that using planning may speed up the habit formation process. Implementation intentions could influence habit formation by helping people to remember to perform the intended behaviour. They could also speed the process because they create an association between situation and action which mimics the association formed through repetition. Although this association will be strengthened through repetition its initial presence may place an individual further ahead in the process. Orbell and Verplanken (2005)[7] found that when participants repeated a behaviour due to an implementation intention they reported more experiences of habitual control (score higher on the SRHI) than when they performed these actions without the implementation intention. This suggests that due to the automatic operation

[7] Cited in Gollwitzer and Sheeran (2006) as manuscript under review.

of implementation intentions, habit formation is faster when these plans have been formed. How the mode of operation transfers from the intentional goal-dependency of implementation intentions to a habit is a matter for debate.

Some studies have used more general planning instructions and found significant effects, such as Armitage (2004) whose instruction to participants was: "We want you to plan to eat a low-fat diet during the next month. You are free to choose how you will do this, but we want you to formulate your plans in as much detail as possible. Please pay particular attention to the situations in which you will implement these plans." (p320). It is likely this operated by helping participants to think about the barriers and facilitators to them following through with their intentions and may have helped them to remember their intention and exert the necessary self-control to implement their plans. It is unlikely to have resulted in forming the relevant associations between situation and action required for the cue to trigger the behaviour automatically, unless participants form their plans in a more structured way (specifying whe,n where, and how they will perform the relevant behaviours) in response to these less specific instructions.

Breaking habits

Habits are often found to dominate over intentions when the two are in opposition. Webb and Sheeran (2006) showed this in a meta-analysis of studies that changed intention with the aim of changing behaviour. They categorised behaviours using Wood's definition as having the potential to become habitual when they could be performed frequently in consistent contexts. In circumstances conducive to habit formation, intention change was a much weaker predictor of behaviour change than in situations not conducive to habit formation. This highlights the fact that interventions aimed at changing behaviour through changing intentions are unlikely to be successful for behaviours that are performed habitually. And as the work using the RFM shows, people are less likely to attend to this information to change their intentions.

The different models discussed above could result in different approaches to breaking habits. Because the Motivational Contexts Model is based on animal-learning, it can be assumed that animal research on extinction would apply to breaking habits when this model is applied.[8] This research shows that if a response to a cue that was previously rewarded is associated with either no reward or a negative outcome, then with enough

[8] Note Wood does not specifically argue for this understanding of how to break habits.

repetition of this new association the behaviour stops being performed, and in effect the habit is broken. A wide range of studies have shown that extinction is the result of new learning dominating over old, rather than an unlearning of the original association. Therefore both associations remain with one dominating the responding (Bouton, 2004). The difficulty in applying this model to people in real-life situations is that it may be very difficult to remove rewards for behaviours, as they may be inherently rewarding, for example many eating behaviours produce hedonic rewards.

Sheeran et al (2005) discussed how the Goal Mediated Model relates to breaking habits. They argue that blocking (or inhibiting) the link between the goal and the action is critical. However, inhibiting the association between the cue and response, even though this is considered to be mediated through a goal, should also be effective. All the models fit with the argument that blocking the cue-response link should break the habit. However it is unclear how to block this link. Consciously preventing the response from being performed on one occasion is plausible, but permanently removing the cue-response association is improbable, particularly in light of the extinction literature described above. Alternatively if the environment can be controlled so the cue is not encountered, the response will not be triggered.

Breaking habits by changing the environment

There is a good deal of evidence that when people's lives change, habits are likely to be broken (e.g. Wood et al., 2005). This has been found in people's own stories of successful life changes. Heatherton and Nichols (1994) used content analysis on 119 stories of successful or failed behaviour-change. Of the successful changers, 13% had 'altered the immediate environment' and 36% had 'moved to a new location', whereas for failed changers none had 'changed their immediate environment' and only 13% had 'moved to a new location'. Times of change might be a potentially useful opportunity to target information-based interventions to encourage people to develop different habits in their 'new' life. However people also want to change their habits when they are not encountering a life change.

One approach used in behavioural interventions is stimulus control: teaching individuals how to choose their environments so that exposure to triggers of unwanted behaviours is deliberate, not accidental (Wadden & Phelan, 2002a). It involves people identifying triggers to behaviour, and working out how to control their exposure to these cues or

how to avoid the cues. This approach therefore requires significant self-control on the part of the individual, but is likely to be easier than exerting self-control once the cue has been encountered.

An alternative way in which environments can be changed, to diminish exposure to cues that trigger undesirable behaviours, is at a public health level. For example, taxation on unhealthy products or city planning to encourage physical activity often involve altering the environment to remove the cues for unhealthy habits (Verplanken & Wood, 2006). However, even if changing the environment may be an effective way of stopping habits from being performed, it is often difficult to achieve. There are some aspects of people's daily lives for which it would be impractical to suggest this approach.

Breaking habits using self-control

The importance of self-control has been shown in two studies. Firstly, as discussed above, when self-control was reduced, habits were performed but non-habits were not (Neal and Wood, 2006)[1]. Secondly, Aarts and Dijksterhuis (2000a) primed participants to think about the goal of travelling and then asked them to name a travel mode after being presented with a destination. Some participants were asked not to respond with their usual travel mode. They found that habitual actions were harder to suppress than non-habitual actions and that suppression of habitual responses was harder under cognitive load (when participants had to perform a second task as well). This suggests that people can override habits if they have the self-control capacity available to do so.

Quinn, Pascoe and Wood (2007)[9] assessed spontaneous change attempts in a diary study. Participants reported when they tried to change a response and how they tried to do this. When change involved inhibiting a response participants were more likely to report prevention strategies (involving monitoring for triggers, control so that unwanted responses are not performed and focusing on negative outcomes of the response). Participants were more successful in inhibiting unwanted responses when they used prevention compared to promotion approaches (seeking solutions and approaching desired outcomes). This shows again that it is necessary to be vigilant and monitor one's behaviour to control habitual responses.

[9] Referenced as an unpublished manuscript in Wood et al (2007)

Mindfulness is an individual difference variable which characterises the clarity and vividness of current experience (i.e. how much attention an individual pays to the present) and has been argued to affect the relationship between habits and intentions. Chatzisarantis & Hagger (2007) showed that binge-drinking habit strength was predictive of physical exercise behaviour among those low on mindfulness, but not those high on this measure. This suggests that some people are more able to exert the self-control required to overcome habits, than others. Unfortunately, this evidence would have been stronger if the habits examined were for the behaviour outcome of interest. In this study those who were mindful may have performed their habits of binge drinking but also exerted the necessary self control to exercise despite the physiological consequences of their drinking. This would then not prove that they can control habits but that they can control other behaviours in difficult situations.

Although it is possible to stop a habitual response from being performed through self-control, the animal learning literature on extinction shows that new learning does not overwrite the original learning and therefore the original cue-response association remains intact (Bouton, 2004). It would be logical to assume that for a new association between the old habit cue and a non-response to be stronger than the original cue-response association the non-response would need to be repeated at least as many times as the response had been, so that it is more likely to be retrieved from memory when the cue is encountered. This would require self-control being exerted for a long time to break a habit. An alternative to learning not to perform the behavioural response to the cue could be to perform an alternative behaviour, although self-control would still be required until the link between the new behaviour and the cue was stronger than the old behaviour and the cue. Although, the learning processes in extinction and counterconditioning have been argued to be similar (Bouton, 2000), whether learning a link for a new behaviour is easier than learning a link for non-behaviour is an empirical question that we do not currently have an answer to.

Breaking habits using implementation intentions

A recent meta-analysis (Lion & Webb, 2007) found that for food-related behaviour the average effect size of implementation intentions on behaviour was d=0.30. This is lower than that found by Gollwitzer and Sheeran (2006) across a range of behaviours (d=0.65). The authors suggest this may be because food-related behaviours are more likely to be habitual than other behaviours. Implementation intentions may have less

success in promoting new behaviours when they are competing with established habits than when a behaviour is novel. Although this suggests implementation intentions may not be able to disrupt established habits, some authors have still suggested that implementation intentions may be useful in breaking habits. It has been argued that through forming plans to initiate and implement a new behaviour in response to a cue, people may be able to implement new responses and suppress old ones (Chatzisarantis & Hagger, 2007; Ouellette & Wood, 1998; Verplanken, 2005). However none of these authors explain why a newly formed association developed through making a plan would dominate over the habit association that had been established through repetition.

Two studies found that implementation intentions had no impact on habitual behaviours. The first showed that participants were faster at responding to the word bicycle as a realistic means of travelling to a number of destinations if they had formed implementation intentions, but only when they did not have a bicycle use habit (Aarts & Dijksterhuis, 2000b). The second found that forming implementation intentions to eat healthily for one day out of the following five influenced positive dietary intake over the next five days, but this was independent of the impact of unhealthy eating habits, implying participants changed their diet in other ways (Verplanken & Faes, 1999).

Implementation intentions may be able to affect habitual responding if they help people to exert the necessary self-control over their behaviour. Bamberg (2000) showed that habits for a travel mode other than public transport did influence whether participants succeeded in trying a new bus route over a week, having committed to doing so, but that this was only within those who had not formed implementation intentions to use the bus. It is possible this effect was due to participants who formed implementation intentions exerting sufficient self-control to override their habits and remembering to do this on a specific day because they had made plans to do so.

Support for the argument that implementation intentions can help overcome habits when self-control is exerted is found in a laboratory study testing routinized decision making (Betsch, Haberstroh, Molter, & Glockner, 2004). In this study, a low level of repetition was used so that the behaviours had not yet become habits. Participants often chose their routinized option (repeatedly chosen before) even when they had formed an implementation intention to act otherwise. Participants were encouraged to be accurate as they were paid based on performance. When not under pressure, 70% of participants

were able to override their routine response, in comparison to 30% when under time pressure. It is likely that fewer people would have succeeded in overriding their routines if the routines had been repeated more. The impact of time pressure suggests that the implementation intentions were working through self-control rather than through an automatic link which was stronger than that developed through repetition.

Sheeran et al. (2005) suggested that an implementation intention focusing on how to avoid performing a habit (e.g. that addresses how you would refuse a drink), might work towards breaking the link between a goal and action (e.g. socialising and drinking). This is a slightly different approach as the plan would be about how not to perform the habitual response rather than to perform an alternative action in response to the habit cue. Webb et al. (2006)[10] found that implementation intentions about what to do in difficult situations reduced the number of cigarettes smoked per day, although only in those with a weak habit. Therefore this more direct approach has not yet been shown to affect habits.

In summary it has not yet been shown convincingly that implementation intentions can be used to break habits beyond helping people to exert self-control over their behaviours. Nor is it clear theoretically how it would be possible to make these newly formed associations dominate over established associations developed through repetition.

SUMMARY AND CONCLUSIONS

I approached this review with the aim of investigating how to create habits. Although I found no literature since Hull specifically focusing on this question, the review presented does provide a starting point for investigating this. In bringing the literature together it has been important to consider the different models and measures researchers have used to address this topic. Despite these differences it is possible to view the findings on habitual behaviour as a whole and to find a number of points on which different researchers agree.

[10] Cited in Verplanken and Wood (2006) as a working paper.

The various studies have shown that habits are common in everyday life and control many behaviours. Although habits and intentions are frequently in agreement, when they are opposing, habits often dominate. Habits can be controlled if enough self-control is available but are difficult to suppress when self-control is depleted. When people have strong habits they are less motivated to engage in decision-making about their choices, and access and use less information to make decisions. This is strong evidence that social cognition models such as the Theory of Planned Behaviour (Ajzen, 1991) can be applied better to behaviours which are not yet habitual, and that interventions aimed at changing behaviour through targeting intentions will have greater success for non-habitual behaviours.

What mechanisms operate to produce habitual responses remains unresolved and there may be different subgroups within the category of automatic behaviours which develop through repetition, that operate in different ways. In this thesis automatic behaviours which develop through repetition are all considered to be habitual. Central to all models is that habits are formed through Context Dependent Repetition (CDR). To create a habit, people need to repeat a behaviour in a consistent context. Whether it is necessary to provide explicit rewards each time the behaviour is performed is unresolved.

The easiest way to break habits is to remove the cues that trigger them. The alternative is to exert self-control to stop the cued response and possibly to perform an alternative behaviour. Although it has been suggested that implementation intentions could be used to form a new link with the same cue, how to make this the dominant response has not yet been established.

Despite the fact that behaviour change interventions aim to establish behaviours that will be maintained long-term, and therefore there is significant potential in specifically aiming to form habits, to date no studies have explicitly attempted to do this. What advice people need in order to help them develop habits, remains unanswered. I have argued that it may be possible to simply recommend Context Dependent Repetition, but this needs to be tested. Another interesting question is whether directing people to form new healthy habits will result in them exerting sufficient self-control over unhealthy habits to 'break' these and to establish the new healthy alternatives as habits. In this thesis I investigate the potential of using the habit concept in a weight loss intervention, as well as examining the habit formation process in more detail. In Chapter 2 I discuss

weight loss interventions and in Chapter 3 I outline the studies which are reported in this thesis.

CHAPTER 2
WEIGHT CONTROL

WEIGHT CONTROL

Obesity

The World Health Organization (1999) estimates that over 1 billion people globally are overweight and this is set to increase to 1.5 billion by 2015. In England in 2003 43% of men were overweight and another 22% obese, while among women 33% were overweight and 23% obese (Zaninotto, Wardle, Stamatakis, Mindell, & Head, 2006). These findings are based on the widely used measurement of overweight and obesity, Body Mass Index (BMI) which is calculated as weight (kg), divided by height (in meters) squared. A BMI between 25 kg/m^2 and 30 kg/m^2 is classed as overweight and 30 kg/m^2 and over is obese. A higher BMI is related to increased risk of cardiovascular disease, stroke, type 2 diabetes, some cancers, osteoarthritis, gallbladder disease, respiratory problems, sleep apnea, and ultimately mortality (Visscher & Seidell, 2001; Racette, Deusinger, & Deusinger, 2003).

The obesity epidemic has been attributed to the 'toxic' environment (Wadden, Brownell, & Foster, 2002) which discourages physical activity and encourages consumption of large portions of food, particularly foods which are high in fat and sugar. These environmental factors override homeostatic mechanisms linking energy intake to energy expenditure and create an energy imbalance that causes weight gain. This may be because humans have evolved to store energy in times of plenty in order to survive famines, and now find it difficult to adapt to the current food environment in which food is abundant and inexpensive.

One approach to tackling the problem of obesity would be for policy initiatives to alter the environment (Horgen & Brownell, 2002; Wadden et al., 2002). However because many of the features of the environment which promote obesity also make people's lives easier in many other ways, it is unlikely there will be popular support to remove them all (Hill, Catenacci, & Wyatt, 2005). This makes it important to continue to discover how to help individuals regulate their own behaviour in order to control their weight. Ideally these two approaches will ultimately complement one another and

individuals will approach the task of self-regulation in an environment that is more supportive of weight control behaviours.

Weight losses of as little as 5-10% of initial body weight have been shown to reduce the risk of a number of obesity-related illnesses including diabetes (Lindstrom, Peltonen, & Tuomilehto, 2005; Knowler et al., 2002), hypertension (Stevens et al., 2001), and risk factors for cardiovascular disease (Blackburn, 2002). Associations have also been found between weight loss and a reduction of some cancers (Parker & Folsom, 2003). Weight loss interventions are therefore often evaluated as successful or not based on the proportion of participants who have or have not succeeded in a reducing their weight by 5-10% (for example Foster et al., 2004; Gardner et al., 2007; Tate, Wing, & Winett, 2001; and Wadden & Phelan, 2002b).

Clinical weight loss programmes

Although pharmacotherapy and surgery are important treatment options (Padwal, Li, & Lau, 2003; Colquitt, Clegg, Loveman, Royle, & Sidhu, 2005), this thesis focuses on interventions aimed at helping individuals change weight-related behaviours to improve weight control. The literature covering weight loss interventions is vast and this chapter will review only the studies that are particularly relevant to the research reported in the following chapters. However it is important to begin with a brief discussion of clinical weight loss programmes, as these are the most widely researched treatments. These types of intervention teach patients how to achieve eating and exercise goals using a range of strategies (Wadden, Butryn, & Bryne, 2004; Cooper, Fairburn, & Hawker, 2003). They usually encourage a reduction in energy intake of 500 to 1000 kcal a day through reducing portion sizes and fat and sugar intake. Regular meetings focusing on how to meet eating and activity goals and homework tasks are central components. Strategies used often include stimulus control (identifying triggers for eating and negotiating goals to avoid acting on these), reinforcement, social support, self-monitoring (food diaries), problem solving, goal setting, cognitive restructuring (realistic weight loss goals, challenging self-defeating thoughts), and relapse prevention (planning how to prevent lapses, listing coping strategies) (Cooper et al., 2003). The programmes are usually delivered in groups, both because this is more economical and because there is some evidence that group treatment is more successful than individual (Wadden & Butryn, 2003).

Weight loss programmes including the combination of diet and exercise advice and behaviour therapy, and lasting for 16 to 26 weeks, have been found to result in an average weight loss of 10 kg, equivalent to 10% of initial weight after 30 weeks from programme initiation (Wadden et al., 2004). However, despite this initial success most people who lose weight regain it over time (Shaw, O'Rourke, Del, & Kenardy, 2005). Diet and behaviour therapy (compared to no treatment) results in a weighted mean difference of 7 kg after a year, which is reduced to only 2 kg at two years (Avenell et al., 2004). To put this another way, those treated for 20 to 30 weeks regain 30-35% of their lost weight in a year (Wadden et al., 2004) and by 5 years 50% of patients have returned to their baseline weight (Perri & Corsica, 2002).

Longer treatment programmes appear to be more effective for maintenance of weight loss. Perri and Corsica (2002) reviewed 13 studies involving long-term treatment (an average of 41 maintenance sessions over 54 weeks), and found that participants maintained 10.3 kg of an average 10.7 kg loss over this one-year of treatment, which is a significant improvement on the usual weight regain observed. However there is concern that prolonged treatment may only delay rather than prevent weight regain (Perri et al., 1988; Perri et al., 2001; Perri, McAdoo, McAllister, Lauer, & Yancey, 1986).

A high level of motivation and commitment is required to join and complete a behavioural programme and therefore retention of participants in clinical programmes tends to be low. Weight loss research correspondingly suffers from attrition. Across studies on average, 32% of participants drop out (Davis & Addis, 1999), a finding that has not improved over the last 20 years (Goldberg & Kiernan, 2005). Additionally, drop out is higher for longer term treatment (Wing, Venditti, Jakicic, Polley, & Lang, 1998). Therefore, although some authors have argued for a chronic disease model of obesity with continued behavioural support (Latner et al., 2000), this will only help those who continue to attend and other strategies are needed to re-engage the dropouts.

Research into obesity treatment is usually conducted in academic medical centres. Such intensive lifestyle interventions attract self-selected motivated participants and may not be as appropriate for most of the overweight and obese adults in the population (Foster, Makris, & Bailer, 2005). Therefore there is interest in low-cost but effective treatments that involve less contact with health professionals and can be disseminated on a large

scale to meet the growing need for intervention (Berkel, Poston, Reeves, & Foreyt, 2005; Wadden et al., 2004).

Prevention of weight gain

Looking at the obesity epidemic from a public health perspective has led to a call for a shift in focus from weight loss to prevention of weight gain (Hill, Wyatt, Reed, & Peters, 2003). This is based on the argument that reducing the numbers of overweight and obese people in the population through treatment alone is unachievable, and a more important aim is to halt weight gain and reduce incidence of new cases. It is possible to calculate, based on population level data on increases in weight over time, the amount of change in energy balance that would be required to prevent weight gain. Mean annual weight gain over time in the population is small and Hill (2003) calculated that in order to reach energy balance among 90% of the population, people need only reduce their intake or increase their expenditure (or a combination of the two) by 100kcal a day.

Hill's calculations were based on data from 20 to 40 year olds in the US. A recent study has applied a similar formula to data was 45-55 year old women in Australia and suggested that the positive energy accumulation is as little as 10kcal a day (Brown, Williams, Ford, Ball, & Dobson, 2005) within this group. Whatever the exact value of the energy imbalance the argument that relatively small changes could prevent weight gain is interesting, but it is important to raise the question of why, if it is so easy, aren't people doing it. Hill (2003) suggests two behavioural approaches to tipping the energy balance; increasing life-style physical activity and reducing portion sizes. A small number of intervention studies that have attempted to target weight gain prevention are discussed shortly.

LOW INTENSITY WEIGHT CONTROL INTERVENTIONS

In order to give an appropriate context to the work which will be presented in this thesis, a review of low-intensity weight control interventions is given here. This focuses on non-medical (i.e. not involving provision of food or meal replacements, prescription medication or surgery) interventions with adults where the intervention is designed to be delivered with minimal or no contact with health professionals, with

weight change as the outcome. Some of the studies discussed involved more health professional contact than would be used if the interventions were disseminated on a wider scale, but it is interesting to consider these 'best case scenario' results. Studies of commercial weight loss programmes are included because these are a readily available option for members of the public and therefore of interest.[11]

As discussed above, there are two different targets of weight control programmes[12]; weight loss (for those who are overweight and obese), and prevention of weight gain in the population as a whole, or in subgroups of the population. Low-intensity interventions have focused on both, but the reality is that the behaviours they promote are often similar and could result in either outcome depending on the characteristics of the individual at the start of a study, and the intensity of the change. For example when the recommendation is to perform certain behaviours, someone who is already performing these behaviours at the start of a study may succeed in avoiding weight gain, whereas someone who, prior to the study was performing many unhealthy behaviours, may lose weight.

Weight loss interventions

A number of different approaches have been taken to designing low-intensity weight loss interventions. The types of intervention described in this section include those based on written materials (often in the form of a manual) provided alongside differing levels of health professional input, Diet Books (e.g. Atkins), commercial weight loss programmes (e.g. Weight Watchers), and internet interventions.

Written materials with brief health professional support

A number of studies have assessed the impact of brief advice from health professionals alongside written information (Table 2.1). A recent Italian study investigated the impact of a 15-minute personalised nutrition education delivered by a GP (Sacerdote et al., 2006). It was based around a brochure which summarised the Italian guidelines for correct nutrition and recommended a diet high in fruit and vegetables, fish, and olive oil, and was personalised based on the sex, age and dietary habits of each patient. A

[11] However a recent study of the Jenny Craig programme (Finley et al., 2007) is not discussed as this programme provides participants with pre-packaged food and is therefore considered to provide a different level of intervention.

[12] Some research has also focused on maintenance of weight loss however low-intensity interventions rarely focus on those who have already lost weight, and therefore maintenance interventions are not included here.

control group were given simpler non-personalised information without a brochure. This intervention was aimed at reducing risk factors for chronic diseases, including placing BMI in the healthy range (under 25 kg/m^2), and was intended for patients who were not obese (although a small number with BMI over 30 kg/m^2 were included, 84% of participants had a BMI between 25 kg/m^2 and 30 kg/m^2). This was a large study with a low drop-out rate, and showed a BMI change equivalent to approximately a 1 kg weight loss over a year. This was significantly different from those in the control group who lost no weight. The proportion of participants with a BMI of less than 25 kg/m^2 increased by 1.3% in the intervention group, compared to 0.1% in the control group.

A second Italian study examined the impact of an 18-week guided self-help programme for weight loss (Dalle Grave, Todesco, Banderali, & Guardini, 2004). This used a self-help manual based on cognitive-behavioural principles, the title of which translates to 'Losing weight without losing your mind'.[13] Guided self-help involved nine 20-minute bi-weekly sessions with health professionals who received minimal training in treating obesity. Their role was to support the participants as they went through the programme outlined in the book. A second group used minimal guided self-help where they used the manual and received nine bi-weekly 5 minute check-up phone calls from the health professionals. A waiting list control group received the book after 18 weeks. An intention-to-treat analysis using baseline values for missing data showed a weight loss of 3.5 kg in the guided-self-help group, and 2.2 kg in the minimal self-help group, compared with a gain of 0.3kg in the control group at 18 weeks. This was significantly different between the control group and both intervention groups. Those in the intervention groups maintained this weight loss for a further six months (weight change from baseline was 3.9kg and 2.2 kg in the guided and minimal groups respectively). The two intervention groups were significantly different at follow-up when the outcome considered was the number of participants who had been able to reduce their weight by 5% at 6 months; 33% of the guided group had achieved this compared to 15% of the minimal contact group. This suggests that the health professional input had an additional effect.

At the University of Minnesota, a research team have conducted a number of community weight control studies (Jeffery, 2001). One was a study of a telephone-

[13] This manual covers self-monitoring, planning, stimulus control, problem solving, realistic weight loss goals and maintenance.

based intervention (Hellerstedt & Jeffery, 1997), although the experimental group of interest here is the group without any telephone contact. All participants received the same treatment for the first 2 weeks of the study. They attended two 1 hour group sessions of behavioural weight-loss education delivered by a health educator.[14] They were also given a weight-loss manual with details of the topics covered in the meetings, 6-months of food and exercise diaries, menu plans and the telephone number of a study nutritionist to use if they needed individual counselling at any time during the study. One group (minimal-contact) received only this and no further contact (three calls were received from participants in this group over the 6 months) and the other two groups received phone calls during the study. Weight loss was not significantly different in the three groups, and the largest weight loss (5.8kg) was in the minimal-contact group. It is not clear why this group should do better than those who received additional support, but as this was a small study this may be due to chance.

Two earlier studies have shown significant weight loss with minimal health professional contact. In a study of a correspondence program based at the University of Minnesota, invitations to participate were posted to all households in a suburb of Minneapolis and 1304 signed-up for the intervention (Jeffery, Hellerstedt, & Schmid, 1990). Two thirds of households were offered a newsletter-only programme ($5 enrolment fee) and one third a newsletter-plus-incentive programme (a $60 incentive deposit which was refunded when participants had succeeded in weight loss: based on a self-defined goal of less than or equal to 4lb a month). This was a 6-month programme and participants were given a self-help manual, monthly newsletters and a return postcard on which they reported their weight, diet and exercise habits. The newsletters contained information on behaviour change strategies, motivational testimonials from successful weight losers and tips (e.g. recipes). Interestingly five times more of those offered the newsletter-only scheme chose this in comparison to the newsletter-plus-incentive programme. A sample of participants from each programme was telephoned to report success at 6 months and a smaller sample were weighed at baseline and at 6 months to give values to adjust the self-reported weights. Weight loss (using adjusted values) at 6 months was 2kg in the newsletter-only group and 4kg in the incentive group. This shows that the incentive gave additional benefit but as fewer people were interested in this approach it shows less potential as a public health intervention.

[14]This covered reduction of calorie intake, regular exercise, stimulus control, relapse prevention and a focus on monitoring.

A second study with a low level of professional contact tested a workbook-based programme (Miller, Eggert, Wallace, Lindeman, & Jastremski, 1993). Participants attended one-hour briefings where they were given a workbook which detailed a behavioural monitoring programme, diet and exercise without severe restrictions on energy intake. Monitoring was based on daily completing of a self-monitoring sheet which awarded points for achieving different behaviours (e.g. 4 points were awarded for having no refined sugar and 2 points for having low-fat dairy products). The workbook described how to use the monitoring sheet and create a prescription of diet and exercise. It also covered further monitoring techniques and justification for the behaviours outlined in the book. In the initial meeting the importance of following the guidelines was emphasised. Those in the intervention group who completed the study lost 8.1kg over six months compared to the control group whose weight remained stable. This is an impressive result, although if we assume that those who dropped-out did not change weight during the study, this is reduced to 5kg, a loss more in line with the other studies reviewed here.

One recent study found much lower levels of weight loss. This study used written information without health professional support as a control condition to compare against a cognitive behavioural group intervention and an individualised dietetic intervention (Ash et al., 2006). The booklet was a nutrition resources booklet based on cognitive therapy principles. Those in the booklet group lost 1.4 kg at 3 months, reducing to 1 kg at 6 months and 0.5 kg at a year in an analysis including only people who completed each assessment.

These studies varied in the written materials used and the amount of health professional support participants received, and the characteristics of the people who chose to participate. Table 2.1 presents the main characteristics of these studies. Together they suggest that these types of interventions can be effective, but as reports rarely give detailed information on the content of either the written information or the health professional support provided it is difficult to assess which components of these interventions produce weight loss. In addition some of these studies were small and need replication in larger samples. Therefore it is currently not possible to predict the levels of weight loss which can be expected when individuals use interventions that involve written materials and brief health professional support.

Table 2.1: Written materials with brief health professional support

Study	Participants	Follow-up	Drop-out	Recruitment method	Intervention	Completers weight loss	Intention to treat weight loss	Intention to treat method used	Control Group weight change
Sacerdote et al (2006)	N=3186 ~85% BMI 25-30 ~50% male Average age 44	12 months	7%	All patients visiting GP for reasons unrelated to gastrointestinal problems and without dietary restrictions	15 minute nutrition education from GP and brochure about nutritional guidelines	0.41BMI points, estimated weight loss of 1.2 kg for men and 1.1 kg for women[1]	Not given.		0kg
Dalle Grave et al. (2004)	N=161 Average BMI 34 11% men Average age 36	18 weeks[2]	45%	Newspaper advertisements	Self-help manual either with bi-weekly meetings with professionals (guided) or bi-weekly check-up phone calls (minimal)	Not given	3.5kg guided self-help 2.2 kg minimal self-help	Baseline values carried forward	0.3kg gain
Hellerstedt & Jeffery, (1997)	N=64 Average BMI 31 Average age 41 Over 90% female	6 months	14%	Newspaper advertisements	2 one-hour group sessions on weight-loss and weight-loss manual. One group no further intervention (minimal contact), 2 other groups received telephone counselling	3.7kg in one phone group, 3.4 kg in second phone group and 5.8kg in minimal-contact group	Not given.		N/A
Jeffery et al., (1990)	N=203 is weight loss analysis. Among all those in the programme: (N=1304): Average BMI 28 Age: ~60% over 45 ~67% female	6 months	N/A	Invitations to all households in a suburb of Minneapolis	Self-help manual plus monthly newsletters. Alone or plus incentive ($60 deposit refunded upon successful completion)	2kg in newsletter only group and 4kg in newsletter + incentive group	N/A		N/A

Study	Participants	Follow-up	Drop-out	Recruitment method	Intervention	Completers weight loss	Intention to treat weight loss	Intention to treat method used	Control Group weight change
Miller et al. (1993)	N=53 in the intervention and 10 in the control Average weight 97kg Average age 44 56% men	6 months	35% (1 participant from the control group)	Not given	One-hour briefing and a workbook focusing on monitoring behaviours	8.1kg	Not given.		0kg
Ash et al. (2006)	N=54 in the group of interest Average BMI 36 Average age 47 20% male	3, 6 and 12 months	56%	Hospital referrals and newspaper advertisements	Nutritional resources booklet based on cognitive therapy principles	3months: 1.4kg 6months:1kg 12months:0.5kg	Not given.		N/A

[1] Actual weight loss was not reported in this publication and therefore an estimate is reported. Average height in Italy for men is 1.72m and women is 1.62m (Cavelaars et al., 2000). Weight change was estimated by multiplying height squared by BMI change.
[2]The weight loss was maintained in the intervention groups at 6 month follow-up.

'Diet' Books

Written information is also the basis of many well-known 'diets' for weight loss. A number of studies have tested their impact, with some comparing within these types of written information, and others comparing them with commercial programmes such as Weight Watchers (Table 2.2). One programme included in a number of these studies is the LEARN programme (Brownell, 2000). This is a 243 page, self-help weight loss manual. It involves a 16 lesson step-by-step guide to changing eating, activity behaviours and thoughts. It recommends a 1200-1500 kcal diet of conventional foods (fitting with nutritional guidelines) and covers various cognitive-behavioural techniques[15] and is therefore similar to some of the manuals included in the previous section.

One study which gives information on results using the LEARN programme has tested the impact of brief counselling alone in comparison to the impact of the weight-loss drug Orlistat and the combination of the two (Poston et al., 2006). Participants in the brief counselling condition attended monthly meetings of 15-20 minutes with a nurse or dietician and were given the LEARN manual. The monthly meetings involved participants signing a behavioural contract agreeing to make one behavioural change each month. The number of calories needed per day was calculated and participants were given individualised dietary instruction. Food and exercise diaries were encouraged. At each follow-up session, problem-solving and individual goals were discussed. In the conservative intention-to-treat analysis used, the average weight change was a gain of 1.7kg for the 85 participants in this group after 12 months. However, as only 33% of the participants in this group provided data at 12 months and the intention-to-treat procedure assumed a gain in weight once participants left the study, this is a pessimistic estimate. The 33% who remained had an average weight loss of 2.4kg.

The LEARN programme has also been compared with three other diet programmes (Gardner et al., 2007); Atkins (very low carbohydrate), Zone (low carbohydrate), and Ornish (very high carbohydrate) in a study with a relatively high level of health professional input. Participants were randomised to receive one of the four diet books, and each group attended one hour classes led by a dietitian each week for 8 weeks.

[15] The LEARN manual covers stimulus control, cognitive restructuring, self-monitoring, stress management, relapse prevention, preparation, planning and goal setting.

Participants had telephone and email contact with staff for the remainder of the 12 month study. A range of behavioural techniques were discussed in the classes, based on the material in the books. The Orish and Zone books discuss stimulus-control but do not emphasise behaviour modification whereas the Atkins and LEARN books include many different behavioural techniques e.g. planning and relapse prevention. LEARN has the most emphasis on these. An intention-to-treat analysis using baseline values when data were missing showed a mean 12-month weight loss of 4.7kg in the Atkins group, 1.6kg in the Zone group, 2.2kg with those using the LEARN manual and 2.6kg with the Ornish diet. The only significant difference was between the Atkins and Zone groups.

Although the above results are interesting, the impact of the diets can not be separated from that of the health professional support received. Foster et al (2003) compared the Atkins diet and the LEARN programme keeping professional contact to a minimum to replicate as closely as possible the way in which these books would be used by most dieters. Participants met with a dietitian at baseline, 3, 6 and 12 months for 15 to 30 minutes. Both groups were given a copy of the book relevant to their diet and asked to follow its advice, which was also discussed with them in the meetings. In an intention-to-treat analysis similar to that used by Gardner et al (2007), those in the Atkins group lost 7% of their initial weight at 6 months and 4.4% at 12 months, and those in the LEARN group lost 3.2% at 6 months and 2.5% at 12 months.[16] The groups were significantly different at 6 months but not at 12 months. As this study found similar 12-month weight losses as the previous study, without the extra contact with health professionals, this suggests the contact it is not required to aid weight loss. However direct tests of the impact of extra professional support would be helpful, as well as an assessment with no support.

One study compared four different diets, focusing on the dietary advice while keeping all other features constant (Atkins, Ornish, Weight Watchers and Zone[17]) (Dansinger, Gleason, Griffith, Selker, & Schaefer, 2005). Participants were asked to follow the diet to the best of their ability for two months (during this time they attended four 1-hour

[16] As the average weight of participants at baseline was 98kg, these percentage weight losses can be read as approximately equivalent to weight loss in kg.

[17] Atkins group aim for less than 20g carbohydrate daily, increaseing gradually to 50g. Zone aim for a 40:30:30 balance of carbohydrate, fat and protein respectively. Weight Watchers aim to keep points in a range determined by their current weight, each point is approximately 50 calories, and most aimed for between 24 and 32 points a day. Ornish aimed for a vegetarian diet with 10% calories from fat.

group meetings) and after this to follow their diet as they chose based on their own motivation. They were provided with the rationale, written-materials and official diet cook-book for their assigned programme. They were all advised to take a multivitamin daily and to do 60 minutes of exercise a week. The group sessions reinforced the diet messages and addressed barriers to adherence. There was no significant difference between the diet groups in weight loss at one year. In an intention-to-treat analysis with baseline values carried forward, the weight losses were 2.1kg, 3.2kg, 3kg and 3.3kg for the Atkins, Zone, Weight Watchers and Ornish groups respectively. There was a non-significant trend for those following the more extreme diets (Atkins and Ornish) to drop-out more than those following the less extreme diets. Adherence significantly decreased over the course of the study, and after 1 year, only 25% had a level of adherence considered to be clinically significant. There was a strong relationship between adherence and weight loss. In this study men lost more weight than women (3.3 kg in men and 2.4kg in women at 12 months), but this was not a significant difference. Weight loss using the Atkins diet in this study was less than in the previous two discussed. This may be partly due to the specific instruction in this study for participants to use the diet in accordance with their own interest level after the initial two months.

Table 2.2 presents the details of these studies. Together they show that giving interested volunteers any of these 'diet' books with some level of health professional support can result in weight loss of approximately 2-3kg in analyses that include all those who start a study and assume no weight change in those who drop-out, and up to 5kg in those who continue until 12 months. However, the lack of no treatment controls is a limitation of these studies. The first study discussed, where brief counselling with the LEARN manual was compared with a weight loss drug, showed the lowest levels of weight loss. Although not stated to be the case, participants should have been informed of the different interventions they might be randomised to when they agreed to participate in the study. The lower levels of weight loss could therefore reflect disappointment on the part of participants that they had not been offered drug treatment. Weight loss changes between different diet groups in the early stages appear to reduce over time (Gardner et al., 2007).

Table 2.2: 'Diet' Books

Study	Participants	Follow-up	Drop-out	Recruitment method	Intervention	Completers weight loss	Intention to treat weight loss	Intention to treat method used	Control Group weight change
Poston et al. (2006)	N=250 Average BMI 36 Average age 41 95% female	12 months	46%	Pre-screen questionnaires sent to all those who requested information about the study	Brief counselling and LEARN Orlistat Orlistat and brief counselling and LEARN	Brief Counselling: 2.4kg Orlistat: 3.4kg Both: 4.0kg	Brief Counselling: 1.7kg gain Orlistat: 1.7kg Both: 1.7kg	Assumed an increase of 0.3kg a month after last visit	N/A
Gardner et al. (2007)	N=311 Average BM I 32 Average age 41 women	12 months	20%	Media advertisements	LEARN Atkins Zone Ornish	Not given	LEARN: 2.2kg Atkins: 4.7kg Zone: 1.6kg Ornish: 2.6kg	Baseline values carried forward	N/A
Foster et al (2003)	N=63 Average BMI 34 Average age 44 32% male	12 months	41%	Not given	Atkins LEARN	Atkins: 7.3% LEARN: 4.5%	Atkins:4.4% LEARN: 2.5%	Baseline values carried forward	N/A
Dansinger et al. (2005)	N=160 Average BMI 35 Average age 49 81% women	12 months	42%	Newspaper advertisements	Atkins Zone Weight Watchers Ornish	Atkins: 3.9kg Zone: 4.9kg Weight Watchers: 4.6kg Ornish: 6.6kg	Atkins: 2.1kg Zone: 3.2kg Weight Watchers: 3.0kg Ornish: 3.3kg	Baseline values carried forward	N/A

Commercial weight loss programmes

Although the findings of the studies above are interesting, they all involved the input of health professionals in addition to the popular diet books. One UK-based study compared several popular diets for the BBC television programme 'Diet Trials' and tested these as they would be used by members of the public. The four diets were Weight Watchers (an energy controlled diet with weekly group meetings), Rosemary Conley (a low-fat diet with weekly group exercise classes), Dr Atkins Diet Revolution (a book) and Slim-Fast (2 meal replacements per day and a support pack). At six months, weight loss (using an intention-to-treat analysis with baseline values carried forward for missing values) in the four groups was 6kg in the Atkins diet, 6.6kg in the Weight Watchers group, 4.8kg in the Slim-fast group and 6.3kg in the Rosemary Conley group. The control group gained 0.6kg. There was no significant difference between the diet groups. At 12 months just over half the original sample returned for assessment and many had changed diet or stopped dieting. More participants in the group based diets had continued with their assigned diet than those in the unsupported diet groups. Within those who stuck with their allotted diet, weight losses at 12 months were 9kg, 9.1kg, 10.7kg and 10.9kg respectively, but the numbers of participants in this analysis were very small (N=9,20,9,20 respectively). As this study was conducted for a TV programme, participants were likely to have been motivated by TV interest and as a result adherence may have been better than in usual circumstances.

A small number of other studies have assessed the Weight Watchers programme. Weight Watchers is a behaviourally-orientated, weight loss programme that includes specific advice on behaviour and nutrition changes, group support, weekly weigh-ins and incentives for good performance. Four week changes in weight among a group of women given coupons to attend Weight Watchers classes was found to be 1.9kg which was significantly different to the 0.8kg weight loss in a group who were asked to try to lose weight on their own (Lowe, Miller-Kovach, Frye, & Phelan, 1999). Twelve-week weight loss (within those who completed the study) was found to be 6kg in a group using Weight Watchers compared with a control group (asked to maintain their current nutritional and activity practices) who gained 1.3kg (Rippe et al., 1998). Weight loss after a year of using the Weight Watchers programme was found to be 2.6kg in a group of obese breast cancer survivors but this was not significantly different from the gain of 0.85kg in controls, in this small study (Djuric et al., 2002). A recent study compared weight loss over two months between women using the Weight Watchers programme

alone and those who used this programme but were also asked to form implementation intentions about how they would perform the recommended behaviours during each week (Luszczynska, Sobczyk, & Abraham, 2007). This included planning when, were and how they would perform nutrition and activity behaviours, as well as planning how they would cope in difficult situations where they may be tempted to perform unhealthy behaviours or not perform the new healthy behaviours. Over two months, those using Weight Watchers alone lost 2.1kg, and those who had the additional intervention lost 4.2kg. This was a significant difference and suggests that there is potential for the impact of commercial programmes to be enhanced.

One well-run, large scale study has assessed the impact of Weight Watchers in comparison to self-help over 2 years (Heshka et al., 2003). Those in the self-help group received a 20 minute consultation with a dietitian at baseline and week 12 and were given publicly available printed materials on diet and exercise for weight loss. Their attention was drawn to other resources (e.g. websites and health promotion organisations offering free weight control information). Those in the weight watchers group were given vouchers allowing them to attend Weight Watchers at no cost for the 2 years of the study. At a year, intention-to-treat weight loss, with the last observation carried forward for those who dropped out, was 4.3kg in the Weight Watchers group and 1.3kg in the self-help group and at 2 years this was 2.9kg and 0.2kg respectively. The weight loss in this study of Weight Watchers (Heshka et al., 2003) was less than in the Diet Trials (Truby et al., 2006) possibly due to the media interest in those in the diet trials. This study extends the previous findings by showing that weight loss at 2 years remains higher in Weight Watchers participants than controls but is lower than at earlier time points. It is interesting to note that although weight loss was correlated with self-reported attendance at weight watchers classes, even those with the highest level of attendance regained weight from a year to 2 years after they started the programme.

The UK weight loss programme Slimming World has recently reported on a referral scheme used with GP practices (Lavin et al., 2006). This involved GP's referring obese patients to Slimming World groups and providing vouchers for 12 weeks attendance. Participants could then continue to attend if they paid the fee of £3.75 a week. The Slimming World programme involves modest energy restriction, based around eating limitless fruit and vegetables, restricting fat and sugar consumption, and a daily choice of eating limitless carbohydrates or limitless protein (Slimming World Website, 2007).

At 12 weeks those who completed this period (N=62) lost 5.4kg and at 24 weeks completers (N=29) lost 11.1kg. Although this information was not given in the paper, if no weight loss is assumed for those not included in these analyses and calculate the weight loss for the 91 participants who attended at least one group session, the values would be 3.7 kg at 12 weeks and 3.5kg at 24 weeks. The idea of GPs prescribing commercial weight loss programmes is interesting and there is potential for more research in this area. In those who completed 6 months of treatment the weight loss here is impressive. Despite the high levels of attrition in this study, this could still make a significant impact if large numbers of patients were referred and the loss was maintained.

Some programmes are offered free of charge. The Trevose Behaviour Modification Programme is one such treatment (Latner et al., 2000). This is a lay-directed, self-help programme that uses behavioural techniques delivered in 1-hour meetings in groups of about 10 people. It includes weigh-ins, self-monitoring, slow eating and social support. Final weight loss goals are set in the normal range between 20 and 100 pounds (9 to 45 kg) less than initial weight, with monthly interim weight loss goals. The aspect of this approach which is different from all previously discussed programmes is that attendance is mandatory, and if participants fail to attend they are not permitted to return to the programme. A five week trial period is used where all sessions must be attended and 15% of the final weight loss goal must be achieved. Only when participants are successful in this do they become members of the programme. When members reach their goal and maintain this for 4 months they reduce attendance to once every two weeks, and after 8 months to once a month. After a year they can stop attending but continue to mail in weight reports. If they gain up to 10lbs in weight they attend meetings to lose this, if they gain more than this they are not permitted to return.

Five-year outcomes of the Trevose Behaviour Modification Programme have been reported (Latner et al., 2000); 329 people applied to the programme during the study period (1992-1993), 202 entered a trial phase and 171 became members. Average intention-to-treat weight loss (last observation carried forward) for all full members, was 12.8kg at 5 years. This weight loss is large but considering that participants were not permitted to enter the programme unless they had been successful during the trial period, and were not permitted to stay in the programme if they were not meeting weight loss goals it is unsurprising that the final observations would show weight loss.

However 58% of participants who dropped out were contacted to assess weight loss an average of 47 months after they left the study and the average loss was 4.5kg. In addition, retention of participants was higher in this study than in other weight loss trials with 47% remaining in the study at 2 years and 22% at 5 years. A further study found similar results in three satellite groups implementing the programme (Latner, Wilson, Stunkard, & Jackson, 2002). This programme is advertised by word of mouth and therefore those who apply to participate know the strict nature of the approach and are highly motivated.

Two studies have examined the longer-term outcomes of Weight Watchers.[18] Lowe et al (2001) surveyed participants who had reached their weight loss goal in Weight Watchers programmes in the United States one to five years previously. Weight loss goals are set by the individual member but must be at least 5lbs (2.3kg) less than their joining weight. They are encouraged to set a goal within the BMI range of 20-25 kg/m^2, and most choose a goal equivalent to a BMI of 25 kg/m^2, although at times higher goals are set if recommended by a health professional. After a year about one third of lost weight was regained, and at 5 years 77% was regained. However 43% of participants had maintained a loss of 5% for 5 years or more and 70% were below their starting weight at 5 years. A survey of' lifetime members' of weight watchers (those who reached their weight loss goals 5-12 years previously) (Christakis & Miller-Kovach, 1996) found that 37% had maintained their weight loss and were within 5lbs of their goal weight. These studies show slightly different levels of weight-regain, and although both suggest that regain is common after using Weight Watchers, it is encouraging that a significant minority maintain their weight loss and a large number remain lower than their starting weight years after participation in Weight Watchers.

The studies described here are varied in design. As the authors of a recent systematic review of this area concluded (Tsai & Wadden, 2005): 'with the exception of one trial of Weight Watchers (referring to the Heshka study discussed above) the evidence to support the use of the major commercial and self-help weight loss programs is suboptimal' (p56). Table 2.3 summarises the results from the studies described. These results are encouraging, and along with the long-term maintenance of weight loss found in a significant proportion of those using Weight Watchers, suggest that commercial

[18] These two studies are not included in Table 2.3 because they are surveys of previous members in commercial programmes rather than prospective studies examining weight changes over time and therefore cannot be compared on the same criteria as the prospective studies.

programmes are a useful approach for weight loss. It is worth mentioning that it is not possible to directly compare these results with those from clinical programmes as the populations in the two types of studies are likely to be very different. Those in clinical programmes have often failed to lose weight with alternative approaches before enrolling in a clinical programme. Despite these positive results commercial programmes will not suit everyone, and some are likely to appeal only to a minority of individuals.

Table 2.3 Commercial weight loss programmes

Study	Participants	Follow-up	Drop-out	Recruitment method	Intervention	Completers weight loss	Intention to treat weight loss	Intention to treat method used	Control Group weight change
Truby et al. (2006)	N=293 Average BMI 32 Average age 40 27% male	6 months	28%	BBC advertising campaign	Atkins Weight Watchers Slim-fast Rosemary Conley	Atkins: 8.5kg Weight Watchers: 8.0kg Slim-fast: 6.5kg Rosemary Conley: 8.8kg	Atkins: 6.0kg Weight Watchers: 6.6kg Slim-fast: 4.8kg Rosemary Conley: 6.3kg	Baseline Carried Forward	Gained 0.6kg
Lowe et al. (1999)	N=1, 475 Average BMI 30.7 Average age 49 women	4 weeks	33%	Newspaper advertisements	Weight Watchers Self-help	Weight Watchers: 1.87kg Self-help: 0.77kg	Not given.		N/A
Rippe et al.(1998)	N=80 Average BMI ~31 Average age 37 women	12 weeks	45%	Newspaper advertisements and fliers	Weight Watchers	6.0kg	Not given.		Gained 1.3kg
Djuric et al. (2002)	N=48 Average BMI 36 Age 36-70 women: breast cancer survivors	12 months	19%	Mail sent to cancer survivors involved with a charity, press releases and brochures at breast clinics	Weight Watchers Individualised counselling Both interventions	Weight Watchers: 2.6kg Individualised counselling: 8kg Both : 9.4kg	Not given.		Gained 0.85kg
(Luszczynska et al. (2007)	N=55 Average BMI 33 Average age 44 women	2 months	0%	Participants attending their first Weight Watchers session were invited to participate	Weight Watchers Weight Watchers plus implementation intentions	Weight Watchers: 2.1kg Weight Watchers plus implementation intentions: 4.2kg	N/A		N/A

Study	Participants	Follow-up	Drop-out	Recruitment method	Intervention	Completers weight loss	Intention to treat weight loss	Intention to treat method used	Control Group weight change
Heshka et al. (2003)	N=423 Average BMI 34 Average age 45 85% women	24 months	27%	Clinic records and advertisements	Weight Watchers Self-help	12 months: Weight Watchers: 5kg Self-help: 1.4kg 24 months: Weight Watchers: 3kg Self-help: 0.1kg	12 months: Weight Watchers: 4.3kg Self-help 24 months: 1.3kg Weight Watchers: 2.9kg Self-help: 0.2kg	Last observation carried forward	N/A
Lavin et al.(2007)	N=107 Average BMI 36 Average age 50 83% women	12 and 24 weeks	42% at 12 weeks and 73% at 24 weeks	Doctors asked patients if they would be interested in participating	Slimming World	12 weeks:5.4kg 24 weeks:11.1kg	Not given.		N/A
Latner et al (2000)	N=171 (full members) Average BMI 33 Average age 45 85% women	5 years	78%	Applied to the programme and successfully completed trial period	Trevose Behaviour Modification Programme	15.7 kg	12.8 kg	Last observation carried forward	N/A

Internet weight loss programmes

A number of the commercial programmes discussed above are now available as internet based interventions, but only one commercial internet programme has been assessed in a research study. The eDiets programme prescribes a diet of conventional foods tailored to an individual's needs and gives customised shopping lists. Social support is provided through a number of features, including on-line meetings, bulletin boards, a 24-hour help-desk and e-mail reminders. A randomised controlled trial compared weight loss in women using this programme with those using the LEARN manual followed by the Weight Maintenance Survival Guide which reiterates the messages from the LEARN programme (Womble et al., 2004). Participants in both groups met with a psychologist for 20 minutes at baseline, week 8, 16, 26 and 52. In an intention-to-treat analysis with baseline values carried forward, 1-year weight loss was 1.3kg in the eDiets group and 3.1kg in the LEARN group. The weight loss in this study for the LEARN programme is similar to the studies discussed above.

Tate and colleagues have conducted a series of studies investigating the delivery of weight loss programmes over the internet. The first study (Tate et al., 2001) compared an internet behavioural weight loss programme with an educational website. All participants attended a one-hour introductory session which covered standard behavioural instruction on recommended behaviours and self-monitoring. Participants were also given details on using the internet programme and encouraged to use internet self-monitoring resources. All participants had access to the study website which included a directory of internet resources on diet, exercise self-monitoring and other resources, e.g. on stimulus control. A daily intake of 1200 to 1500 kcal was recommended and activity levels to burn at least 100 kcal a week. At 3 and 6 months all participants attended 15 minute check-in appointments with a psychologist. The behaviour therapy group were asked to submit their self-monitoring diaries to the therapist by email each week. They could also submit questions and received a weekly email message for the 24 week programme including a behavioural lesson and individualised feedback. They were sent an email reminder if they had not sent their monitoring diaries. They also had access to a bulletin board. Using an intention-to-treat analysis with baseline values for missing values, the losses at 6 months were 2.9g and 1.3kg in the behaviour therapy and the education group, respectively.

Tate et al (2003) extended this work to adults at risk of Type 2 diabetes. All participants again attended a one-hour introductory session. They were also given details on using the internet programme and were provided with self-monitoring booklets. The website was similar to that in the previous study. In this study half the participants received behavioural e-counselling, where they communicated with an e-counsellor by email. Participants emailed daily reports of their behaviours and questions and the counsellors gave advice 5 times a week for the first month and weekly for the remaining 11 months. When participants did not email they were sent personal reminders. Those in the internet programme only group received weekly reminders to submit monitoring information and received weight loss information. At 12 months those with the programme alone lost 2.0kg, significantly less than the 4.4kg loss in the intervention plus e-counselling group, in an intention-to-treat baseline carried forward analysis. This suggests that the e-counselling was an important component of the intervention.

Because individual e-mail counselling is expensive, internet programmes would ideally incorporate automated response systems to substantially reduce the cost of implementation. Tate et al (2006) examined the possibility of providing tailored automated counselling compared with human e-mail counselling as an addition to an internet weight loss program. 192 participants attended a group face-to-face session where they were introduced to behavioural weight loss recommendations. Meal replacements were recommended and liquid weight loss beverages (SlimFast) were provided for the first week along with vouchers to offset the price of further beverages. All participants were encouraged to increase physical activity and used the SlimFast Website which is free to the public and includes weekly reporting of weight, emailed weight loss tips, recipes and a buddy system. Because this study used meal replacements it does not directly add to our understanding of the impact of internet based behavioural approaches in which participants are encouraged to manage their intake of a conventional diet, but comparing groups with different forms of feedback is interesting.[19] One group received no other intervention and two groups received e-counselling. The counselling groups had access to an additional website where they reported their weight and weight-related behaviours and used a message board. They received an email from this website weekly with behavioural lessons. For the automated feedback group they received weekly feedback instantaneously on the webpage when they completed their diary. The human counselling group received

[19] This study is therefore not included in Table 2.4.

feedback on their dairy via email from a counsellor. The webpage feedback used algorithms based on cognitive behavioural theory and focused on week-to-week behavioural changes. The human counsellors were blinded to the algorithms of the automated feedback. In an analysis of study completers at 6 months the no counselling group lost 2.6kg, the automated feedback group lost 4.9kg and the human counselling group lost 7.3kg. This suggests that reporting behaviours and receiving tailored feedback has an additional impact on weight loss (although this was not significant) but that this is not as effective as having contact with a human counsellor.

A larger study (N=2862) has also assessed the effect of computer generated personalised information in an internet intervention. Rothert et al (2006) conducted a randomized controlled trial of an internet weight loss programme, either tailored using an expert system or giving information only. The tailored programme was a 6-week self-help programme which creates an individually tailored plan based on questionnaire responses. It recommends a healthy diet, focuses on cues to eating, physical activity, understanding relationships with food and activity, attributions for previous weight management efforts, body image and social support. Participants also had the option of enrolling a supportive 'buddy' to help them lose weight. Those in the information-only condition were given information on the importance of weight management, definitions of healthy weight, determinants of overweight, information on preparing for weight management and facts on weight loss diets and weight management strategies. All participants could go back to any parts of their website at any time. An intention-to-treat analysis with last observations carried forward showed a self-reported weight loss of 0.9kg in the tailored condition and 0.4kg in the information-only condition at 6 months (a significant difference in this large study). These low levels of weight loss are partly due to the high level of attrition in this study, although even among completers they are only 2.8 and 1.1 kg respectively.

These studies (Table 2.4) show that the most successful internet weight loss interventions are those which involve a health professional providing individualised feedback regularly to participants. Large scale implementation of such interventions would be costly. However automated counselling may improve to allow the programmes to be implemented without health professional involvement. Many of these studies found that participants did not log-on as much as the researchers had hoped (Womble et al., 2004), and participants logged-on more in the interventions with

e-counselling than those without (Tate et al., 2001; Tate, James, & Wing, 2003). Drawing conclusions across these studies is difficult as the programme contents are varied and, as with other weight loss interventions, there is often a lack of detail given in reports of these studies, preventing assessment of which aspects are important in promoting weight loss.

This review of low-intensity weight loss interventions has shown that many studies show weight loss with a variety of approaches. However many of these interventions involved more health professional input that is ideal if they are to be disseminated widely. I now move on to consider studies which focus on the prevention of weight gain before drawing more general conclusions.

Table 2.4: Internet weight loss programmes

Study	Participants	Follow-up	Drop-out	Recruitment method	Intervention	Completers weight loss	Intention to treat weight loss	Intention to treat method used	Control Group weight change
Womble et al. (2004)	N=47 Average BMI 33 Average age 44 women	12 months	34%	Telephone calls to volunteers who had responded to advertisements for a range of weight loss studies	eDiets LEARN	eDiets: 2.1kg LEARN: 4.4kg	eDiets: 1.3kg LEARN: 3.1kg	Baseline carried forward	N/A
Tate et al. (2001)	N=91 Average BMI 29 Average age 41 89% women	6 months	29%	Email advertisements to hospital employees	Internet behavioural programme Educational website	Internet behavioural programme: 4.1kg Educational website: 1.6kg	Internet behavioural programme: 2.9kg Educational website: 1.3kg	Baseline carried forward	N/A
Tate et al. (2003)	N=92 Average BMI 33 Average age 48 90% women	12 months	16%	Newspaper advertisements	Internet Internet plus e-counselling	Internet: 2.3kg Internet plus e-counselling: 5.3kg	Internet: 2.0kg Internet plus e-counselling: 4.4kg	Baseline carried forward	N/A
Rothert et al (2006)	N=2862 Average BMI 32 Average age 45 83% female	6 months	80%	Advertisements to members of a non-profit integrated heath care delivery system	Tailored internet weight loss programme Information-only weight management programme	Tailored internet weight loss programme: 2.8kg Information-only weight management programme:1.1kg	Tailored internet weight loss programme: 0.9kg Information-only weight management programme: 0.4kg	Last observation carried forward	N/A

Prevention of Weight Gain Interventions

A small number of studies have targeted prevention of weight gain with low intensity interventions, using a number of different approaches (Table 2.5). One of the best known studies in this area is the Pound of Prevention study, an educational community intervention (Jeffery & French, 1999) which aimed to encourage individuals to pay more attention to weight and make small changes in their diet and exercise behaviours. The specific themes of the study were regular self-weighing, increasing fruit and vegetable intake, reducing consumption of high-fat foods and increasing exercise, especially walking (Jeffery & French, 1999). The educational messages were delivered via monthly newsletters each focusing on one of the main themes, with optional additional activities for participants every 6 months, for example 4-session weight control classes staffed by a nutritionist and a one month free membership to a community exercise facility. Over three years, those in the intervention groups reported positive changes in weighing and healthy dietary practices in comparison with the control group and these behaviours were related to reduced weight gain within the group. However there was no difference between groups on weight gain over the three years and the average weight change was a gain of 1.7kg. The authors conclude that education alone may not be enough to prevent weight gain in the population. However, as the intervention was successful at keeping people's interest over three years it indicates that simpler interventions may be popular with the public.

Winnett et al (2005) report on the initial findings of a weight gain prevention intervention delivered via the internet. They delivered it through churches, with and without social support from within the church. The intervention involved tailored messages based on personal goals and progress over time. It included self-regulation components such as planning for activity and fast food consumption. Participants were provided with pedometers and were encouraged to set goals to increase activity through walking. The content was split into 12 modules, with a new module available each week. Participants received automated tailored feedback on the behavioural data they entered. Within the final sample of 849 participants at follow-up (7-9 months) those in the control groups had gained weight (0.57 kg) and those in the intervention groups had lost weight (0.1kg in the programme only group and 0.27kg with the programme and social support). The difference between the control group and the programme only group was marginally significant ($p<0.10$) whereas the difference between the control group and the programme plus social support group was significant at the 0.05 level.

Rodearmel et al (2006) tested a family-based intervention aimed at preventing weight gain in children and their parents. Here I will focus on the results for the parents. This is part of the America on the Move US national programme to prevent weight gain (America on the Move, 2007) which promotes small lifestyle changes to positively impact on weight and health. Participants were provided with step-counters and group-specific step and cereal logs. After 7 days participants in the experimental group were asked to increase their steps by 2000 a day from their baseline level and to gradually increase this every day as much as possible. They were also asked to consume 2 portions of cereal a day[20], one at breakfast and the other as a snack (replacing a usual snack). Experimental families were given free Kellogg's cereals and "fun educational logs" to record steps and cereal servings. These had cartoon characters reminding participants to eat cereal and increase steps and to record this. All families received refrigerator magnets and stickers and were given calculators to work out averages of steps and cereal servings. Only those families who completed this study were included in the analyses. Among all parents there was a significant difference between groups on weight change over 14 weeks with the experimental group losing an average of 0.44 kg and the control group gaining 0.35 kg.

An alternative approach is to focus less on changing behaviour and instead on monitoring weight and only changing behaviour if a gain in weight is noted. Levine et al (2007) focused on prevention of weight gain among women. They used three experimental groups: a clinic-based treatment, a correspondence course and an information only condition. The intervention lasted for 2 years and was based on the proposal that weight gain can be prevented through regular self-weighing and small changes in diet and activity behaviours to reverse small increases in weight. Weight gain was defined as a gain of 2 lbs (0.91kg) or more that is maintained for 2 or more weeks. The clinic based group had group meetings with nutritionists or interventionists, biweekly for the first 2 months then bimonthly. The first meetings focused on self-monitoring of energy intake and expenditure and strategies for making behavioural changes. Participants were also given written information of diet and activity topics and directed to set goals for these behaviours. They were given recommended calorie intake goals to apply if weight gain occurred. During the first 2 months participants were given homework tasks to practice behavioural strategies. In the bimonthly meetings participants were given information on change strategies, stimulus control, problem

[20] this study was sponsored by Kellogg

solving, goal setting, stress and time management and relapse prevention. At each meeting participants were weighed and if they had gained weight they had an individual meeting with a project interventionist where behavioural strategies to create modest changes in intake and activity were discussed and a follow-up meeting in person or by phone was scheduled for 4 weeks later. If they had then returned to baseline weight they were encouraged to continue as before, if not then more behavioural strategies were discussed.

The correspondence programme mimicked the clinic programme with lessons sent in the post. Homework assignments were submitted by mail and included reporting current weight. People who had maintained their weight at the end of the first 2 months were sent a letter of congratulations and encouraged to make modest changes in eating and activity. Those reporting a weight gain were sent a letter addressing a weight control topic and encouraging changes in eating and activity. They were asked to submit a postcard reporting their eating and exercise activities and which behavioural strategies they endorsed. If on subsequent assignments they reported a return to baseline weight they received a letter of congratulations, if weight continued to be above baseline they received additional letters encouraging self-monitoring, behavioural strategies and to complete and return postcards. The information-only condition received a booklet with information about the benefits of weight maintenance, low-fat eating and regular physical activity. On average in the clinic group participants attended 50% of meetings and in the correspondence group 38% of homework assignments were returned. Generalised estimating equations were used to assess differences between groups on weight change over time. Participants were assessed over 3 years, and no differences were found between the three groups on weight change. At the end of the intervention (2 years) the average weight change was -0.6kg in the clinic group,+ 0.3kg in the correspondence group and +0.8kg in the information only group. At three years this was -0.1kg, +1.3kg and +0.7kg respectively. 46%, 33% and 41% in each group remained weight stable over 3 years. The 60% of the sample who were not successful at weight maintenance gained 4kg over the 3 years.

Wammes et al (2005) report the initial findings of a national mass media campaign in the Netherlands aimed at prevention of weight gain. This was targeted at young adults with a BMI under 30 kg/m^2. It aimed to improve knowledge that gaining one kg a year would result in a heath-compromising body weight, the need to actively prevent weight

gain by making small changes in diet and physical activity, and an awareness of weight gain and own weight status. It involved radio advertising, a brochure, newspaper advertisements, free cards and a website. The assessment of this campaign used telephone surveys of non-obese Dutch adults aged 25-35 before and after the campaign (November and December 2002 and then January and February 2003). Unfortunately they found a significant *increase* in self-reported BMI (calculated from self-reported height and weight) even after controlling for secular time-trends. One possible explanation was that the campaign resulted in people checking their weights and therefore being more accurate in their reports. Another is that the campaign was launched in December and the assessments were therefore before and after the Christmas period when participants are likely to have gained weight.

Table 2.5 presents the details of the studies described here (except for the mass media campaign which cannot be summarised in these terms). It shows that thus far, low-intensity weight gain prevention studies have had little success. The most successful approaches have focused on specific behavioural change recommendations rather than on monitoring weight.

Table 2.5: Low-intensity prevention of weight gain interventions

Study	Participants	Follow-up	Drop-out	Recruitment method	Intervention	Completers weight change	Intention to treat weight change	Intention to treat method used	Control Group weight change
Jeffery & French (1999)	N=1126 For completers: Average BMI 27 Average age 38 80% women	3 years	28%	Advertising through phone solicitation, newspaper advertisements and mail to staff at a university	Education through newsletters Education through newsletters plus incentives	Education through newsletters: +1.6kg Education through newsletters plus incentives: +1.5kg	Not given		+1.8kg
Winnett et al (2005)	N=849 (completers) Average BMI 29 Average Age 52 65% female	7-9 months	Not given	Recruited through churches, no further detail given	Internet weight gain prevention programme, with and without social support	Without social support: -0.1kg With social support: -0.27kg	Not given		+0.57 kg
Rodearmel et al (2006)	N=100 mothers and 59 fathers. For completers: Average BMI 28 and 30 Average age 41 and 43	14 weeks	22%	Flyers and email advertising	Family based intervention focusing on increasing steps and cereal consumption	-0.44kg	Not given		+0.35 kg
Levine et al (2007)	N=284 Average BMI 25 Average age 36 women	2 and 3 years	26% and 28%	Advertisements	Clinic-based course Correspondence course Information only	Not given	2 years: Clinic-based course: -0.6kg Correspondence course: +0.3kg Information only: +0.8kg 3 years: Clinic-based course: -0.1kg Correspondence course: +1.3kg Information only: +0.7kg	Generalised estimating equations	N/A

CONCLUSION

There is a need for effective interventions that can be disseminated at a population level (Wadden et al., 2004). This review has shown that a range of (relatively) low-intensity intervention approaches have been able to help people to lose weight but few have, thus far, had success when targeting prevention of weight gain. Some of these interventions involve little or no input from health professionals and would therefore be economic to disseminate to the entire population with a BMI over 25kg/m^2, although those with more professional advice generally result in larger weight losses. Others are commercial programmes so there is a cost but this is borne by the consumer not the health care system. The long-term benefits of these interventions are unknown although some encouraging results have been shown for commercial programmes. The potential benefit of low-intensity interventions is that they can often be used long-term, i.e. an internet programme or self-help manual can be returned to as often as is required where-as clinical interventions often run for a specified period of time. However, whether people are willing to 're-try' the same method is unknown.

A survey of UK adults found that in the previous three years, 33% of overweight or obese women had used a slimming club and 22% had used a diet from a book or magazine, while 3% of overweight and obese men had used a slimming club and 5% a diet from a book or magazine (Wardle & Johnson, 2002). This can be seen both as a sign that there are high levels of interest in weight loss interventions among women, or as an indication that there remain a large number of overweight and obese adults who are not engaging with programmes from which they could potentially benefit. The Pound of Prevention (POP) study (Jeffery & French, 1999) kept participants engaged over three years. Participants in this study (POP) rated correspondence formats as preferable for health education, compared to face-to-face interventions, and were more likely to participate when this type of programme was offered (Sherwood et al., 1998). In addition, an internet search for 'weight loss program' reportedly returned 678,000 results (Weinstein, 2006) suggesting that people are seeking information on how to lose weight. Therefore it may be possible to get more people engaged with weight loss by providing simple advice in a written format.

CHAPTER 3
HABITUAL BEHAVIOUR AND WEIGHT CONTROL

HABITUAL BEHAVIOUR AND WEIGHT CONTROL

In order to lose weight and prevent weight gain (and re-gain) people need to make sustained changes to their lifestyle. The habit concept may be able to inform interventions to help people to do this. It is therefore important to firstly consider what we know about the habitual nature of eating or physical activity behaviours.

As discussed in Chapter 1 habits develop when behaviours are repeated often in similar situations. It is therefore likely that many eating and physical activity behaviours are habitual. Habit strength (measured using the SRHI, or items from this measure) has been shown to be associated with various eating behaviours including snacking and fruit and vegetable consumption in adults and sugar-sweetened beverage consumption in adolescents (Brug, de Vet, de Nooijer, & Verplanken, 2006; Verplanken & Orbell, 2003; Kremers et al., 2007; Verplanken, 2006; Reinaerts et al., 2007; de Bruijn et al., 2007). Habit strength has also recently been shown to be predictive of physical activity (Chatzisarantis & Hagger, 2007). Food diaries have shown stability across days in people's eating patterns (Khare & Inman, 2006) and habits have also been mentioned in some theories of food choice, although the concept is poorly developed (Furst, Connors, Bisogni, Sobal, & Falk, 1996; Booth & Sheperd, 2006). Although many eating behaviours are probably habitual, and activity behaviours may also be habitual, this has been neglected in developing weight loss interventions.

Results from recruits to the National Weight Control Registry, a panel of individuals who have maintained a weight loss of at least 30 lbs (approximately 14kg) for at least 1 year (Wing & Hill , 2001), suggest that it becomes easier to maintain weight losses as time goes on. After longer weight loss maintenance, participants reported using fewer weight maintenance strategies and said that it required less effort and attention to maintain weight (Klem, Wing, Lang, McGuire, & Hill, 2000). It has been suggested that over time a shift may occur in weight maintainers so that the pleasure of maintenance becomes greater than the costs of performing the behaviours, and this may help to sustain the necessary behaviours to maintain weight loss (Klem et al., 2000).

One part of this explanation may be that as time goes on, behaviours become more habitual and this makes it easier for participants to continue to perform them. These findings support the proposition that helping people to establish new habits could potentially help them to make healthy choices automatically and consequently to lose weight and maintain this loss.

As discussed in Chapter 1 it may be possible to create habits simply by repeating a behaviour in the same situation (Context Dependent Repetition). If giving this advice can result in habit formation, then it has the potential to make an important contribution to low-intensity weight loss interventions because such advice can easily be given on a wide scale at relatively little cost. As far as I am aware no studies have specifically targeted habit formation in an intervention. As argued previously, an interesting question is whether directing people to form new healthy habits can result in them exerting sufficient self-control over unhealthy habits to 'break' these and to establish new healthy alternatives as habits.

SUMMARY OF THESIS RESEARCH

The aim of the research presented in this thesis is to investigate the utility of a theory of habit formation in designing weight loss advice. This involves investigating the habit formation process in order to better understand how this operates (Study 3) and testing advice based on the habit concept (Study 1 and 2).

Study 1 was an eight week pilot study of a weight loss intervention based on the theory of habit formation, and presented as a leaflet. This study aimed to assess the acceptability of the intervention and determine whether participation in the programme was associated with weight loss among a small group of participants who were weighed weekly. A second aim was to assess the subjective experience of habit formation through qualitative interviews with the participants. The results of this study are presented in Chapter 4.

Study 2 was a randomised controlled trial of the intervention piloted in Study 1, comparing two intervention groups (who both received a habit-based intervention but differed by weighing frequency) with a control group. One intervention group was

weighed weekly (to mimic the pilot study) and the other was weighed every four weeks. The primary outcome was weight change in comparison to the control group over 8 weeks. The secondary outcome was weight loss maintenance over 32 weeks in the intervention groups. An additional outcome was change in psychological well-being during the study. These first analyses are presented in Chapter 5. Chapter 6 then reports on an exploratory analysis of predictors of weight loss during the study and Chapter 7 examines change in automaticity of the recommended behaviours over 6 months of using the intervention.

Study 3 was an investigation of the habit formation process. Each participant chose an eating or activity behaviour which they would try to perform every day in the same situation for 12 weeks (Context Dependent Repetition). The main analysis investigated the relationship between repetition and self-reported automaticity for these behaviours.[21] This study is reported in Chapter 8.

[21] Due to missing data, a direct analysis relating repetition and automaticity was not possible. However, it was possible to model the relationship between day of the study and automaticity and then investigate the levels of performance reported by participants in the study.

CHAPTER 4

STUDY 1: A PILOT STUDY OF A HABIT-BASED WEIGHT LOSS INTERVENTION[22]

INTRODUCTION

In order to deliver weight control advice at a population level, interventions need to be simple to deliver and easy for individuals to understand and implement in their lives. The aim should be to establish permanent behaviour change, rather than temporary changes aimed at short-term weight loss. Forming habits for healthy behaviours could be a useful approach to help people make and maintain changes in their behaviours.

A team of dietitians and psychologists worked together to develop a leaflet-based intervention based on the concept of habit formation.[23] The aim was to identify 10 weight control behaviours that could be recommended in a quick and easy format and have the potential to become habitual, and for which there was scientific evidence in support of their efficacy. We also consulted a population survey of weight control and eating habits in British adults (Wardle, Griffith, Johnson, & Rapoport, 2000). Many of the recommendations chosen had been included in the survey, and were reported by a significant percentage of the population, which provided evidence that they are compatible with normal everyday life. We do not claim the final set is an exhaustive list of weight control recommendations because there are likely to be many alternatives that could be suggested. But they are a set that cover many areas of everyday eating and activity behaviours. Recent work has shown that if dieting rules are too complex, adherence can be reduced (Mata, Todd, & Lippke, 2007). Every effort was made to give the advice in a way which would be simple and easy to understand. The behaviours were given short, fun names to make them interesting and easy to remember.

The final ten recommendations, formed the 'TenTopTips' (Box 4.1, Table 4.1 and Appendix 4.1). All the behaviours were broadly health-promoting so that in the (optimistic) event of long-term adherence, health outcomes would be favourable. The

[22] A version of this chapter has been submitted for publication to *Psychology, Health and Medicine.*
[23] This intervention was designed by Weight Concern (a charity based in the Health Behaviour Unit) for Cancer Research UK as part of their Reduce the Risk campaign. I was part of the design team.

leaflet recommends doing all the behaviours because any one alone would be unlikely to have a significant impact on weight.

Box 4.1: Ten Top Tips for Weight Loss

1. **Keep to your meal routine**
   Try to eat at roughly the same times each day, whether this is two or five times a day.
2. **Go reduced fat**
   Choose reduced fat foods (e.g. dairy foods, spreads, salad dressings) where you can. Use high fat foods (e.g. butter and oils) sparingly, if at all.
3. **Walk off the weight**
   Walk 10,000 steps (equivalent to 60-90 minutes moderate activity) each day. You can use a pedometer to help count the steps.
4. **Pack a healthy snack**
   If you snack, choose a healthy option such as fresh fruit or low calorie yogurts instead of chocolate or crisps.
5. **Learn the labels**
   Be careful about food claims. Check the fat and sugar content on food labels when shopping and preparing food.
6. **Caution with your portions**
   Don't heap food on your plate (except vegetables). Think twice before having second helpings.
7. **Up on your feet**
   Break up your sitting time. Stand up for ten minutes out of every hour.
8. **Think about your drinks**
   Choose water or sugar-free squashes. Unsweetened fruit juice contains natural sugar so limit to one glass a day (200ml/ 1/3 pint). Alcohol is high in calories; limit to one unit a day for women and two for men.
9. **Focus on your food**
   Slow down. Don't eat on the go or while watching TV. Eat at a table if possible.
10. **Don't forget your 5 a day**
    Eat at least 5 portions of fruit and vegetables a day (400g in total).

The recommended behaviours included four tips targeting a reduction in energy intake (choose low fat options, choose low-calorie snacks, choose low-calorie drinks, have small portions and no second helpings), one focusing on increasing expenditure (walk 10,000 steps a day) and one on reducing sedentary behaviour (sit for no more than 50 minutes of each hour). All these related to a change in energy balance. One of the remaining recommended behaviours promotes routines (eat at the same times each day). This was designed to help participants to establish stability in eating patterns to promote repetition of the other behaviours recommended, in consistent situations, and therefore habit formation. The final tip recommends eating five portions of fruit and vegetables a day, because this is important for health outcomes (National Health Service, 2006). Two tips were designed to improve awareness of food intake (don't perform other activities while eating, read food labels). We decided to focus the intervention on creating healthy habits rather than breaking 'bad' habits, however these 'tips' draw attention to current behaviour and therefore have the potential to aid people in

identifying and exerting self-control over their current unhealthy habits. The recommendation to read food labels is supplemented with simple advice on interpreting these labels to help participants make healthy choices.[24]

Estimates of energy deficit were calculated for the six tips relating to a change in energy balance. It was estimated that replacing high fat foods with low-fat alternatives would result in a reduction of 200 kcal a day. Examples of the different ways this advice would result in a reduction in calorie intake are; replacing 300mls of full-fat milk with semi-skimmed (-60 kcal), using 30g low fat spread instead of butter (-135 kcal) or cooking foods without oil (15mls = 135 kcal). Replacing a high-calorie snack with a low-calorie alternative was estimated to result in a reduction of 150 kcals, for example replacing a snack-size chocolate bar with a banana (-240 kcal) or a packet of crisps with an apple (-130 kcal). Encouraging a decrease in portion sizes was estimated to result in a reduction of 100 kcal, which could be achieved in a number of ways depending on the foods being eaten. An example is that eating 30g less pasta (dry weight) would reduce calorie intake by 100 kcal. Cutting down on high-calorie drinks was estimated to result in an intake of 150 kcals less. This could either be through cutting out a can of coke, a large glass of wine, or a beer.

Two tips promote an increase in energy expenditure and estimates of the change in energy balance were calculated using Metabolic equivalents (METs) which are defined as the ratio of the work rate to the resting metabolic rate (Ainsworth et al., 2000). One MET is the rate at which adults burn kcal at rest, expressed as 1kcal/kg/hr. The increase in energy expenditure of either walking or standing, compared to sitting, was calculated by subtracting 1 MET (the level at resting) from the MET level for the relevant activity (e.g. 3.3kcal/kg/hr for walking at 3 mph). Energy expenditure is calculated by multiplying the MET value by the weight of the individual multiplied by the time the behaviour is performed in hours. Because both the weight of individuals using the tips and the speed of walking will vary, a wide range of estimates were found for the recommendation to walk 10,000 steps a day. For example a 70 kg person who walks at 3mph for an additional 40 minutes will increase their energy expenditure by 107 kcal[25], but a person who weighs 100 kg who starts walking at 4mph for the same time will

[24] This is given in the leaflet with further optional information provided in the 'Additional Information', discussed later.

[25] 2.3 (METs for walking at 3 mph - METs when sitting quietly) * 70 (weight) * 0.667 (40 minutes)

increase their expenditure by 267 kcal.[26] Therefore we estimated the deficit to be between 100 and 200 kcal. Standing has a MET value of 2 kcal/kg/hr. If a 70 kg person increased their standing time by 90 minutes a day this would result in a 105 kcal increase in expenditure,[27] and if a 100 kg person increased their standing time by 60 minutes they would increase their expenditure by 100 kcal.[28] We therefore estimated this tip would result in a 100 kcal deficit. Together the recommended behaviours were calculated to produce an estimated daily calorie deficit of 800-900 kcal for an individual changing from doing none, to doing all, of the tips. However as many participants would be likely to already be doing some of them they would not achieve this deficit.

The recommended behaviours are presented with a short introduction. This advises participants to plan ahead, incorporate the tips into their daily routines and to monitor their progress on a simple monitoring sheet provided. This is intended to encourage participants to perform the behaviours regularly in consistent contexts (Context Dependent Repetition) to promote habit formation. The planning recommended does not give the level of detail involved in implementation intentions (Gollwitzer, 1993), but is informed by this work which shows that planning increases the likelihood that a behaviour will be performed. Although ideally participants would form thorough plans, as with implementation intentions, it was decided that recommending this level of planning, for such a large number of behaviours, would reduce the simplicity of the programme.

Self-monitoring is a central component in behavioural weight loss programmes (Cooper et al., 2003), both keeping food and activity diaries and regular monitoring of weight. Diet self-monitoring has consistently been found to predict weight loss (Boutelle & Kirschenbaum, 1998; Boutelle, Kirschenbaum, Baker, & Mitchell, 1999; Baker & Kirschenbaum, 1993; Streit, Stevens, Stevens, & Rossner, 1991). For example, Boutelle and Kirschenbaum (1998) found that people who were more consistent in using a diary to monitor their food intake lost the most weight while participating in a cognitive behavioural programme. In addition participants lost more weight during their two most consistent monitoring weeks in comparison to their two least consistent.

[26] 4 (METs for walking at 4 mph - METs when sitting quietly) *100 (weight) * 0.667 (40 minutes)
[27] 1 (MET for standing - METs when sitting quietly) * 70 (weight) * 1.5 (90 minutes)
[28] 1 (MET for standing - METs when sitting quietly) * 100 (weight) * 1 (60 minutes)

Self-monitoring of exercise has also been shown to relate to greater weight loss within a behavioural weight loss program (Carels et al., 2005).

Keeping a food diary is time-consuming, and calculating calories requires effort and a high level of knowledge. Although using personal digital assistants (PDAs) has been suggested as a way to make it easier to self-monitor, this still requires time and effort on the part of the participant, and has not been found to improve levels of monitoring or weight loss in a behavioural weight control program (Yon, Johnson, Harvey-Berino, Gold, & Howard, 2007). People may be able to monitor their behaviour more simply but also benefit from the focus this places on their behaviours. We designed a simple 'tick-sheet' where participants recorded daily whether they had achieved each of the 'tips'. This was made part of the leaflet (Appendix 4.1). It can be completed very quickly but enables people to identify areas they need to focus on, and then plan how to do this. We also included a column where at the end of a week participants could rate if they had achieved each 'tip' on five days or more. The rationale being that this would encourage a high level of behavioural frequency, required for habit formation.

One previous study has incorporated a simple self-monitoring sheet but this was more detailed that in the 'TenTopTips', with participants scoring different points for achieving different behaviours, and was incorporated in a workbook where participants created their own behavioural prescriptions and further monitoring techniques were recommended (Miller et al., 1993). The weight loss in this study was one of the largest shown among the low-intensity interventions reviewed in Chapter 2, suggesting this monitoring may have been an important addition. To our knowledge, this is the only previous study that has used a simplified monitoring approach, and it was more complicated than the tick sheet in the 'TenTopTips'.

Higher levels of self-weighing have been related to more weight loss in a weight loss programme and less weight gain in a weight gain prevention trial (Linde, Jeffery, French, Pronk, & Boyle, 2005). In an intervention designed to aid maintenance of weight loss through regular monitoring of weight Wing et al (2006) found a significant difference between those who did and did not report weighing themselves daily. Of those who reported this self-monitoring 26% gained 2.3kg or more compared to 58% of those who did not weigh themselves daily. We therefore recommended daily weighing and provided space on the tick-sheet for this to be recorded.

As a first test of this intervention, I conducted a pilot study with ten participants. This study had three aims: i) to measure weight change over eight weeks, ii) to assess the acceptability of the intervention, and iii) to investigate participants' experiences when given advice on habit formation (e.g.how they applied the advice in their day-to-day lives, and whether they experienced the behaviors as becoming increasingly automatic over time). I conducted qualitative interviews with the participants at the end of the eight week study. These included questions on the acceptability of the intervention as well as discussion on all aspects of participants' experiences, allowing for consideration of various characteristics of the habit formation process. I conducted a thematic analysis on the transcripts of these interviews. Qualitative methodology can be used to gain an understanding of the subjective experience of phenomena through consideration of people's own accounts and can complement quantitative methods (Ritchie & Lewis, 2003; Yardley, 2000). It was therefore appropriate as a first step in investigating the habit formation process.

Table 4.1: Scientific justification for 'TenTopTips'

Tip	Scientific Justification	Estimated Calorie Deficit
1. Keep to your meal routine Try to eat at roughly the same times each day, whether this is two or five times a day.	People who succeed at long term weight loss tend to have a regular meal rhythm (avoidance of snacking and nibbling) and show 'flexible' rather than 'rigid' control' of eating (Westenhoefoer, von Falck, Stellfeldt, & Fintelmann, 2004). A consistent diet regimen across the week and year also predicts subsequent long-term weight loss maintenance (Gorin, Phelan, Wing, & Hill, 2004).	This tip helps encourage habit development.
2. Go reduced fat Choose reduced fat foods (e.g. dairy foods, spreads, salad dressings) where you can. Use high fat foods (e.g. butter and oils) sparingly, if at all.	There is a great deal of evidence to support the effectiveness of low-fat diets (where 30% or less of total daily energy is from fat), which produce weight loss by decreasing calorie intake (Mulvihill & Quigley, 2003). Following a low-fat diet is also associated with better weight maintenance (Wing & Hill , 2001).	- 200 Kcal
3. Walk off the weight Walk 10,000 steps (equivalent to 60-90 minutes moderate activity) each day. You can use a pedometer to help count the steps.	Achieving the UK government recommendation of at least 30 minutes of at least moderate intensity physical activity on 5 or more days a week would increase most people's energy expenditure and contribute to weight management (Department of Health, 2004). More activity (45-60 mins) may be required to prevent the transition to overweight and obesity and maximize weight loss (Saris et al., 2003). People who have lost weight may need to do 60-90 minutes of activity a day to maintain their weight loss (Department of Health, 2004; Saris et al., 2003). Doing 10,000 steps / day is approximately the equivalent to at least 60 minutes of walking at a brisk pace (4.5 mph) (Tudor-Locke & Bassett, 2004).	- 100 to 200 Kcal
4. Pack a healthy snack If you snack, choose a healthy option such as fresh fruit or low calorie yogurts instead of chocolate or crisps.	Readily-available snack foods and drinks are often high in energy and tend to be used to supplement rather than replace meals. Between 1993 and 1998 sales of snacks more than tripled in the UK from £173 million to £541 million (House of Commons Health Select Committee, 2004). Snack consumption is related to a higher daily energy intake (Forslund, Torgerson, Sjostrom, & Lindroos, 2005).	- 150 Kcal
5. Learn the labels Be careful about food claims. Check the fat and sugar content on food labels when shopping and preparing food.	Food labels detailing the caloric and nutritional content of foods provide a basis for making healthy food choices (House of Commons Health Select Committee, 2004). Inadequate labeling can have a negative impact on nutrition (House of Commons Health Select Committee, 2004). Providing individuals with simple methods to understand labels will facilitate informed choices (Food Standards Agency, 2004).	This tip helps people to make informed choices.

Tip	Scientific Justification	Estimated Calorie Deficit
6. Caution with your portions Don't heap food on your plate (except vegetables). Think twice before having second helpings.	Portion sizes have increased inside and outside the home in the past 30 years (Nielsen & Popkin, 2003; Young & Nestle, 2003). Larger portions contain more calories and can contribute to excess energy intake and weight gain. Eating satisfying portions of low-energy-dense foods can help enhance satiety and control hunger while restricting energy intake for weight management (Ello-Martin, Ledikwe, & Rolls, 2005).	- 100 Kcal
7. Up on your feet Break up your sitting time. Stand up for ten minutes out of every hour.	Inactive people are more likely to be obese than active people (Department of Health, 2004). Time spent in sedentary behaviors (e.g. TV watching, sitting at work) is related to overweight and obesity, independent of physical activity level (Hu, Li, Colditz, Willett, & Manson, 2003; Mummery, Schofield, Steele, Eakin, & Brown, 2005). Decreasing sedentary time and increasing light–to-moderate activity such as household chores may bring substantial health benefits (Department of Health, 2004; Hu et al., 2003).	- 100 Kcal
8. Think about your drinks Choose water or sugar-free squashes. Unsweetened fruit juice contains natural sugar so limit to one glass a day (200ml/ 1/3 pint). Alcohol is high in calories; limit to one unit a day for women and two for men.	Intake of sugar-sweetened soft drinks has increased over the last 30 years; up by 135% (278 kcal) in 5 years (Nielsen & Popkin, 2004). Higher consumption of sugar-sweetened beverages is associated with greater weight gain (Schulze et al., 2004). Intake of calorific drinks may lead to excess energy intake that is not compensated for elsewhere in the daily diet (Schulze et al., 2004).	- 150 Kcal
9. Focus on your food Slow down. Don't eat on the go or while watching TV. Eat at a table if possible.	More TV viewing tends to be associated with a higher calorie intake. Internal cues regulating food intake may not be as effective while distracted by the TV (Stroebele & de Castro, 2004).	This tip helps place the focus on current habits and to avoid unconscious slips in behavior.
10. Don't forget your 5 a day Eat at least 5 portions of fruit and vegetables a day (400g in total).	The UK Department of Health recommends 400g of fruit and vegetables a day. Fruits and vegetables have high nutritional quality and low energy density. Eating the recommended amount produces health benefits including reduction in the risk of cancer and coronary heart disease (National Health Service, 2006).	This tip is important for health.
Total Calorie Deficit		- 800 to 900 Kcal

METHODS

Volunteers were recruited with an email circular sent to staff in a large organisation inviting participation in a pilot study of a weight loss programme. The first ten volunteers were invited to participate in the pilot study and to attend a meeting in which the programme and study were described and the materials provided. Inclusion criteria were age over 18 years and Body Mass Index (BMI) equal to or greater than 25 kg/m^2. At the initial meeting participants were given:

- the 'TenTopTips' leaflet[29] (Appendix 4.1),
- additional information[30] (Appendix 4.2), and
- blank tick sheets[31]

Participants attended to be weighed and to hand in a copy of their tick sheet once a week for eight weeks. The tick sheets were used to assess the tip completion rates. Completion rates were calculated for each tip across participants to show the average percentage of days during the eight weeks that participants ticked each tip. An average completion score was also calculated for each participant, across the ten tips (the percentage of possible ticks over the eight weeks that participants had ticked). Weight loss over the eight weeks was also calculated.

Semi-structured interviews were conducted with participants after at the end of the study. The interviews were conducted in a private room at the organisation's offices, and lasted between twenty and forty minutes. A schedule was used to guide the interviews in order to gain information on the acceptability of the advice given, how people incorporated the tips into their lives, whether the behaviours developed into habits, and how the participants subjectively experienced this. The interview schedule included open-ended questions such as 'How have you found using the tips', 'Can you explain to me how you did each of the tips', 'Were some tips harder than others', and 'Did you plan how you were going to do the tips'. The interviews were based around the schedule but the researcher was flexible and responsive to the participants. The

[29] The 'TenTopTips' leaflet had not been designed by the Cancer Research UK design team at this time. The tips given to participants were the same as those in Appendix 4.1 but were presented on an A4 sheet rather than in this format.
[30] The additional information shown in the appendix is that used in Study 2, in this pilot study the information was similar but less detailed, for example some of the suggestions for how to achieve the tips were developed through discussions with participants in the pilot study.
[31] a tick sheet is part of the leaflet. Additional sheets were provided so that participants did not have to photocopy the leaflet sheet.

interview began with a very open question; 'How have you found using the tips' to allow the participant to feel comfortable and discuss the aspects of the experience they felt were most important. Prompts, such as 'Can you tell me more?', were used to encourage participants to discuss topics in detail. Interviews were recorded and transcribed.

A thematic analysis approach was used to analyse the interviews (Joffe & Yardley, 2004). This allows for an examination of the experience from the point of view of the participant as well as asking critical questions of the data. The approach taken is an idiographic case-study approach which begins with particular examples and works up to a more general categorisation. The analysis was performed by reading each transcript a number of times and making notes, in the margins, which helped to identify preliminary themes. These were compared across the interviews and used to create shared themes. These shared themes were clustered to form super-ordinate categories, both of which are presented in the results. This qualitative approach was chosen because the aim was to investigate participant's views and understand their experience of using the tips. The interview method allowed participants to discuss any issues they felt were relevant, many of which may not have been predicted in advance.

The validity of the interpretation was assessed by creating an audit trail of the theme development process (Holloway & Wheeler, 1996). A second researcher conducted an independent audit and used the trail to check that the theme development process was valid, that themes were credible in relation to the words of the participants, and that the quotes presented were representative of all the interviews. This confirmed the appropriateness of the themes. Appendix 4.3 - 4.5 show an example interview transcript (with shared themes marked), a table showing which themes were evidenced in each of the ten interviews and the final list of themes with the example quotes which are presented in the results section below.

RESULTS

Quantitative results

Three men and seven women participated in the study. Their average age was 43 years (range 24-59). Baseline mean weight was 88.6 kg (range: 72.4 kg to 112.3 kg) and mean BMI was 32 kg/m^2 (range: 26 to 39.5).

Eight out of the ten participants lost weight during the study (Table 4.2), with a mean weight loss of 3.1kg ($t(9)=3.1$, $p=0.012$), a mean BMI reduction of one unit, and a mean percentage weight loss of 3.3%. Weight change ranged from a loss of 9.9kg to a gain of 1.3kg. The median weight loss was also 3.1kg.

Two participants did not complete their tick sheets. The average completion across the eight participants who provided this data, ranged from 52% (Go Reduced Fat) to 90% (Don't Forget your Five a Day). The percentage completion rate of the tips over the eight weeks for individual participants ranged from 61% to 100% (Table 4.2).

Table 4.2: Participant characteristics and results

ID	Gender	Age (years)	Baseline weight (kg)	Average Completion (%)	Weight change (kg)
	Female	24	72.4	89.5	+1.3
	Female	47	82.1	---	+0.5
	Female	46	80.7	83.0	-1.3
	Male	46	97.3	61.8	-2.1
	Female	54	103.7	57.6	-2.6
	Male	37	95.5	61.4	-3.6
	Female	59	84.2	---	-3.7
	Female	52	74.9	100.0	-4.7
	Female	34	83.2	81.3	-5.4
	Male	41	112.3	72.1	-9.9

Qualitative results

Qualitative analysis of the interviews revealed 22 themes which were grouped into five super-ordinate categories. The themes within each super-ordinate category are shown in Box 4.2. These are described below with example quotes.

Box 4.2: Shared themes grouped into super-ordinate categories	
Attitudes towards the tips Overall positive Simple and easy to remember Flexible Not restricted Initially performing some tips Strict compliance not critical Tricks **Developing a Routine** Developing a routine is important Planning Trial and error A wish to have planned more Success in developing routines	**Automaticity development** Initial thought and effort required Became easier with repetition Required little thought after some time **Cues** Context Time Internal stimuli **Habits** Behaviours are habits Feel 'strange' if don't do it Time to form a habit Confidence in continuing with tips

Attitudes towards the tips

The interviews revealed that the advice given in the 'TenTopTips' was viewed positively (e.g. '*Yeah I think most of us have enjoyed doing it'* (SC)). Participants found the tips easy to understand and remember (e.g. '*I found them just simple to understand'* (KW). *'I just think they are kind of pretty easy to remember, they're quite straightforward and don't really take much memorising*'(PW)), although one participant did find them difficult to remember to start with (*'I just found that quite difficult because well just because I kept forgetting you know'* (HM)). HM found that once she planned how she was going to perform the tips they were easier to remember. Participants reported that they liked the fact that the tips were flexible enough to be interpreted individually and allowed them to adapt them to fit with their lifestyle (e.g. '*I'm trying to make it work in my own way rather than sticking to it very rigidly*' (RH)). They hadn't felt restricted and had enjoyed eating their 'normal' food, (e.g. '*I'm going to continue because it isn't like I stopped eating something that I have to go back to that's what usually happens when you go on a diet you are eating soup or toast and then you are watching your calories, I didn't watch my calories at all and yet I felt healthier and I still lost weight and I feel good as well* (LK)).

Most participants were already doing some of the tips when they started, but this was viewed positively as being some way ahead already (e.g. '*I think a number of us found that it was quite good that there were one or two on here that weren't difficult for us to do ... like so for me, the drinking one was not a problem at all because I don't drink it anyway and that's quite nice because you feel oh I've got that under my belt'* (HM)). Participants also took the view that perfect compliance was not critical. For some this

meant deciding that one tip wasn't going to fit into their lifestyle and leaving it out; others took the occasional day-off which was experienced as being in charge of their own behaviour (e.g. *'we are usually still watching TV and eating food, it's not that I just go to the dining table always, I still eat there but I will just not take any more food'* (LK). *'When I did break it I knew I was breaking it and I felt it was my, sort of my choice if you like so it wasn't a bad thing and since I've been back from holiday I've gone straight back onto it'* (KW)). Participants also used their own 'tricks' to help them to do the tips (e.g. *'the caution with your portions....I mainly did that by having smaller plates'* (RH). *'I found that have my supper, brush my teeth, and I won't eat again, I think I won't eat again because I'm too lazy to go and brush them again'* (EM).

Developing a Routine

Participants found that developing a routine was important, and believed that establishing the behaviours as part of their daily routine helped to incorporate them into their lives *(e.g. 'some things have to be routine otherwise it won't work' (AL). 'I have to just to name a routine of how I am going to watch what I eat' (LK)).* Some participants had made specific plans to get into a routine *(e.g. 'I thought about the walking and how I would achieve that' (RS)),* but others used trial and error *(e.g. 'that first week it was all just sort of a whole heap of things, and you're – like - oh I'm on to this one now, and oh have I done that,.. sort of thing' (HM)).*

The non-planners sometimes expressed a wish that they had planned more *(e.g. 'maybe if I had planned around it, it might have helped' (KW)).* However, whether they planned or not, all participants described having developed routines for the recommended behaviors *(e.g. 'Just following them from one week to the next, they just become sort of one routine the more it goes on' (PW)).*

Automaticity development

Participants described that at first doing the tips each day required thought and effort, and they had to consciously keep them in mind *(e.g. 'more thought at the beginning was required' (GC). 'week 1 I think it was the case that I felt that I had to do all ten all in one go and I just found that quite difficult because well just because I kept forgetting you know' (HM)).* Over time carrying out the behaviors became easier *(e.g. 'initially it was sort of difficult because obviously you've got to change your eating habits, your drinking habits and your exercise habits and it was good that it covered all three bases*

... but it got easier, it did get easier over time' (RH)). By the end of the eight weeks, most participants reported that doing the tips required little thought *(e.g. 'I don't really think too much about it' (RS); 'I think that some of them just worm their way into your brain' (SC))*.

Cues

The majority of participants had chosen contextual cues *(e.g. 'every lunchtime since I started I've been out for a walk regardless of how short or long' (EM); 'first thing in the morning .. prepare carrots or radishes or whatever' (RS); 'I tend to automatically think - oh I'll walk somewhere to add a few more steps on rather than to catch a bus or whatever and things' (GC))*. Other participants gave examples of behaviors being cued by time or internal stimuli, but these were less common *('I will have it 1 o'clock or half past one' (LK: talking about lunch); 'in the evenings when I've had the munchies sitting there watching telly, I'm just opening a packet of raisins and eaten them or an apple and stuff' (KW))*.

Habit strength

Some of the tips were spontaneously described as having become habits *(e.g. 'I think in the eight weeks ... I don't think all of these are still ingrained behavior but I think that a good - say - 7 or 8 of them actually are, so I think that's a good outcome' (HM))*. A few participants even expressed feeling strange if they did not do the tips, giving further support to their habitual nature *(e.g. 'it's easy to have a salad and now I actually feel quite strange if I haven't done that' (HM))*.

Participants made a number of statements that were indicative of how long they felt it took the behaviors to become habitual (time to form a habit). These included: *'I think after the first couple of weeks all of them became sort of second nature' (KW)*, and *'they are quite easy to do and I'd say after the third or fourth week you sort of fall into a routine' (RH)*.

Most participants said that they felt confident continuing with the behaviors over the longer-term *(e.g. 'It was fine, I'm going to continue' (LK); 'they are ingrained' (HM)*. However this was not the case for everyone. PW was interviewed 5 days after the 8 week program was complete and had already found himself reverting to his old ways

(e.g. *'I've slipped up a bit actually in the four or five days since it finished, but not too much' (PW)).*

DISCUSSION

The 'TenTopTips'

The primary aims of this study were to assess the acceptability of this simple advice based on habit theory, and to measure weight loss in a small sample of participants following the advice. The results indicate that advice on small behaviour changes in daily life was acceptable, viewed positively and resulted in weight loss.

Compliance (assessed using the returned tick sheets) with these simple recommendations was good, and results from the qualitative interviews showed that the format was acceptable. Participants liked the level of detail in the 'TenTopTips' which gave enough information to know what they needed to do, but in a format that was flexible enough to allow them to fit the new behaviours into their lives in their own way. A popular aspect of the 'tips' was that major changes were not needed; participants just modified what they were already doing.

On average, participants lost 3.1kg and reduced their BMI by one unit over the eight weeks, representing a loss of 3.3% of initial body weight. Given that the 'TenTopTips' involved only brief written information, the impact of this program looked promising relative to the outlay. The results suggested that it is possible to generate simple advice about behaviour that is straightforward to follow, easy to remember, undemanding to carry out and compatible with normal everyday life, which results in weight loss.

Habit formation

The second focus of this study was to investigate whether carrying out a set of behaviors in the same contexts on a daily basis for 8 weeks resulted in them becoming subjectively more 'automatic', in line with the concept of habit acquisition. In this small case series, all participants reported that the behaviors became part of their daily routine and felt more automatic over time. By the end of the 8 week period, most of the participants reported that at least some of the behaviors had become habits (e.g. *'they have wormed their way into my brain')* and would persist. This suggests that it is not

necessary to provide explicit rewards for performing the behavior at each repetition, nor to identify relevant cues and goals.

Across the group, people chose external situations, times and internal stimuli as cues, but situation cues predominated. Prospective memory research indicates that situation cues permit external cueing of an intended action, whereas time of day cues require monitoring to identify the time to act (McDaniel & Einstein, 2000), which suggests situation cues are likely to be more effective. The results of this study support this proposal.

Planning has been shown to increase the chances of carrying out an intended behavior (Gollwitzer, 1999) and has been proposed as a potential first step in habit formation (Orbell and Verplanken, 2005).[32] In this study, some participants used planning to aid completion of the 'tips', while those who did not often wished they had done so. Nevertheless, relying on trial and error did not appear to prevent habit development, although this may be because the participants were all highly motivated and therefore persevered until trial and error enabled them to establish routines. In a less motivated group it could be more important to help people establish routines to allow habit development to occur. However, the down-side of that is that most participants appreciated the relative simplicity of the 'TenTopTips' advice, and would not necessarily welcome the added complication of being more strongly encouraged to make plans.

The existing literature on habits appears to make no predictions about the length of time the process of habit acquisition takes. Perceptions of the time it took for the behaviours to become habits among the participants in this study varied, and there was also variability between behaviors. One person reported that all the behaviors felt habitual after two weeks, but others felt they were not fully automatic even after 8 weeks, indicated by them easily reverting to their 'old ways'. This could be due to differences between individuals in their propensities to form habits, different levels of motivation to perform the necessary number of repetitions, differences in the stability of the performance situation, or differential regularity of performance. Nothing from the interviews appeared to explain the variation. Individuals who reported carrying out the behaviors assiduously could still feel that they were not yet habitual; while others who

[32] Cited in Gollwitzer and Sheeran (2006) as manuscript under review.

had the occasional omission felt that they were habits. Whether the habits they formed were resistant to change beyond the 8 week period is unknown. It seems likely, based on Hull's (1943, 1951) research that some degree of perceived automaticity occurs before a habit has reached its final level of automaticity.

It has been suggested that in order to form habits, no opportunities to perform the behavioural response can be missed (James, 1890). However analysis of the tick sheets showed that all but one participant reported at least a few missed opportunities to perform the behaviors and although it was not possible in this study to assess whether this slowed the habit formation process, it did not appear to preclude habit acquisition. The unexpected finding that some participants reported feeling 'strange' if they did not perform a behaviour which they thought had become habitual, may indicate that the behaviour had become part of their sense of self (Verplanken & Orbell, 2003). This supports the suggestion that habitual behaviours may be associated with an intuition-based self-knowledge (Lieberman et al., 2004).

Limitations

This was a pilot study with many limitations. There was no information as to which tips individual participants were already doing before they started the study. The weekly contact was brief, but participants were weighed and this feedback is likely to have contributed to weight loss in its own right (O'Neil & Brown, 2005). Furthermore, without a control group, the impact of the 'TenTopTips' on weight outcomes is uncertain.

The information presented contained brief supporting information to help people know how to perform the recommended behaviours (e.g. what is a portion of fruit) as well as the 'tips', and we cannot assess the impact of the advice without this additional information. However, giving this information was no more difficult than giving the 'tips' without it. It would seem advisable to make such information available.

Qualitative analysis is not designed to generalise to populations. The experiences of the ten participants in this study are reflective of their experiences, rather than giving results that can be directly applied to others. In addition, although I endeavoured to be reflective as I conducted the analysis, and to consider alternative interpretations as I progressed, the results remain my interpretation of the text. However a second

researcher conducted an independent audit to assess the credibility of the interpretation and quotes are provided to allow the reader to assess if they agree with these interpretations. Despite the limitations - which are inherent in qualitative research - the findings are useful in helping to generate hypotheses for further work, and in combination with the quantitative results were an interesting first test of the theory of Context Dependent Repetition as a route to habit formation.

CHAPTER 5

STUDY 2: A RANDOMISED CONTROLLED TRIAL OF A HABIT-BASED WEIGHT LOSS INTERVENTION[33,34]

INTRODUCTION

The results from Study 1 suggested that a habit-based weight loss intervention can promote weight loss. The intervention consisted of a leaflet recommending a set of everyday eating and activity behaviours which together could promote weight loss. It incorporated advice on making the behaviours routine to encourage repetition in consistent contexts, and consequently, habit formation. The leaflet also contained a brief self-monitoring form. In the pilot study (Study 1) the average weight loss was 3.1kg over 8 weeks in a group of 7 women and 3 men. Study 2 aimed to replicate the weight loss results found in the pilot in a larger sample, to compare the intervention with a control condition, and to assess the impact of using the intervention ('TenTopTips') on psychological well-being (quality of life, body satisfaction and weight-efficacy).

It was designed as an exploratory randomised controlled trial with one intervention group weighed weekly (to replicate the conditions of the pilot study), one intervention group weighed every 4 weeks (to assess the efficacy of the intervention when delivered with less frequent weighing), and a waiting list control group. Participants arranged which of three days they would attend for assessments (Tuesdays, Wednesdays or Thursdays) and the days were randomised to condition. Habit strength was measured during the study and a number of possible predictors of weight loss were assessed. The methodology will be outlined in this chapter along with the primary results (adiposity and psychological well-being). The findings relating to predictors of weight loss and habit formation will be described in Chapter 6 and 7 respectively.

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[33] A version of this chapter has been accepted for publication as: Lally, P, Chipperfield, A. and Wardle, J. 'Healthy habits': efficacy of simple advice on weight control based on a habit-formation model. *International Journal of Obesity* (in press)

[34] The randomisation was performed at a group, rather than an individual level

Hypotheses

The hypotheses tested in this chapter are that:

i) The 'TenTopTips' will result in more weight loss and greater improvements in psychological well-being, than the control group (over eight weeks).

ii) Being given the 'TenTopTips' will result in weight loss and improvements in psychological well-being over 32 weeks.

The design of the trial also allowed for an examination of the difference in weight loss, between those who were given the intervention immediately and those in the waiting list group who had an 8 week delay before being given the leaflet.

Ethical approval

Ethical approval for this study was granted by the UCL Committee for the Ethics of Non-NHS Human Research. A copy of the confirmation letter is given in Appendix 5.1.

METHODS

Design

The design (see Figure 5.1) had two phases: i) a trial phase consisting of an 8 week period when participants were randomly allocated either to one of two intervention conditions (differing in having weekly (I-WW) or monthly (every four weeks) (I-MW) weight checks) or to a waiting-list control condition (WL) who were weighed monthly, and ii) a 32 week follow up of those in the treatment groups (the groups continued to be weighed weekly and monthly in the two intervention groups respectively). Weight outcomes used in analyses were those recorded at 4-weekly intervals over the 32 weeks.

The WL group were offered the intervention after 8 weeks and they continued to be weighed monthly until the end of the study. Therefore data are available for 6 months over which these participants were using the intervention. In this chapter, these data were only used to compare the weight loss in this group over 6 months with that of those in the intervention groups over the first 6 months that they used the intervention.

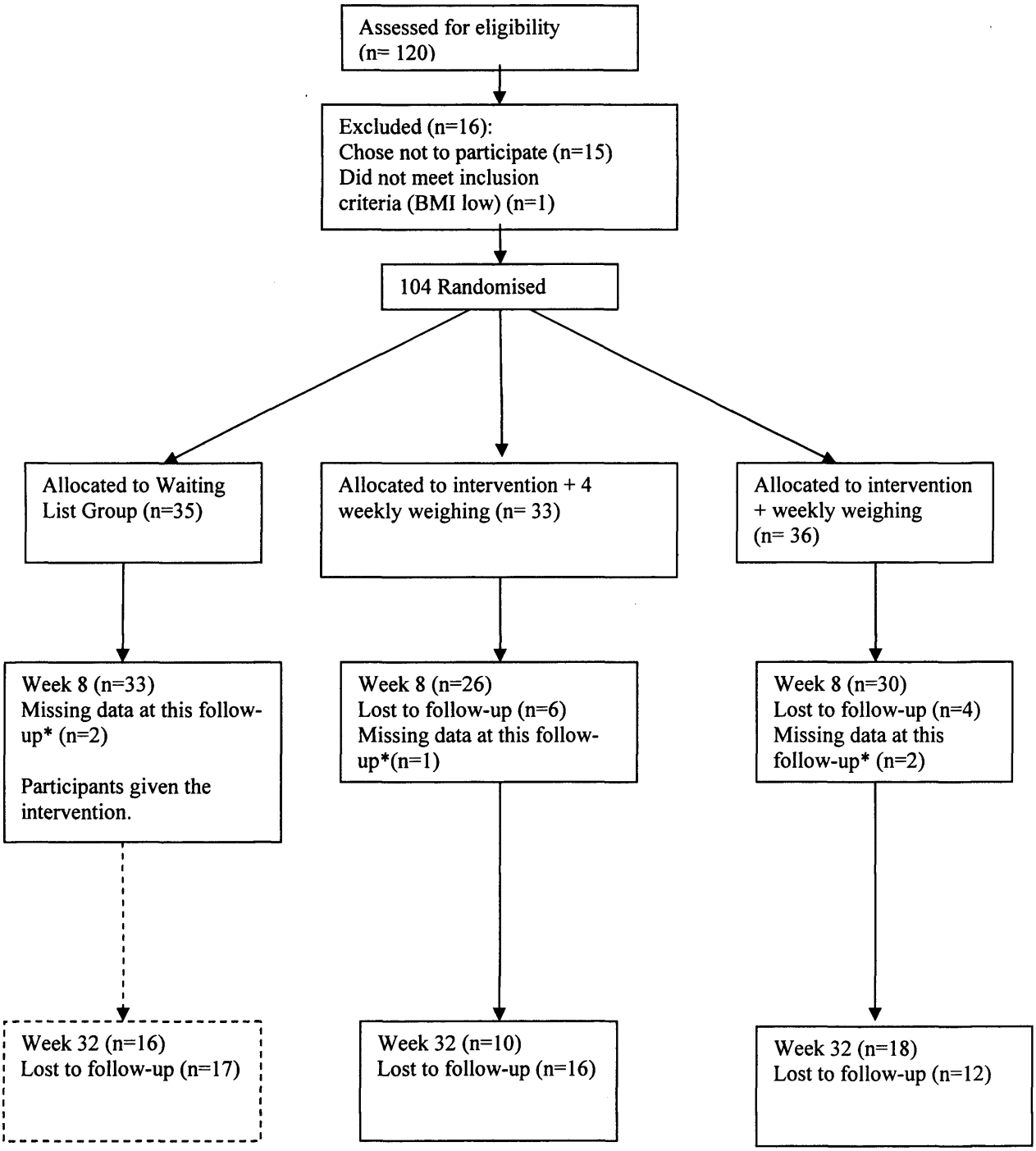
A power calculation was conducted using the software Power and Precision, based on the weight change data from Study 1, assuming that the control group would not lose weight. The values used were a mean difference between groups of 3.1kg and a standard deviation for both groups equivalent to that found in Study 1 for weight change (3.2), a p-value of 0.05 and power of 0.95. This showed that 54 participants would be needed in a study with two groups. As this study involves three experimental groups 81 participants would be required, and to allow for attrition 120 participants were recruited.

Participants

Participants were recruited from local businesses (including staff from University College London). Managers of these organisations sent an email to their staff inviting employees to contact the researcher if they were interested in participating[35] (Appendix 5.2). The advertised inclusion criteria were that participants were aged over 18 and had a Body Mass Index over 25 kg/m^2. In the final sample participants with a BMI over 24 kg/m^2 were included.

[35] At University College London the email came directly from the researcher.

Figure 5.1: Participation Flow



*participants may have returned later in the study but did not provide data at 8 weeks

Procedure

Potential participants (those who contacted the researcher) were sent an information sheet explaining the study (Appendix 5.3). If they were still interested in participating they agreed, with the researcher, which day (of three) they would attend an initial meeting to start the study. Once all participants had been allocated to a day, the days were randomly designated (by a researcher not involved in the study) as the three experimental groups.

Participants in the intervention conditions were provided with

- the 'TenTopTips' leaflet (Appendix 4.1),
- additional information[36] (Appendix 4.2)
- a weight chart to record weights at assessment points and
- blank tick sheets[37]

At the initial meetings the study was explained (reiterating the information provided in the information sheet and also explaining the randomisation procedure), consent (Appendix 5.4) was obtained from those who agreed to take part and baseline measurements were completed. Each group was then told which experimental group they had been assigned to and therefore when they were invited to return for further measurements. The Waiting List group were told that they were acting as a control group to compare with those using the 'tips' and that they would receive the 'tips' in 8 weeks. They were not told either to try to lose weight without the tips or specifically not to try to lose weight. Following the initial meeting, all subsequent measurements were taken at drop-in sessions where participants could attend at a time convenient to them. When participants could not attend on the appropriate day individual arrangements were made for them to come at a different time. At week 8 those in the waiting list group were weighed and completed the questionnaires. They were then given the materials which had previously been provided to those in the intervention groups.

[36] This additional information (shown in Appendix 4.2) was compiled from the information available on the 'TenTopTips' website, the details of which are given on the leaflet.

[37] one tick sheet is part of the leaflet. Additional sheets were provided only so participants did not need to photocopy it.

Measures

All measures completed during the study are shown in Appendix 5.5.[38] Details of how total scores were calculated for the questionnaires, are shown in Appendix 5.6. Three measures of psychological well-being were included (body satisfaction, weight-efficacy and quality of life) and assessed at baseline and weeks 8, 16 and 32 (only baseline and week 8 in the waiting list group). Eating behaviours were assessed at baseline and for the waiting list group at week 8.

Anthropometrics

Height was measured at baseline using a Leicester Freestanding Stadiometer. Weight and percentage body fat were assessed using a TANITA Body Composition Analyzer (Model TBF-410M).

Demographics

Demographics were reported at baseline (questionnaire shown in Appendix 5.7). Number of previous weight loss attempts was recorded at week 8. Participants were asked to list each time in their lives when they had tried to lose weight, and this was used as the number of attempts.

Psychological well-being

Body Satisfaction

The Body Satisfaction Scale (BSS (Slade, Dewey, Newton, Brodie, & Kiemle, 1990) α =0.83[39]), shown in Appendix 5.8 asks respondents to rate their satisfaction with 16 body parts. In the original validation study Slade et al (1990) used a 7-point Likert response scale where 1 represented very satisfied and 7 very unsatisfied. In this study I reversed the scoring so that 1 represented very unsatisfied and 7 represented very satisfied. Slade et al (1990) found that overweight participants had an average score of 64. This is equivalent to a score of 64 on the reverse coded scale.[40]

[38] Some of the questionnaires were completed at more time points during the study but were later not used in analyses so for simplicity are not shown in this Appendix. Details of questionnaires that are used only in the analyses presented in subsequent chapters are described in the relevant chapters.
[39] Alpha values are those obtained in this study.
[40] The scale scores range from 16 to 112, making a score of 64 the mid-point.

Weight-efficacy

The Weight Efficacy Life-Style Questionnaire (WEL (Clark, Abrams, Niaura, Eaton, & Rossi, 1991) $\alpha = 0.85$[39]) shown in Appendix 5.9 measures self-efficacy for resisting eating. The questionnaire consists of 20 items describing different eating situations and respondents are asked to rate how confident they are that they can resist eating in these situations from 0 (not confident) to 9 (very confident). It has been used in a number of different overweight and obese samples with scores ranging from 99 to 140 (Clark et al., 1991; Clark, Cargill, Medeiros, & Pera, 1996; Delahanty, Meigs, Hayden, Williamson, & Nathan, 2002; Richman, Loughnan, Droulers, Steinbeck, & Caterson, 2001).

Quality of life

The shortened Extended Satisfaction With Life Scale (ESWLS (Gregg & Salisbury, 2001) $\alpha = 0.88$[39]), shown in Appendix 5.10 is a measure of quality of life across 11 life domains. It has two items per domain and uses a 5 point Likert response scale. Normative values are not available for the shortened ESWLS, but it is possible to estimate a normative value for the current scale from values found using a previous version of the questionnaire (Alfonso, Allison, Rader, & Gorman, 1996). The older version used 50 items on a 7 point Likert scale. The estimated norm value for the shortened scale is 75.[41] This is not an ideal approach because the original version only covered 9 life domains and the original values were obtained from American students who may be quite different from the current sample. However it gives something against which to anchor the results in the current study, and would indicate if the current values were extreme.

Eating behaviours

A behaviour questionnaire (BQ: Appendix 5.11) was designed specifically for this study to assess which of the recommended behaviours participants were already performing prior to the study. This was similar to the adolescent food habits checklist (Johnson, Wardle, & Griffith, 2002) but the behaviours were appropriate for this study.[42] This

[41] The norm value for the full version is a total score of 237.9. This divided by 50 and multiplied by 22 gives an estimate for the total score on the 22 items which would be expected with the shortened version if this had a 7 item scoring system. Dividing this by 7 and multiplying by 5 gives an estimate for the score on the shortened version with the 5 point scale.

[42] A number of other behaviours were also included in this questionnaire, to reduce the chance that participants would assume this questionnaire was directly related to the recommended behaviours in the 'TenTopTips' and consequently start making changes to their behaviours. These questions are not shown in the appendix.

questionnaire asked participants to rate 16 behaviours with the response options of true or false, with two items also having the option of 'I never...'. For each behaviour the recommended options (healthy) were given a score of 1 and the alternative a score of 0. For example responding true to 'I usually avoid eating fried food' scored 1. For the small number of occasions when a participant had failed to answer one of these questions, the relevant item was scored as zero. The items were summed to give a total for the number of recommended behaviours reported.

Data Analysis

Imputing missing weight data

The analyses focus on weights recorded at the 4 weekly assessments. The first problem was that participants sometimes attended for measurement on days other than that specified in the study design. Initially data were entered for the testing week which was closest to the day they attended. In order to maximise data available for analysis, weights from surrounding weeks were used to impute data for each 4 weekly assessment. Using week 4 as an illustration, when weight was missing the value was estimated using the following in order of preference: i) mean of week 3 and 5, ii) week 5, iii) week 3, iv) mean of week 2 and 6. If none of these estimates were possible the data were considered missing. Corresponding rules were used for week 8, 12, 16, 20, 24, 28 and 32. For the last week (week 32), week 34 and week 35 data were also accepted. The details of how many values were imputed at each stage of this process are shown in Appendix 5.12. An equivalent approach was used for percentage fat data.

Parametric assumptions

Normality was assessed by looking at histograms and skewness and kurtosis statistics (as a rule of thumb values between -1 and 1 were considered acceptable). Levene's test was used to assess homogeneity of variance. Where these assumptions were not met non-parametric tests were run to confirm the parametric findings and are only reported if they differed from the parametric results.

Between group analysis: over 8 weeks

To test the first hypothesis (that the 'TenTopTips' resulted in weight loss and improvements in psychological well-being, compared to the control group) the three groups were compared on change in these variables over the first 8 weeks. Analyses were conducted in two ways. The first included only those participants with data

available at week 8 (completers analysis), and the second used an intention-to-treat approach with the last observation carried forward (ITT LOCF). For those who had dropped-out of the study, missing values at week 8 were estimated by carrying forward the last weight value available. For those who returned later in the study their weight at week 8 was estimated by calculating the difference between the closest available values before and after and distributing the change equally over time. A second intention-to-treat analysis was performed using baseline values carried forward (BCF). In this analysis baseline values were carried forward for all participants who did not provide data at week 8 even if the participant returned for assessments later in the study.

To assess differences between those with and without data at week 8, t-tests (or Mann-Whitney U) were used to compare them to those with data on age, baseline weight and BMI, and Chi-square tests were used to test differences in gender, marital status, education and ethnicity.

Differences between experimental groups on baseline characteristics were assessed using One-way ANOVA's with Tukey post-hoc tests (or Kruskall Wallis ANOVA, using Mann-Whitney U to assess where group differences lie) and Chi-square tests.

Group differences in changes in adiposity and psychological well-being (over 8 weeks) were assessed using ANOVA's with Tukey post-hoc tests (or Kruskall Wallis ANOVA, using Mann-Whitney U to assess where group differences lie) and ANCOVA's (to control for group differences in gender, age and baseline weight) with Bonferroni post-hoc tests.[43] Within the WL Group a paired samples t-test was performed to check if total number of recommended behaviours reported changed from baseline to week 8 within this group.

Follow-up analysis: over 32 weeks

To test the second hypothesis (that being given the 'TenTopTips' resulted in weight loss and improvements in psychological well-being over 32 weeks) a longitudinal analysis assessed weight change during the study within the treatment groups (data was combined).

[43] SPSS does not give the option of Tukey post-hoc analyses in an ANCOVA, therefore a Bonferroni test was used.

To assess the validity of combining the two treatment groups in this analysis, ANCOVA's (controlling for group differences in gender, age and baseline weight) were run comparing the groups on weight change at each time point during the study. These analyses used only those with valid data at each time point.

Again both completers and LOCF analyses were used. The completers analysis included all available data at each time point. The LOCF analysis again carried the last observation forward after a participant had dropped-out of the study. Where values were missing between two other assessments with data, the difference between the two available values were calculated and the missing values estimated by distributing the change equally over time. An ITT BCF analysis was conducted at week 32 which carried forward baseline values for all those with missing data at the end of the study.

To assess differences between drop-outs and those remaining in the study at week 32, t-tests (or Mann-Whitney U) were used to compare them on age, baseline weight and BMI, and Chi-square tests were used to test group differences; on gender, marital status, education and ethnicity. T-tests (Mann-Whitney U) were used to assess differences in weight loss between those who subsequently dropped-out and those who continued, at each assessment point during the study.

Paired-sample t-tests (or Wilkoxon signed-rank test) were used to assess whether changes from baseline to the follow-up points were significant for the psychological well-being variables. This was chosen to allow all participants who provided data at each time point to be included in each analysis rather than restricting it to those with data at all points (required in a repeated measures ANOVA). Associations between weight loss and psychological well-being were assessed using Pearson (or Spearman) correlations.

Waiting List controls: once using the intervention

A final analysis was conducted to examine the difference in weight loss when using the 'TenTopTips', between people who were given the intervention immediately and those who waited for 8 weeks. The waiting list group data were recoded with week 8 as baseline (and week 12 as week 4 and so on). Weight loss over the 24 weeks was then compared between groups. This analysis used only those with data at each time point.

RESULTS

Participants

120 individuals attended the three initial meetings. Characteristics of the 104 who chose to participate are presented in Table 5.1. This table shows that the three treatment groups differed in baseline weight ($F(2,101)=3.77$, $p=0.026$) with the WL group being lighter than the I-MW group, but they were not significantly different on BMI. The waiting list group was also significantly younger ($F(2,100)=4.96$, $p=0.009$) than both other groups. There were no significant differences between the groups on body satisfaction ($F(2,100) = 0.297$, $p= 0.744$, N=103), quality of life ($F(2,101) = 0.516$, $p=0.599$, N=104) or weight-efficacy ($F(2,101) = 0.387$, $p=0.680$, N=104). The mean score for body satisfaction was 74.1 (SD15.5), for quality of life was 72.8, (SD12.9), and for weight-efficacy was 107.5 (SD23.3).

Table 5.1 Participant characteristics[1]

	WL (N=35)	I-MW (N=33)	I-WW (N=36)	p value
Continuous variables[2]	**Mean (SD)**			
Age, years[3]	36.0[a] (9.8)	42.1[b] (9.9)	43.3[b] (11.4)	0.009
Weight, kg	84.1[a] (11.6)	93.6[b] (17.6)	91.6[ab] (15.7)	0.026
BMI, kg/m^2	29.5 (3.0)	31.7 (5.1)	31.6 (5.5)	0.076
Percentage body fat[3]	35.3 (8.2)	33.3 (8.2)	35.6 (8.5)	0.490
Categorical variables				
Gender %(N)				
Male	23 (8)	45 (15)	33 (12)	0.143
Female	77 (27)	55 (18)	67 (24)	
Education %(N)				
GCSE	6 (2)	12 (4)	8 (3)	0.149
Vocational	3 (1)	3 (1)	8 (3)	
A-Level	3 (1)	9 (3)	6 (2)	
Bachelors degree	40 (14)	24 (8)	8 (3)	
Masters	23 (8)	24 (8)	36 (13)	
PhD	26 (9)	18 (6)	31(11)	
Other	0 (0)	9 (3)	3 (1)	
Marital Status %(N)				
Single	40 (14)	24 (8)	17 (6)	0.169
Married	23 (8)	45 (15)	53 (19)	
Cohabiting/Living with partner	29 (10)	24 (8)	19 (7)	
Divorced/Separated/Widowed	9 (3)	6 (2)	11 (4)	
Ethnic Group %(N)				
White	77 (27)	88 (29)	78 (28)	0.138
Black/Black British	6 (2)	3 (1)	8 (3)	
Asian/Asian British	14 (5)	0 (0)	3 (1)	
Other	3 (1)	9 (3)	11 (4)	

[abc] indicates significant differences between subgroups with different superscripts.
[1]Anthropometric measurements taken at baseline.
[2] p values are presented from ANOVAs but the results reflected the same pattern as those found using Mann-Whitney U tests for weight and BMI which were not normally distributed.
[3]Data for these variables was not available for all participants; for age N= 35, 33 and 35 and for percentage body fat N=35, 32 and 34.

8 week results: adiposity and psychological well-being

There were no significant differences between those who did and did not provide data at week 8 in baseline weight, BMI, gender, age, marital status, ethnic group or education (see Table 5.2).

Table 5.2 Comparisons between those who did and did not provide data at week 8

	Data at week 8 (N=89)	Missing data at week 8 (N=15)	p value
Continuous variables[2]	**Mean (SD)**		
Age, years[1]	40.0 (10.7)	42.8 (11.4)	0.356
Baseline weight, kg	89.9 (16.1)	88.6 (11.6)	0.763
Baseline BMI, kg/m^2	31.0 (4.8)	30.6 (4.0)	0.809
Categorical variables			
Gender %(N)			
Male	35 (31)	27 (4)	0.536
Female	65 (58)	73 (11)	
Education %(N)			
GCSE	7 (6)	20 (3)	0.658
Vocational	4 (4)	7 (1)	
A-Level	6 (5)	7 (1)	
Bachelors degree	26 (23)	13 (2)	
Masters	28 (25)	27 (4)	
PhD	26 (23)	20 (3)	
Other	3 (3)	7 (1)	
Marital Status %(N)			
Single	29 (26)	13 (2)	0.218
Married	37 (33)	60 (9)	
Cohabiting/Living with partner	24 (21)	27 (4)	
Divorced/Separated/Widowed	10 (9)	0 (0)	
Ethnic Group %(N)			
White	82 (73)	73 (11)	0.592
Black/Black British	4 (4)	13 (2)	
Asian/Asian British	6 (5)	7 (1)	
Other	8 (7)	7 (1)	

[1]one participant did not provide data so N's were 88 and 15 respectively
[2]presented from t-tests (were similar using Mann-Whitney U for weight and BMI which were not normally distributed)

Table 5.3 shows the 8 week changes in adiposity and psychological well-being using both a completers and LOCF analysis. In the completers analysis, the two intervention groups lost 2.4kg (I-MW) and 1.6kg (I-WW), compared with 0.4kg in the waiting list group. Weight loss was significantly different in the three groups ($F(2,86) = 9.480$, $p<0.001$), with both intervention groups losing significantly more weight than the control group. The difference in weight loss between the two intervention groups was not significant.

Table 5.3 Means and standard deviations of changes in adiposity and quality of life over eight weeks by group

8 week change in:	WL (Completers: N=33) (ITT: N=35)	I-MW (Completers: N=26) (ITT: N=33)	I-WW (Completers: N=30) (ITT: N=36)	Difference (p value)
Weight (kg)				
Completers	-0.42 (1.56)[a]	-2.40 (2.19)[b]	-1.64 (1.59)[b]	<0.001
ITT LOCF	-0.44 (1.53)[a]	-2.03 (2.13)[b]	-1.48 (1.54)[b]	0.001
Percentage Body Fat[1]				
Completers	+0.15 (2.25)	-0.23(1.77)	-0.55 (1.41)	0.357
ITT LOCF	+0.26(2.15)	-0.12(1.67)	-0.55(1.64)	0.184
Quality of Life[1] (ESWLS)				
Completers	-1.94 (9.13)	-0.75 (6.81)	+1.99 (8.69)	0.202
ITT LOCF	-1.72 (8.60)	-0.52 (5.66)	+1.49 (7.54)	0.186
Body Satisfaction[1] (BSS)				
Completers	-2.93 (12.26)	+0.41(10.02)	+0.32(8.46)	0.399
ITT LOCF	-2.51(11.37)	+0.28(8.31)	+0.24(7.30)	0.348
Weight Efficacy[1] (WEL)				
Completers	-1.04(19.29)	-1.27(17.64)	+7.02(20.76)	0.206
ITT LOCF	-0.92 (18.13)	-0.93 (14.96)	+5.26 (18.16)	0.223

[abc] indicate significant differences between subgroups with different superscripts based on uncontrolled analysis

[1]Data for these variables was not available for all participants; for percentage body fat N=31, 26, and 28, and for quality of life, body satisfaction and weight efficacy N= 30, 23, and 27.

Differences in percentage fat and psychological well-being favoured the intervention groups, but were not significant over 8 weeks. The Kurtosis value for change in weight-efficacy (for both completers and LOCF) suggested the normality assumption was not met. In the completers analysis a Kruskal-Wallis ANOVA showed a significant difference between the groups on change in weight-efficacy (χ^2 =6.7, p=0.034, df=2). Mann-Whitney U tests between each pair of groups found a significant difference between Groups 1 and 3 (U=247.5, p=0.012). In the LOCF analysis this remained significant (χ^2 =6.183, p=0.045, df=2) with a significant difference between both WL and I-WW (U=437.5, p=0.026) and between I-MW and I-WW (U=426, p=0.041).

The analysis shown in Table 5.3 was re-run controlling for gender, age and baseline weight.[44] There remained a significant difference between groups on weight change in the completers analysis (F(2,82) = 5.881, p=0.004) and the ITT LOCF analysis (F(2,97) = 4.590, p=0.012) however post-hoc tests revealed these were between the control group and I-MW group. When the two intervention groups were combined and compared to the control group (controlling for gender, age and baseline weight), differences were significant in the completers analysis (F(1,83)=9.839, p=0.002) and the

[44] Although the groups were not significantly different by gender there were potentially important differences and therefore this was included as a covariate, along with age and baseline weight.

ITT LOCF analysis (F(1,98)=8.314, p=0.005). All other group differences remained non-significant.

In a BCF analysis controlling for gender, baseline weight and age, there was a significant group difference (F(2,97)=3.430, p=0.036) in weight loss with this falling between the WL and I-MW groups. The unadjusted means for the WL, I-MW and I-WW were 0.39kg (SD1.51), 1.89kg (SD2.18) and 1.39kg (SD1.59) respectively. When the two intervention groups were combined the difference remained significant between intervention and control (again controlling for gender, weight and age) (F(1,98)=6.130, p=0.015).

A paired-samples t-test showed a significant change in the number of the recommended behaviours reported by the waiting list group over the first eight weeks (t(29)=2.134, p=0.041, N=30). The number of recommended behaviours reported increased from a mean of 8.7 (SD2.6) to 9.6 (SD3.3).

32 week results: weight

Differences between the two intervention groups were not significant at any time point when age, baseline weight and gender were included as covariates (Table 5.4). Therefore data from the two groups were combined (N=69) in the following analyses.

Table 5.4 Means and standard deviations of weight loss (kg) in the two treatment groups*

	I-MW			I-WW			ANCOVA
	Mean	SD	N	Mean	SD	N	p value
Week 4	1.33	1.50	32	0.99	1.06	35	0.493
Week 8	2.40	2.19	26	1.64	1.59	30	0.263
Week 12	3.27	3.19	20	1.54	1.85	27	0.114
Week 16	3.70	2.82	27	2.23	2.13	26	0.093
Week 20	2.99	3.78	16	2.75	2.32	21	0.905
Week 24	5.18	4.34	14	3.25	2.64	22	0.372
Week 28	4.64	3.20	11	2.76	2.56	19	0.429
Week 32	4.64	3.82	10	3.34	3.43	18	0.897

*the means shown are unadjusted and the p values are from analyses controlling for age, gender and baseline weight

As expected, there was progressive loss to follow-up, with 46 participants providing data at 16 weeks and 28 (41% of those who started the study) at 32 weeks (Figure 5.1, and Appendix 5.13). Those lost to follow-up were not significantly different from those who completed the study on baseline weight, BMI, gender, age, marital status, ethnic group or education (Table 5.5). 70% of those in the monthly weighing group and 50%

in the weekly weighing group dropped-out during the 32 week study but this was not a significant difference ($\chi^2 = 2.770$, p=0.096, df=1).

Table 5.5 Comparisons between completers and drop-outs (within the treatment groups)

	Completers (N=28)	Drop-outs (N=41)	p value
Continuous variables[2]	**Mean (SD)**		
Age, years[1]	45.5 (10.5)	40.7 (10.4)	0.068
Baseline weight, kg	93.1 (16.4)	92.2 (16.9)	0.825
Baseline BMI, kg/m^2	31.0 (5.0)	32.1 (5.4)	0.402
Categorical variables			
Gender %(N)			
Male	46 (13)	34 (14)	0.305
Female	54 (15)	66 (27)	
Education %(N)			
GCSE	4 (1)	15 (6)	0.299
Vocational	4 (1)	7 (3)	
A-Level	14 (4)	2 (1)	
Bachelors degree	14 (4)	17 (7)	
Masters	29 (8)	32 (13)	
PhD	32 (9)	20 (8)	
Other	4 (1)	7(3)	
Marital Status %(N)			
Single	14 (4)	24 (10)	0.126
Married	50 (14)	49 (20)	
Cohabiting/Living with partner	18 (5)	24 (10)	
Divorced/Separated/Widowed	18 (5)	2 (1)	
Ethnic Group %(N)			
White	93 (26)	76 (31)	0.297
Black/Black British	4 (1)	7 (3)	
Asian/Asian British	0 (0)	2 (1)	
Other	4 (1)	15 (6)	

[1]one participant did not provide data so N's were 28 and 40 respectively
[2]presented from t-tests (were similar using Mann-Whitney U for weight and BMI which were not normally distributed)

Although not significant, there was a trend for drop-outs to have lost less weight, at the last weighing session they attended, than those who remained in the study (Table 5.6).

Table 5.6: Comparison of weight loss (kg) in those who dropped out and those who continued after each time point*

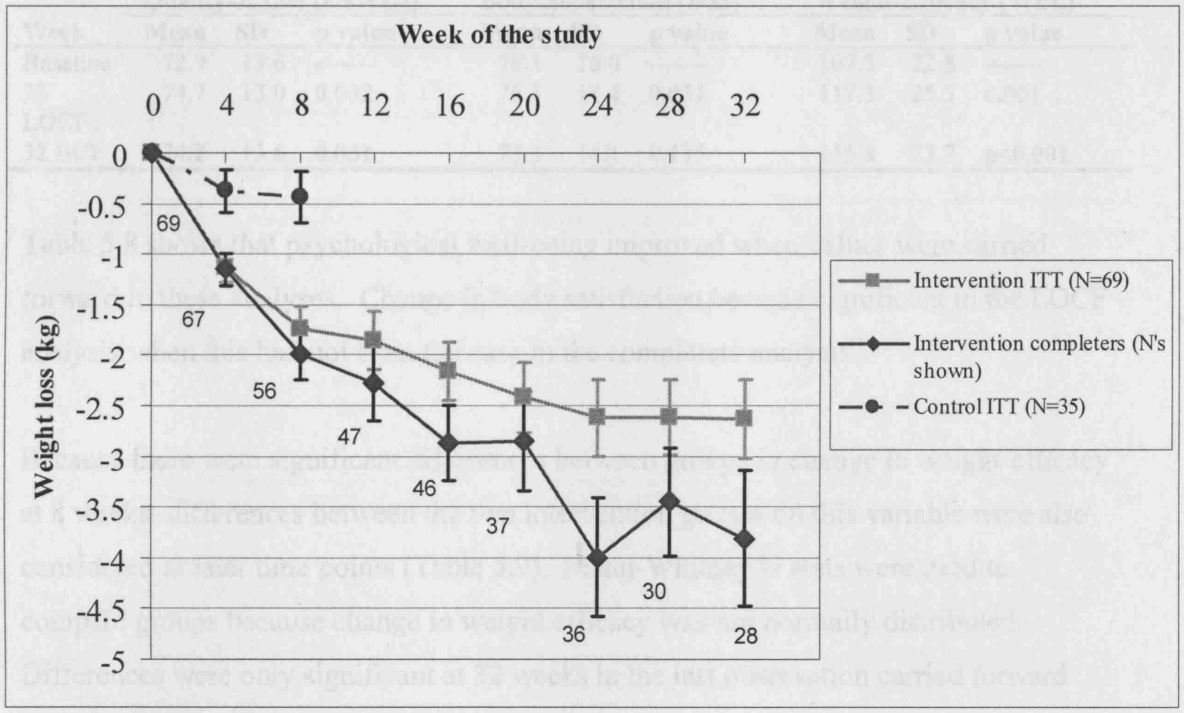
	Last week			Continued			
Week	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**t-test p value**
4	10	**0.77**	0.85	57	**1.22**	1.35	0.315
8	6	**1.02**	1.75	50	**2.11**	1.91	0.189
12	5	**0.98**	1.43	42	**2.43**	2.70	0.246
16	5	**2.90**	3.01	41	**2.86**	2.51	0.976
20	3	**0.70**	2.35	34	**3.04**	2.99	0.198
24	4	**4.06**	6.44	32	**4.00**	3.11	0.985
28	7	**2.47**	1.35	23	**3.75**	3.20	0.141

*all confirmed using Mann-Whitney U tests

Figure 5.2 shows the mean weight changes at each assessment point for completers and for all cases using LOCF. Data from the WL group are shown for the first 8 weeks.

Completers showed a pattern of continuing weight loss over follow-up, reaching 3.8kg (SD 3.6) at 6 months. Using a LOCF analysis this was reduced to 2.6kg (SD 3.2).[45] A BCF analysis showed that at 32 weeks weight loss would have been 1.54kg (SD 2.93, N=69). Of those who completed the study, 54% lost 5% or more of their initial body weight. A LOCF analysis reduced this to 26%, and BCF to 22%. Percentage body fat reduced by 1.96% (SD 2.47%) over the 32 weeks in the 27 participants who provided data at both time points.

Figure 5.2: Weight change over 8 months using the tips (N=69)*



* Error bars indicate Standard Errors.

32 week results: psychological well-being

Psychological well-being was assessed at four time points during the study. Some participants failed to complete questionnaires, reducing the numbers in these analyses. The means are presented, along with the paired-sample t-test results, comparing each follow-up to baseline, in Table 5.7. All three variables significantly improved from baseline to 16 weeks and quality of life and weight-efficacy improved from baseline to 32 weeks.

[45] The data used for this graph are shown in Appendix 5.14.

Table 5.7: Psychological well-being changes over 32 weeks

	Quality of Life (ESWLS)				Body Satisfaction (BSS)				Weight-Efficacy (WEL)			
Week	**N**	**Mean**	**SD**	**p value**	**N**	**Mean**	**SD**	**p value**	**N**	**Mean**	**SD**	**p value**
Baseline	69	72.9	13.6	-------	69	74.1	16.0	-------	69	107.3	22.8	-------
8	50	74.5	13.0	0.517	50	74.6	15.6	0.779	51	109.9	24.7	0.262
16	38	78.3	18.5	**0.007**	38	78.3	17.0	**0.018**	38	116.9	27.2	**0.001**
32	24	79.2	12.5	**0.029**	24	78.8	14.7	0.137	24	122.7	25.4	**p<0.001**

A LOCF and BCF analysis were conducted for these variables at 32 weeks and are presented in Table 5.8.

Table 5.8: Intention to treat analyses for psychological variables at 32 weeks (N=69)

	Quality of Life (ESWLS)			Body Satisfaction (BSS)			Weight-Efficacy (WEL)		
Week	**Mean**	**SD**	**p value**	**Mean**	**SD**	**p value**	**Mean**	**SD**	**p value**
Baseline	72.9	13.6	-------	74.1	16.0	-------	107.3	22.8	-------
32	74.7	13.0	0.052	76.3	14.4	**0.031**	117.3	25.5	**0.001**
LOCF									
32 BCF	74.2	13.6	**0.031**	75.3	14.1	0.135	115.8	23.7	**p<0.001**

Table 5.8 shows that psychological well-being improved when values were carried forward in these analyses. Change in body satisfaction became significant in the LOCF analysis when this had not been the case in the completers analysis.

Because there were significant differences between groups in change in weight-efficacy at 8 weeks, differences between the two intervention groups on this variable were also considered at later time points (Table 5.9). Mann-Whitney U tests were used to compare groups because change in weight efficacy was not normally distributed. Differences were only significant at 32 weeks in the last observation carried forward analysis.

Table 5.9: Medians and quartiles for change in weight efficacy

	I-MW	**I-WW**	**p value**
Week16, N=18, 20	9.5 (-4.5:15.75)	15.3 (8.4: 27.8)	0.148
Week32, N=8,16	21 (6:48.5)	21.5 (13:36.5)	0.976
Week 16 LOCF, N=33, 36	0 (-5:13.5)	6.4 (0:23.8)	0.182
Week 32 LOCF N=33, 36	0 (-3:14.5)	18 (0:18)	**0.038**

Table 5.10 shows the correlations between change in psychological wellbeing and weight loss over 16 and 32 weeks.

Table 5.10: Correlations between change in psychological wellbeing and weight loss

	Week 16 (N=38)		Week 32 (N=21)	
	r	p	r	p
Weight Efficacy[1]	0.198	0.233	0.143	0.535
Body Satisfaction[1]	-0.319	0.051	-0.403	0.070
Quality of Life[2]	-0.169	0.312	-0.412	0.064

[1] these were not all normally distributed but the Spearman correlations were very similar so the Pearson are presented here.
[2] this variable was not normally distributed and the Spearman correlation was very different from the Pearson so the values presented are from this analysis.

Waiting List controls: results when using the intervention

Table 5.11 shows the differences in weight loss between the intervention and waiting list groups from when each started using the 'TenTopTips' (Baseline for the intervention groups and week 8 for the waiting list group).

Table 5.11: Differences between groups in weight loss once using the intervention

	Waiting List Group			Treatment groups		
Week after given the tips	**Mean**	**SD**	**N**	**Mean**	**SD**	**N**
Week 4**	**0.34**	0.98	25	**1.15**	1.29	67
Week 8**	**0.55**	1.82	22	**1.99**	1.91	56
Week 12*	**0.67**	1.88	18	**2.28**	2.62	47
Week 16**	**0.81**	2.01	16	**2.87**	2.53	46
Week 20	**1.12**	2.34	15	**2.85**	2.99	37
Week 24**	**0.82**	2.16	16	**4.00**	3.48	36

* indicate significant differences at $p < 0.05$. ** indicate significant differences at $p < 0.01$.

The significant differences shown above remained for weeks 4,8,16, and 24 when the analysis was run as an ANCOVA with age, baseline weight and gender as covariates (at the 0.05 level).

DISCUSSION

Hypothesis 1: The 'TenTopTips' will result in more weight loss and greater improvements in psychological well-being, than in the control group (over eight weeks)

The central finding from this study is that overweight and obese adults who were given a leaflet containing nutrition and activity recommendations and simple advice on habit formation without any health professional intervention, achieved a clinically significant weight loss and lost more weight over the trial phase than an untreated control group.

During the trial phase one intervention group was directly comparable to the control group in terms of the number of times they were weighed. These two groups had significantly different weight loss in all analyses (using different intention-to-treat procedures) and when baseline differences were controlled. This is strong support that this intervention has a significant effect on weight loss.

The control group lost a small amount of weight suggesting they made some changes without the intervention materials. This is supported by the finding that the number of recommended behaviours they reported performing increased over the eight weeks. However the intervention resulted in significantly more weight loss.

The two experimental groups differed only in the frequency that they were weighed and lost similar amounts of weight over 8 weeks, suggesting that the intervention is equally effective with weekly or monthly weighing. Additional work will be needed to assess whether the intervention is effective without any 'official' weighing.[46] Percentage body fat did not differ significantly between groups, however this is likely to be due to the variability in this measure in relation to the small changes observed.[47]

Psychological well-being did not improve significantly more in the treatment groups than the control group over the eight week trial period except for weight-efficacy, which increased more in the group who attended weekly weighing sessions. It is possible that weekly weighing promotes a feeling of increased control by providing more opportunities for assessment of the relationship between behaviours and weight. Alternatively those in this group may have felt more supported in their weight loss attempts because they had contact with a researcher each week, and this may have resulted in them feeling more in control of their eating. However the extra weighing did not result in any greater weight loss, suggesting the difference in weight-efficacy does not reflect a true increase in participant's ability to control their weight. This will be discussed later.

[46] Note that self-weighing is recommended in the 'TenTopTips' leaflet.
[47] The TANITA scales are useful for giving an estimate of the level of body fat a person has, but anecdotally they can produce variable results. Colleagues and I have used the scales frequently over a number of days and found that the readings for fat percentage are highly variable.

Hypothesis 2: Being given the 'TenTopTips' will result in weight loss and improvements in psychological well-being over 32 weeks

Weight

Participants who remained in the study continued to lose weight over the next 6 months, with an average weight loss of 3.8 kg at 32 weeks. A conventional approach to dealing with missing data in longitudinal studies is to assume that weight remains stable once participants leave the study (last observation carried forward). It is difficult to know whether this is an overestimate or an underestimate of the true figures. If people leave the study because they do not want to attend follow-up sessions they might have continued to use the tips, and therefore continued to lose weight. If they left the study because they no longer wished to follow the 'TenTopTips' advice, it is likely they would have gained weight.

It is often the case that those who leave a weight loss study prematurely have been less successful (Karlsson et al., 1994; Pratt, McLaughlin, & Gaylord, 1992; Wadden, Foster, Letizia, & Stunkard, 1992). In this study, although not a significant difference, those who dropped-out of the study had lost less weight than those who remained. Therefore using a last-observation-carried forward approach is useful in estimating the impact of the intervention on the group as a whole. Using this approach reduced the mean weight loss to 2.6kg. Using the more pessimistic assumption that those who dropped-out returned to baseline weights reduced the weight loss in the sample to 1.5kg.

The fact that 54% of those who completed the study (26% in the last-observation-carried-forward analysis and 22% in the baseline-carried-forward analysis) lost 5% or more of their initial body weight is encouraging. As discussed in Chapter 2, a weight loss of 5% can have significant health benefits (Lindstrom et al., 2005; Knowler et al., 2002; Stevens et al., 2001; Blackburn, 2002) although no biological indicators were assessed in this study. The average weight loss in this study was equivalent to a 4% loss at 32 weeks among those who completed the study. As these participants were continuing to lose weight at this time, weight loss over a longer time period may be greater.

The greatest challenge for all weight loss interventions is maintenance (Wing, Tate, Gorin, Raynor, & Fava, 2006). Due to the nature of the intervention in this study it is not possible to define 'treatment' and 'follow-up' phases of the study but,

encouragingly, those who returned for weight measurements continued to lose weight over 32 weeks. The basis for the intervention was that the behaviours recommended in the intervention would become habitual, and therefore should be maintained, which in turn would aid maintenance of weight loss. Habit strength for the behaviours will be considered in Chapter 7.

Psychological well-being

Baseline scores on the psychological variables were compared with results from previous studies using the measures. As a group, the participants in this study had scores that were similar to previous studies, except that they were slightly more satisfied with their bodies than the overweight participants who completed the measure in the 1990 validation paper (Slade et al., 1990). This could possibly be because the response scale was reversed.

Psychological wellbeing continued to improve in the intervention groups over the 32 weeks. This was stronger for quality of life and weight-efficacy than for body satisfaction. This finding is significant even when intention-to-treat analyses are used, showing the improvements are important at a group as well as an individual level. It is interesting that these improvements were not strongly correlated with weight loss. This suggests that using the intervention independently improved well-being, however, it could be that these participants would have improved their well-being over time with or without the intervention and so this hypothesis cannot be confirmed.

Papers that report on the outcomes of non-pharmacological interventions for weight loss often omit data on psychological well-being. This is evidenced in three recent Cochrane reviews of interventions (Shaw et al., 2005; Norris et al., 2005a; Norris et al., 2005b), which all failed to find data on change in quality of life in the papers reviewed. Nevertheless a small number of studies have looked at these changes. Two studies have shown an increase in body satisfaction among participants using cognitive behavioural therapy for weight loss. Rapoport et al (2000) used an adapted version of the Body Satisfaction Scale[48] and Foster et al (1997) used the Body Area Satisfaction scale of the Multidimensional Body-Self Relations Questionnaire (a similar measure assessing satisfaction with different areas of the body). The size of the increase in Body Satisfaction in the current study was smaller than in these previous studies. This would

[48] This used a reduced number of areas of the body and used a 6 instead of a 7 point Likert scale.

be expected because the interventions used previously were intensive and directly addressed this issue. Although not significant, there was a negative correlation found between change in body satisfaction and weight loss which neared significance in the present study. This suggests that those who lost more weight improved less on body satisfaction. This could be a chance finding but may reflect a real phenomenon where those who lost more weight become more focused on their body and more critical of areas they wanted to change. Foster et al (1997) found that increases in body satisfaction were not significantly correlated with weight loss during weight loss treatment. The relationship between weight loss and body image may be complex, and could depend on whether it is addressed in the intervention. This area requires further investigation.

The improvement in weight-efficacy found in this study is comparable to, although slightly smaller than those found in previous research using the same measure with participants in behavioural programmes (Clark et al., 1991; 1996; Richman et al., 2001). Richman et al (2001) found an improvement in weight-efficacy after a behavioural programme although this improvement was not significantly correlated with percentage weight loss. The parallel lack of correlation found in this study suggests that the intervention (rather than the weight loss) made participants feel more in control of their weight. Whether the important component was the guidance given in the leaflet or this in combination with regular 'official' weighing, cannot be determined.

There was a suggestion in the results of this study that those in the weekly weighing group improved on weight-efficacy significantly more than the monthly weighing group (although this was only significant in a last-observation-carried forward analysis). As discussed above, it could be that attending to be weighed more frequently impacted on participant's feelings of efficacy by providing support or giving information on the consequences of weight control behaviours. Bandura (1997) has argued that social support can be a source of information upon which people make efficacy judgements and a recent study of exercise maintenance in cardiac rehabilitation patients has shown that higher perceived social support is related to higher self-efficacy ratings (Woodgate, Brawley, & Shields, 2007). The suggestion that those in the weekly weighing group got something more out of the study than those in the monthly weighing group is backed up by the lower levels of drop-out in this group. Although this group did not lose more weight than those weighed less frequently, if implementing this intervention on a larger

scale it would be valid to consider whether to include frequent weighing because it may provide participants with additional benefit, and encourage them to continue with the programme. Further research assessing perceived support would be helpful in order to make such a decision.

No studies that I am aware of have considered change in general quality of life as a result of a weight loss intervention. Previous research has focused on health related quality of life (HRQOL: the multidimensional subjective experience of physical, psychological and social health (Blissmer et al., 2006)). Maciejewski et al (2005) conducted a review of 34 randomised controlled trials looking at health related quality of life with behavioural, surgical and pharmacological weight loss interventions. They found that only 9 of these showed significant improvement in generic measures and obesity-specific measures more often showed improvement. A small number of studies have examined the relationship between weight loss and change in health related quality of life in weight loss studies with some finding no relationship between the two (Blissmer et al., 2006) and others finding that those who lost more weight had improved health related quality of life (Kolotkin, Crosby, Williams, Hartley, & Nicol, 2001; Engel et al., 2003). Again studies that found a relationship usually used an obesity specific measure.

The current study found that the intervention improved general quality of life and that this was correlated, although not significantly, with weight loss at 32 weeks. This suggests that the intervention, as well as the weight loss, may have improved quality of life. It is possible that feeling more in control of weight, performing healthy behaviours and feeling more satisfied with one's body would relate to an improved overall quality of life, in addition to any improvement resulting from actual weight loss. It is interesting that such a simple intervention can improve a global rating of quality of life and it would be useful if more research considered this outcome.

Weight loss differences between the intervention groups and the Waiting List Group after being given the intervention

Many weight loss studies have used a waiting list group (e.g.Lowe et al., 1999; Dalle Grave et al., 2004), usually because it is considered unethical to offer no help to those in a control group, and because recruitment is often based on an offer of help with weight control. However the success of these participants once they receive the intervention is

rarely reported. In the present study those who had been asked to wait for 8 weeks lost significantly less weight than those who were given the intervention at the start of the study.

The p.r.i.m.e. theory of motivation (West, 2006) provides a possible explanation of why this should be the case. This theory focuses on the importance of moment-to-moment control of behaviour and argues that the motivational system is in constant flux due to the influences of a changing environment (both internal and external). Based on this, West argues that public health interventions should encourage those who are ready to make a change to do so without delay rather than planning to do so in the future. In the current study, people who responded to an advertisement to participate in a weight loss study were likely to have been ready to make a change at that moment, and after 8 weeks the prevailing influences could have changed and they may be less motivated to make changes to their lifestyle. In addition they may have tried to make changes on their own and found this difficult, which could reduce motivation to try again eight weeks later.

Limitations

There were a number of limitations to this study. The cluster randomisation with only three groups was a pragmatic decision, and is not ideal for interpreting causal effects, but it is an appropriate next step from the case series used in the pilot study. Drop-out rates for later assessments was high, but at a similar level to previous weight loss trials (Davis & Addis, 1999; Teixeira, Going, Sardinha, & Lohman, 2005). Given the low intensity of this intervention and the absence of any incentive to return (previous studies have paid participants for attending follow-up appointments (e.g.Tate et al., 2001), the rate of attrition was not surprising. The number of questionnaires participants were asked to complete during the study may have contributed to this rate of attrition. Finding a balance between minimising participant burden and collecting data on all the variables of interest in a study is challenging. Future studies testing this intervention may be able to reduce participant burden and this could result in a lower level of attrition.

The study would have benefited from including more participants to increase the power for subgroup analyses, having a longer follow-up to assess maintenance and including a control group for the full length of the study. Ideally all researchers who carried out the

weighing would have been blind to group allocation, but this was not practical. The fact that there were no baseline differences between drop-outs and completers is encouraging for generalising the results. But despite the lack of significant findings, there are some relationships evident when effect sizes are examined, which give hints as to who may be more likely to remain engaged with the intervention over time. This will be discussed further in Chapter 6.

A limitation of many weight loss studies is that participants are usually white, well-educated women and findings may be specific to this group (Weinstein, 2006). It has been suggested that interventions which do not involve face-to-face contact may be of more interest to other population groups (Jeffery & Utter, 2003), but few studies using such interventions have found this to be the case. For example Jeffery et al (2003) tested a mail and phone based intervention,[49] but despite advertising to a wide range of individuals, volunteers were predominantly women with a history of prior weight loss – very similar to those who would enrol in a clinical weight loss programme. Wardle and Johnson (2002) found that men were more likely to use a diet from a book or magazine than use a slimming club, suggesting there may be more interest among men in interventions that don't involve face-to-face contact. The present study included 34% men which is higher than in many of the studies described in Chapter 2, but as the study did involve face-to-face contact with a researcher the interest levels for this study may not reflect the levels of interest in the intervention in the population.

Participants in this study had relatively high levels of education, not representative of the general population. However, there were individuals - both in the present study and the pilot - with very little education, and they appeared to have no difficulty in understanding the leaflet and following the advice. In addition, as will be shown in the following chapter, education was unrelated to weight loss.

As in the pilot study, the tips were given with additional supporting information. This information remains at a much lower level than is given in self-help manuals (for example the LEARN manual (Brownell, 2000)) and was easy to provide. It was not necessary for participants to read this material in order to follow the programme, but was provided to help those who were seeking more information. At the time of the

[49] This intervention was not reviewed in Chapter 2 because it involved regular feedback from health professionals on reported behaviour changes. As a point of interest at 12 months there was no difference in weight loss between those in the intervention and usual care groups.

study, Cancer Research UK had placed the 'TenTopTips' on their website with additional information, for example suggestions for low calorie drinks and snacks. The information given to participants in this study was compiled from the information on the Cancer Research UK website[50] but participants could directly access the website if they chose to do so, because the details were given in the 'Ten TopTips' leaflet. Anecdotally few participants mentioned accessing the website during the study. There are numerous similar websites that participants could have chosen to use if they were seeking further information on how to achieve each of the recommended behaviours. Although it is not possible to assess the impact of the 'TenTopTips' without this information, it is cheap and easy to provide it both in written form and on a website and, conversely, participants could follow the recommended advice without accessing this further information. Therefore it does not minimise the appeal of this intervention in terms of simplicity or cost of delivery.

It is possible that participants assigned to the control group could have accessed the 'TenTopTips' information from the Cancer Research UK website. However at the time of the study there had been little publicity so it is unlikely they would have known about it. None of the control participants said they had discovered the intervention during the waiting phase of the study. The finding that they only changed their behaviours a small amount during the 8 weeks also suggests they had not come across the 'TenTopTips' and started using them.

Similarly to the pilot study participants were motivated to lose weight, and it is not possible to know how the intervention would affect people who were not so highly motivated. An effectiveness trial would be the next step to investigate the impact of the intervention if it was given, for example, to all overweight patients in an NHS general practice surgery.

Weighing people on a regular basis may have an independent effect on weight loss (O'Neil & Brown, 2005) and therefore I am unable to draw conclusions about the long-term efficacy of the intervention if participants are not weighed. However, weight loss over 8 weeks was greater in the intervention group than the control group who were weighed equally often, so I can be confident that the intervention has effects beyond

[50] Not all information from the website was given to participants as it also included suggestions for other areas of nutrition and physical activity.

regular weighing. In addition, the intervention group given weekly weighing lost no more weight than the monthly weighing group, suggesting the impact of weighing is not a dose-response relationship and less frequent weighing may be adequate to produce the level of weight loss found in this study.

Conclusions

Giving motivated overweight and obese adults the 'TenTopTips' leaflet resulted in significant weight loss over 8 months, together with improvement in psychological well-being. This intervention shows promise as a programme that could be easily disseminated and has the potential to result in significant benefits relative to the professional effort required. Chapters 6 and 7 report on further analysis of the trial, and focus on predictors of weight loss and habit formation during the study.

CHAPTER 6
STUDY 2: AN EXPLORATION OF PREDICTORS OF WEIGHT LOSS WITHIN A TRIAL OF A HABIT-BASED WEIGHT LOSS INTERVENTION

INTRODUCTION

The primary focus of Study 2 was the efficacy of the 'TenTopTips' intervention in producing weight loss. The data also allow for an examination of potential predictors of weight loss to investigate if this intervention resulted in more weight loss for certain sub-groups of the population. No intervention is likely to be equally effective for everyone who is overweight or obese, but each type of intervention may be useful to some individuals. It is likely that some predictors of success reflect characteristics of individuals which would influence their success with any weight loss intervention, but other predictors may be more relevant for some interventions than others.

A review of pre-treatment psychological predictors of weight control in intervention studies found that having had few previous weight loss attempts, and having an autonomous, self-motivated cognitive style, were the best predictors. Suggestive evidence was found for a number of other constructs (e.g. eating self-efficacy and body image) but studies was inconsistent or scarce and therefore conclusions could not be drawn (Teixeira et al., 2005).

Demographic predictors of weight loss are rarely reported, often due to a lack of variation in these variables. There are frequently no, or few, men in research studies which precludes a comparison of genders. In many studies participants are predominantly from one ethnic group, usually white, preventing an analysis of ethnic differences. However, gender differences in weight loss have attracted some interest. One low-intensity intervention reported on gender differences in weight loss. Invest in Your Health was a direct mail intervention (Jeffery et al., 1990), with and without an incentive (($60 deposit refunded upon successful completion), which had a higher response rate from men (37%) than is usually the case in clinical programmes (Jeffery, 1993). In this study men lost significantly more weight in both groups, approximately

4.5 kg vs 1.1kg for women in the newsletter only group, and 5.1kg vs 2.9kg in the incentive group. However this was not a statistically significant difference, due to the small sample sizes.[51]

The 'TenTopTips' intervention is likely to have more or less impact on weight depending on how many of the recommended behaviours the person was already performing before they started the intervention. In this study, baseline levels of the recommended behaviours were assessed using a behaviour questionnaire where participants reported whether or not they performed a list of behaviours. In this chapter this questionnaire is used to investigate the possible relationship between baseline behaviours and subsequent weight loss.

Psychological well-being (weight efficacy, body satisfaction and quality of life) was assessed in the study, primarily as an outcome measure. However there has been suggestive evidence that some well-being variables are predictive of weight loss. For example weight efficacy has been found to predict weight control behaviours and consequently weight loss during an 8 week treatment programme (Linde, Rothman, Baldwin, & Jeffery, 2006). Body satisfaction has been associated with greater weight loss (Kiernan, King, Kraemer, Stefanick, & Killen, 1998), and health related quality of life has been related to higher levels of weight loss (Teixeira et al., 2004). Therefore I also assessed whether baseline scores for these constructs were predictive of weight loss.

Because the intervention used in the present study was based on the concept of habit formation, it is interesting to investigate predictors which could have a specific impact on this process. Two personality measures (impulsivity and personal need for structure) were hypothesised to predict habit formation. This, in turn, was hypothesised to aid maintenance of the recommended behaviours and consequently to increase weight loss.[52] I hypothesised that people with a high need for structure or low impulsivity would find it easier to establish the new routines which incorporate the recommended behaviours into their lives than those who like less structure in their lives or are impulsive, and consequently would be more successful in forming new habits.

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[51] The p value was approximately 0.09 showing this difference did near significance.

[52] In this chapter the association between personality and weight loss is assessed; in Chapter 7 the association between personality and habit formation (automaticity change) will be considered, as well as the association between automaticity change and weight loss.

A small number of studies have suggested that impulsivity may impact people's success in weight control. Obese individuals have been found to be more impulsive than those who are lean (Sullivan, Cloninger, Przybeck, & Klein, 2007; Ryden et al., 2003; Nederkoorn, Jansen, Mulkens, & Jansen, 2006), and Nederkoorn et al (2006) found that impulsivity predicted treatment outcome in obese children. A laboratory study found that within a sample of healthy women (Guerrieri, Nederkoorn, & Jansen, 2007) those who had higher impulsiveness scores on the Barrat Impulsiveness Scale ate more food than those with a lower score. This suggests impulsivity may have an effect on weight and weight loss through hindering participants' ability to exert the necessary self-control both over current unhealthy habits and each new opportunity to eat high calorie foods. However one study with reasonable power found no association between impulsivity and weight loss during a weight loss programme or at one year follow up (Poston et al., 1999). It is not yet clear why some studies fail to find significant results.

This chapter addresses the question of whether weight loss while using the 'TenTopTips' is predicted by gender, number of previous weight loss attempts, age, marital status, education, ethnic group, personality (personal need for structure and impulsiveness), baseline behaviours, baseline levels of weight-efficacy, quality of life, body satisfaction, or weight. Within the context of exploring which variables predict weight loss, it is also interesting to assess whether these same variables are predictive of study completion. Therefore drop-outs and completers were also compared on the variables listed.

METHODS

The methodology of this study was outlined in Chapter 5. Therefore only measures relevant here that were not described in Chapter 5 and the analyses reported in this chapter are described here.

Measures

Two personality measures were completed at the baseline meetings:

Personal Need for Structure

The Personal Need for Structure (PNS) questionnaire (Neuberg & Newsom, 1993) (α =0.84[53]), shown in Appendix 6.1, measures individual differences in the desire for simple structure. This questionnaire consists of 12 items which describe liking or disliking features of a well-structured or less structured life and participants rate their agreement with these statements using a 6 point Likert scale. The scale has previously been used to divide respondents into those with a high and low need for structure using the mid-point of the scale; an average of 3.5.

Impulsivity

The Barratt Impulsiveness Scale (BIS-11; (Patton, Stanford, & Barratt, 1995) (α =0.79[53]), shown in Appendix 6.2, measures impulsivity. It includes 30 items which are self-statements relating to this construct. Participants rate their level of performance for each behaviour on a four point scale from rarely/never to almost always/always. Previous studies obtained a score of 64 in a student sample (Patton et al., 1995) and 67 in a sample of healthy women (Guerrieri et al., 2007).

Analysis

All the predictor analyses focus on findings at 12 and 24 weeks, and only data from participants in the intervention groups are included. Because in a 'real life' situation, individuals would be given the 'tips' when they were first offered them not after waiting for some time, the Waiting List participants who received the intervention after eight weeks were not included.

For all of the analyses, parametric assumptions were checked (as in Chapter 5). Where these assumptions were not met, non-parametric tests were run to confirm the parametric findings and only reported if they differed from the parametric results. Two participants in the study lost an unusually large amount of weight. This resulted in a Kurtosis value for the weight outcomes which suggested a non-normal distribution. When these two participants were removed, the distribution met the requirement of normality. Therefore all the following analyses that included weight change were run with these participants excluded.

[53] Alpha values are those obtained in this study.

The analysis of predictors was performed using weight change data from individuals with data at each time point (completers). For continuous variables, Pearson (Spearman) correlations were run between each potential predictor and weight loss. Categorical variables were compared using one-way ANOVAs, with Tukey post-hoc tests, and t-tests for dichotomous variables, to assess differences in weight loss between the groups.

Multiple regressions were performed to examine predictors of weight loss at 12 and 24 weeks. All variables that had been significantly associated with weight loss (or were close to significance: $p<0.2$) in any of the previous analyses were included. There was only one categorical predictor with more than 2 groups. This was number of previous weight loss attempts (three categories; 0-1, 2-3 and 4 or more), which was therefore dummy coded. Five participants who had weight data at week 12 and two who had weight data at week 24 did not provide data on number of previous weight loss attempts. In order for the regression to include all participants with weight data, data were imputed for the participants with missing data on this variable. The mean number of weight loss attempts of all those who completed this variable was 2.4,[54] and so the estimates used for those with missing data placed these participants in the category of 2-3 weight loss attempts. Standardised Beta values are reported.

Completers and drop-outs (at 32 weeks) were compared on all the variables in the predictor analyses.[55] T-tests (Mann-Whitney U) were used to assess differences between these two groups on the continuous variables and Chi-square tests were used to assess group differences on categorical variables.

Due to the small sample sizes in many analyses in this chapter, it is likely they are underpowered. Therefore effect sizes are also presented. Where groups are compared on continuous variables, effect sizes are calculated using the square root of the partial Eta^2, which can be considered equivalent to an R^2 value and therefore the square root can be used and Cohen's r criteria applied. In this case, Cohen defined a value of 0.1 as a small effect, 0.3 as medium and 0.5 as large (Cohen, 1992).

[54] The mean of only those participants to be included in each regression was 2.6 for both 12 and 24 weeks.
[55] Some of these analyses are repeated from Chapter 5.

In assessing differences between drop-outs and those who remained in the study, a number of categorical variables were included. For categorical variables, logistic regressions were run with group (drop-outs vs those remaining) as the dependent variable and the categorical variable as an independent variable. This gives an R^2 type measure; the Negelkerke R square which is adjusted to fall between 0 and 1. The square root of this statistic is used here as the effect size and Cohen's r criteria again used to assess the magnitude of effect.

RESULTS

Predictors of weight loss

Continuous variables

The mean value for personal need for structure in this study was 3.5 (SD 0.78) showing that on average participants were in the mid-range for this variable (Neuberg & Newsom, 1993). The mean value for impulsivity was 63.0 (SD 9.6), similar to that found in previous research (Patton et al., 1995; Guerrieri et al., 2007). Correlations between the continuous variables and weight loss are shown in Table 6.1. Only body satisfaction and quality of life were significantly related to weight loss, and only at 24 weeks. Impulsivity and body satisfaction neared significance at 12 weeks.

Table 6.1: The relationships between baseline values of continuous variables and weight loss at 12 and 24 weeks

	12 weeks (N=45)		24 weeks (N=34)	
	Pearson r	**p**	**Pearson r**	**p**
Baseline behaviours	-0.116	0.449	-0.033	0.854
Baseline weight[1]	0.088	0.567	-0.064	0.721
Age	-0.019	0.902	0.157	0.375
Personal Need for Structure	0.009	0.952	0.166	0.349
Impulsivity[1]	***-0.261***	***0.083***	-0.222	0.207
Weight-Efficacy	0.109	0.474	0.044	0.804
Body Satisfaction	***0.262***	***0.082***	**0.356**	**0.039**
Quality of Life	0.045	0.767	**0.412**	**0.016**

[1]results were similar using Spearman correlations.

Number of previous weight loss attempts

Number of previous weight loss attempts was grouped into zero or one, two or three, and four or more attempts. These groups were significantly different in weight loss at both 12 and 24 weeks. The means and standard deviations are shown in Table 6.2. Also shown are the means and standard deviations within these groups, when those with missing data on this variable (who had weight data) were included in the 2-3 attempt

category (this variable is used in the subsequent regressions). This table shows that those with the fewest weight loss attempts lost the most weight followed by those with 4 or more attempts and that those with 2-3 attempts had the lowest weight loss.

Table 6.2: Means and standard deviations of weight loss (kg) for participants with different numbers of previous weight loss attempts.

	0-1 attempts	2-3 attempts	4 or more attempts	p value	effect size
Participants with data on number of attempts					
Week 12 N=15,11,14	3.02(1.92)[a]	0.86(1.52)[b]	1.91(2.35)[ab]	0.032	0.412
Week 24 N=13,6,13	5.30(2.17)[a]	1.80(1.57)[b]	2.55(3.52)[ab]	0.017	0.496
All participants with weight data					
Week 12 N=15,16,14	3.02(1.92)[a]	0.96(1.66)[b]	1.91(2.35)[ab]	0.022	0.409
Week 24 N=13,8,13	5.30(2.17)[a]	3.39(1.98)[b]	2.55(3.52)[ab]	0.024	0.464

[abc] indicates significant differences between subgroups with different superscripts.

Gender

There was a significant difference between men and women over both time periods. (Table 6.3).

Table 6.3: Means and Standard Deviations of weight loss (kg) between men and women

	Men	Women	p value	effect size
Week 12 N=21,24	2.66(2.05)	1.32(2.02)	0.033	0.319
Week 24 N=16, 18	4.66(2.70)	2.59(2.97)	0.041	0.352

Although baseline weight was not a significant predictor of weight loss, because men and women had different starting weights and some previous studies have found this to be predictive (Teixeira et al., 2005), the gender comparison was re-run for percentage weight loss, to control for differences in baseline weight. The results are shown in Table 6.4.

Table 6.4: Means and Standard Deviations of percentage weight loss between men and women

	Men	Women	p value	effect size
Week 12 N=21,24	2.69% (2.08)	1.58% (2.51)	0.117	0.237
Week 24 N=16, 18	4.81% (2.97)	3.25% (3.80)	0.196	0.227

This shows that although no longer significant and with a smaller effect size, there still appeared to be some difference between men and women in this analysis.

Marital Status

Because some of the marital status groups were very small this variable was dichotomised into married/cohabiting and single/divorced/widowed. The differences between these groups are shown in Table 6.5. This shows that weight loss was higher in those who were not married or cohabiting, which neared significance at 12 weeks.

Table 6.5: Means and Standard Deviations of weight loss (kg) by marital status

	married/cohabiting	single/divorced/widowed	p value	effect size
Week 12 N=31, 14	1.54 (2.02)	2.85 (2.12)	0.054	0.289
Week 24 N=25, 9	3.39 (3.00)	4.03 (3.11)	0.589	0.096

Ethnicity

Ethnicity was dichotomised into white or not white due to the low numbers of participants from other ethnic groups. Table 6.6 shows that white participants lost more weight than those from other ethnicities but this did not reach significance.

Table 6.6: Means and Standard Deviations of weight loss (kg) in those of white ethnicity and those from other ethnicities

	White	Other	p value	effect size
Week 12 N=40,5	2.05 (2.18)	1.12 (1.46)	0.363	0.139
Week 24 N=30,4	3.73(3.12)	2.29(1.44)	0.156	0.158

Education

Again because the variable education was made up of many groups, with only a small number of participants in each group, this was dichotomised into having a university education or not. There were no significant results for this variable (Table6.7).

Table 6.7: Means and Standard Deviations of weight loss (kg) in those with and without a university education

	University education	No university education	p value	effect size
Week 12 N= 33, 12	1.99 (2.02)	1.83 (2.46)	0.824	0.034
Week 24 N= 26, 8	3.86 (2.68)	2.61 (3.91)	0.309	0.180

Multivariate analyses

Table 6.8 shows the results of multiple regressions assessing the independent effects of the various predictors of weight loss. Table 6.9 and 6.10 present a correlation matrix of the variables included in the regressions, within the participants included in each

regression. The values of these correlations show that there is no significant multicollinearity.

Table 6.8: Independent predictors of weight loss at 12 and 24 weeks*

		Week 12 (N=45)		Week 24 (N=34)	
		β	p	β	p
N weight loss attempts	0-1	ref	---	ref	---
	2-3	**-0.530**	**0.001**	**-0.534**	**0.004**
	≥ 4	-0.194	0.216	**-0.496**	**0.014**
Gender	Male	ref	---	ref	---
	Female	**-0.354**	**0.010**	**-0.334**	**0.043**
Marital status	Single	ref	---	ref	---
	Married	**-0.326**	**0.022**	**-0.403**	**0.037**
Ethnicity	White	ref	---	ref	---
	Non-White	-0.062	0.637	0.053	0.750
Impulsivity		**-0.295**	**0.025**	**-0.360**	**0.039**
Body Satisfaction		0.051	0.762	-0.394	0.124
Quality of Life		0.037	0.814	**0.450**	**0.030**
Adjusted R^2		**0.383**		**0.373**	

*Standardised Beta values are presented.

Impulsivity was not normally distributed within the participants in each of these regressions. This was based on the Kurtosis statistic which is sensitive to outliers. There were two outliers on this variable at 12 weeks and one at 24 weeks, that when removed provided a distribution of impulsivity scores which met the requirement of normality. Therefore the regressions were run again with these participants excluded from the analysis. At 12 and 24 weeks the results were similar for all other variables, but impulsivity became non-significant; at both 12 weeks β=-0.253, p=0.061, and at 24 weeks β= -0.198, p=0.316. The adjusted R^2 for each regression was reduced very slightly to 0.363 and 0.366 respectively.

In the 24 week multiple regression, baseline body satisfaction was a non-significant predictor, but with a medium to large effect, with the direction of effect being the opposite of that found in the bivariate analysis (high satisfaction relating to less weight loss). This suggests that the difference between body satisfaction and another predictor may be predictive of weight loss. I hypothesised the most likely candidate was quality of life, because these two variables both reflect psychological well-being. I calculated a difference score and an average score for these two variables[56] and entered these into the regression in place of the scale scores.[57] This shows a significant effect of the

[56] Because these questionnaires had scores on different scales I first calculated z scores for the scale scores on each variable (subtracted the mean and divided by the standard deviation) and calculated the difference and average scores based on these.

[57] All participants in the original regression were included.

difference between quality of life and body satisfaction with a Beta value of 0.423 and p value of 0.044. The average of the two was not a significant predictor. This, in combination with the original regression results, shows that those who had a high score for quality of life lost more weight over 24 weeks, especially if they have a low score for body satisfaction.

Table 6.9: Correlation matrix of the variables included in the multiple regressions predicting weight loss at 12 weeks (N=45)*

	Number of weight loss attempts						
	Dummy 1: 2-3 attempts	**Dummy 2: >4 attempts**	**Gender**	**Marital Status**	**Ethnicity**	**Impulsivity**	**Body Satisfaction**
Dummy 1: 2-3 attempts	---	---	---	---	---	---	---
Dummy 2: >4 attempts	**r= -0.499** p<0.001	---	---	---	---	---	---
Gender	**r=-0.143** p=0.350	**r=0.340** p=0.022	---	---	---	---	---
Marital Status	**r=-0.002** p=0.988	**r=-0.067** p=0.663	**r=-0.148** p=.333	---	---	---	---
Ethnicity	**r=0.033** p=0.830	**r=0.068** p=0.658	**r=0.189** p=0.214	**r=-0.068** p=0.658	---	---	---
Impulsivity	**r=-0.043** p=0.779	**r=-0.067** p=0.664	**r=-0.062** p=0.687	**r=0.100** p=0.514	**r=0.022** p=0.887	---	---
Body Satisfaction	**r= 0.125** p=0.412	**r=-0.202** p=0.184	**r=-0.036** p=0.814	**r=-0.259** p=0.086	**r=0.128** p=0.402	**r=-0.243** p=0.108	---
Quality of life	**r=0.145** p=0.342	**r=-0.139** p=0.363	**r=-0.010** p=0.946	**r=0.083** p=0.587	**r=-0.196** p=0.196	**r=-0.074** p=0.629	**r=0.458** p=0.002

*Spearman correlations were used

Table 6.10: Correlation matrix of the variables included in the multiple regressions predicting weight loss at 24 weeks (N=34)*

	N weight loss attempts						
	Dummy 1: 2-3 attempts	**Dummy 2: >4 attempts**	**Gender**	**Marital Status**	**Ethnicity**	**Impulsivity**	**Body Satisfaction**
Dummy 1: 2-3 attempts	---	---	---	---	---	---	---
Dummy 2: >4 attempts	**r=-0.436** p=.010	---	---	---	---	---	---
Gender	**r=-0.172** p=0.332	**r=0.378** p=0.027	---	---	---	---	---
Marital Status	**r=0.018** p=0.917	**r=-0.214** p=0.225	**r=-0.031** p=0.860	---	---	---	---
Ethnicity	**r=0.013** p=0.943	**r=0.088** p=0.619	**r=0.161** p=0.362	**r=-0.195** p=0.270	---	---	---
Impulsivity	**r=-0.007** p=0.968	**r=-0.009** p=0.959	**r=-0.165** p=0.350	**r=-0.071** p=0.688	**r=-0.019** p=0.917	---	---
Body Satisfaction	**r=-0.120** p=0.498	**r=-0.170** p=0.337	**r=-0.120** p=0.498	**r=-0.272** p=0.119	**r=0.186** p=0.291	**r=-0.474** p=0.005	---
Quality of life	**r=0.039** p=0.827	**r=-0.142** p=0.422	**r=-0.066** p=0.710	**r=0.048** p=0.789	**r=-0.336** p=0.052	**r=-0.236** p=0.179	**r=0.425** p=0.012

*Spearman correlations were used

Drop-outs

Table 6.11 shows comparisons between those who completed the full 32 weeks of the study and those who dropped-out, on all the variables included in the analyses of predictors of weight loss.

Table 6.11 Comparisons of baseline data between those who completed the study and drop-outs (within the treatment groups)

	Completed the study (N=28)	Drop-outs (N=41)	p value	effect size
Continuous variables[1]	**Mean (SD)**			
Baseline behaviours	8.8 (2.8)	8.7 (2.7)	0.864	0.021
Baseline weight, kg	93.1 (16.4)	92.2 (16.9)	0.825	0.027
Age, years[2]	45.5 (10.5)	40.7 (10.4)	0.068	0.222
Personal Need for Structure	3.4 (0.9)	3.6 (0.7)	0.245	0.149
Impulsivity	60.8 (9.6)	64.8 (10.6)	0.109	0.195
Weight-Efficacy	105.8 (25.7)	108.3 (20.8)	0.653	0.055
Body Satisfaction	76.9 (18.5)	72.1 (13.9)	0.224	0.148
Quality of Life	76.2 (14.9)	70.6 (12.3)	0.092	0.204
Categorical variables %(N)				
Gender				
Male	46 (13)	34 (14)	0.305	0.143
Female	54 (15)	66 (27)		
Education				
No University Education	25 (7)	32 (13)	0.546	0.085
University Education	75 (21)	68 (28)		
Marital Status				
Single/Divorced/Widowed	32 (9)	27 (11)	0.633	0.067
Married/Cohabiting	68 (19)	73 (30)		
Ethnic Group				
White	93 (26)	76 (31)	0.063	0.269
Other	7 (2)	24 (10)		
Number of previous weight loss attempts[1]				
0-1	48 (12)	30 (7)	0.110	0.346
2-3	16 (4)	43 (10)		
4 or above	36 (9)	26 (6)		

[1]presented from t-tests (were similar using Mann-Whitney U for weight, PNS and WEL which were not normally distributed)
[2]for age and number of previous weight loss attempts N's were 28 and 40, and 25 and 23 respectively.

DISCUSSION

A number of the variables assessed in this study were found to be independent and significant predictors of weight loss during the study at both 12 and 24 weeks; number of previous weight loss attempts, gender and marital status. The assessment of previous weight loss attempts in this study was slightly different to those used previously. The most common approach used has been to dichotomise those with and without a history of dieting or weight loss (e.g. Jeffery et al., 1984; Kiernan et al., 1998). I found that those who had zero or one weight loss attempt in their lifetime lost the most weight but

that those with 2-3 attempts lost less weight than those with 4 or more attempts. It must be acknowledged that this could be a chance finding, but it is possible to speculate why it might be a real effect. One possible explanation is based on the fact that those who have tried to lose weight many times in the past represent people who find it difficult to lose weight and maintain this loss. Through numerous weight loss attempts they may have learned skills that help them to lose weight, but they can only maintain these behaviours for short periods. When they stop using these, they gain weight and then start another weight loss attempt. Those who have tried to lose weight 2-3 times in the past also represent a group who have previously failed to lose weight but they have had less opportunity to learn skills which work for them, even if this is only for the short term. Those who had 2-3 previous weight loss attempts were also more likely to drop-out of the study. This suggests that participants who had tried to lose weight 2-3 times in the past were less interested in the intervention. This could also explain the lower levels of weight loss found in this group. It seems that the intervention is more beneficial for those with few previous weight loss attempts, followed by those with 4 or more attempts, and that those with 2-3 previous weight loss attempts derive the least benefit from the 'TenTopTips'. It may be that this finding will not be replicated in future studies but in order to investigate this it is important researchers do not reduce this variable to a dichotomy.

Gender differences in weight loss are often neglected because many intervention studies include few men or do not focus on differences. This study found that men lost more weight than women. When this was assessed as percentage rather than absolute weight loss the differences reduced in significance and effect size, but were still evident. In addition fewer men dropped out of the study. Therefore it appears that the intervention is more beneficial for men than women. Women are more likely than men to avoid high-fat foods, eat fruit and fibre and limit salt intake (Wardle et al., 2004). Although baseline behaviours were not found to be predictive in this study it is plausible that part of the reason men lost more weight is that they started with more behaviours that could be altered. An alternative explanation is that men started with poorer nutrition knowledge and improving this may therefore have more impact for them. Nutrition knowledge is lower in men than women (Parmenter, Waller, & Wardle, 2000) and is associated with healthy eating (Wardle, Parmenter, & Waller, 2000). As discussed in Chapter 2, women are more interested in weight loss than men and are more likely to be dieting at any time point (Wardle & Johnson, 2002). The difficulty therefore does not

appear to be in helping men to lose weight once they are using an intervention, at least not for this intervention, but engaging them in the first instance. This intervention was of interest to some men and further research will be needed to assess the levels of interest from men when the intervention is advertised more widely.

The results of the study suggested that this intervention was more effective in those who were single than those who were married or cohabiting. Studies rarely report on differences based on marital status although some report no association (e.g. Jeffery et al., 2003). Getting married or becoming divorced has been associated with weight gain and weight loss respectively (Jeffery & Rick, 2002) and spouse BMI was significantly associated with participant BMI and BMI change (Jeffery & Rick, 2002). It may therefore be easier for single people to make changes to their diet and activity than for married people where such decisions are often made jointly.

Quality of life was shown to be an independent predictor at week 24 but not at week 12 and those who completed the study had a higher baseline quality of life than those who dropped-out. General quality of life has not previously been assessed as a potential predictor of weight loss although lower levels of health related quality of life has been related to poorer outcomes (e.g. Teixeira et al., 2004). It could be that a general quality of life measure reflects, in part, the level of day-to-day difficulties in life, and that these daily hassles can both make it difficult for participants to continue participating in a research study and hinder weight loss. These hassles could have more impact after a period of time when the initial motivation and first success with weight loss has reduced. This could potentially be more of an issue in this low-intensity intervention than in interventions which provide higher levels of support. It would be useful if more studies assessed this as a potential predictor and measuring daily hassles could also be informative.

Although quality of life and body satisfaction were found to be correlated with one another (medium to large effect size), and body satisfaction was not independently related to outcome, the difference between these two variables was predictive of weight loss at 24 weeks. Participants with high quality of life and low body satisfaction were more successful than those with a small difference between the two, and those with high body satisfaction and low quality of life were the least successful. The quality of life variable may reflect the resources an individual has, both emotionally and practically, to

make changes to their behaviour, and participants with low body satisfaction are likely to have higher motivation to make these changes, explaining why this combination should relate to more weight loss. Despite the fact that this was not found at 12 weeks, this is an intriguing finding and warrants further investigation in larger samples.

Contrary to my prediction, there was no association between personal need for structure and weight loss. It seems that preference for structured lives does not impact on the ability to establish new behavioural patterns when motivated to do so. However there was an independent effect of impulsivity at 12 weeks which neared significance (when the two outliers were removed from the analysis) but was smaller and not significant at 24 weeks. There was also a suggestion that impulsivity was related to completion of the study with impulsive individuals more likely to drop-out. Together these findings build an argument that people who are lower on impulsivity are more likely to succeed with this intervention. This adds to the recent research in the area. It fits with findings that the obese are more impulsive and that in obese children, those who are more impulsive find it more difficult to lose weight (Ryden et al., 2003; Nederkoorn et al., 2006). If this finding reflects that impulsivity makes it difficult for people to develop routines and habits, the conclusion would be that other diets that focus on variety may be more appropriate for impulsive individuals. However, it is possible this finding does not relate to habit formation, but reflects that impulsive people find it more difficult to avoid eating in tempting situations. If this is the mechanism through which impulsivity impacts weight loss then interventions which focus on how to deal with these temptations will be important. The relationship between impulsivity and habit formation will be discussed in Chapter 7.

It was expected that baseline behaviours would be predictive of weight change because those who were already performing many of the recommended behaviours would have the potential to make fewer changes as a result of the recommendations. However, this predicted association was not found in this study. It is possible that participants were able to make changes whatever their initial behaviours, for example reducing portion sizes from a different starting size but by a similar amount. As all participants in the study were overweight or obese it is unlikely that any were in a situation where no changes could be made to their lifestyle, based on the 'TenTopTips' advice. Alternatively it may be that the simple measure used to assess baseline behaviours was not sensitive enough to detect differences and that participants interpreted the questions

in different ways. Baseline weight was not predictive of weight loss, and this finding fits with previous results showing lower predictive power in studies where baseline BMIs are comparatively low (Teixeira et al., 2005).

In this study, people who identified themselves as white lost more weight than those of other ethnicities, although not significantly. In addition, although again not significant, they were more likely to complete the study. The fact that ethnicity was not predictive in the regression analyses suggests the finding may be due to ethnicity correlating with other predictors. In particular most of those from non-white ethnic groups were women. However in all these analyses, the numbers of participants from ethnicities other than white were very small and therefore it is not possible to draw any firm conclusions from these results.

The only variable that appeared to be more important in predicting drop-out than predicting weight loss was age. Older participants were more likely to complete the study. The small effect of age as a predictor of weight loss showed that older participants lost slightly more weight. These findings suggest this intervention may be more beneficial in older participants but because these effects are not large they have few practical implications.

Limitations

The most important limitation of the analyses presented in this chapter is the small sample sizes for these analyses. This reduces the power to detect significant associations. To account for this, effect sizes were also reported, and for the predictors found to be non-significant effect sizes were small, suggesting the lack of association found was not due to lack of power. The number of participants included in the regressions is very small in relation to the number of variables included. This limits generalisability and means the findings can only be interpreted as preliminary. The regressions were performed despite this limitation because of strong concerns about the independence of the predictors.

It is difficult to interpret the result regarding baseline behaviours because they could potentially result from the lack of detail in the measure used. Ideally a more in-depth analysis of eating and activity behaviours would have been taken at baseline. This was not included in the present study because of the priority to minimise participant burden.

Because the intervention provided was in leaflet form there was a need to try to match the level of burden with the intensity of the intervention. Participants are likely to feel frustrated if they are asked to spend a very long time completing questionnaires and only receive a leaflet in return. With intensive interventions, participants may be happier to invest more time in the study as they are likely to feel they receive more in return.

The predictor analyses and drop-out analyses relate to two different time points in the study. The predictor analyses were completed using 12 and 24 week data but the assessment of drop-outs was related to the full 32 weeks of the study. This is not ideal but the analyses were performed in this way because the sample at 32 weeks for the predictors analysis would have been even smaller, but assessing drop-outs at 32 weeks was a truer reflection of whether or not participants remained in the study.

Conclusions

In this study, men, single people, and those who had made few previous weight loss attempts, were the most successful at losing weight. There was suggestive evidence that a higher quality of life at baseline and lower impulsivity were associated with more success. The multiple regressions were able to explain over 35% of the variance in weight loss and therefore the analyses in this chapter, although preliminary, give some indication of who is likely to lose the most weight when given this intervention. It would be interesting to measure these variables in a larger effectiveness trial of the 'TenTopTips', to see if the results are replicated.

CHAPTER 7
STUDY 2: HABIT FORMATION WITHIN A TRIAL OF A HABIT-BASED WEIGHT LOSS INTERVENTION

INTRODUCTION

The findings from Study 2 are presented in three chapters focusing on different aspects of the trial. This third chapter focuses on habit formation in the recommended weight control behaviours. It also uses an estimate of adherence to the recommendations provided in the 'TenTopTips' leaflet and relates this to change in automaticity and weight change.

The aim of the 'TenTopTips' intervention was to promote habit formation so that the recommended behaviours become part of everyday life, and require little effort to be maintained. Weight loss was therefore the expected outcome. However the two aims - habit formation and weight loss - are not entirely dependent on each another, because participants could perform the behaviours non-habitually and still lose weight. Nevertheless it is important to find out whether habit strength changed during the study, and interesting to investigate whether there was a relationship between habit strength and weight change. I predicted that people who performed the behaviours most consistently would both show stronger habit formation and lose more weight.

As discussed in Chapter 6 two personality measures (impulsivity and personal need for structure) were hypothesised to predict habit formation. I hypothesised that people with a high need for structure or low impulsivity would find it easier to establish new routines which incorporate the recommended behaviours into their lives, than those who like less structure in their lives or are impulsive, and consequently would be more successful in forming new habits. In this chapter I report on associations between personality and automaticity change.

I also report on associations between the Context Habit Measure and the SRHI (both the full scale and an automaticity sub-scale) for eight of the recommended behaviours, because no previous research has used both these measures in the same study. It is important to assess how closely these measures are related when drawing conclusions

about habitual behaviour from studies using different measures. Lastly I discuss participants' reports on the recommendations they found most helpful and their perceptions of habit formation during the trial.

The research questions addressed in this chapter are:

i) Did automaticity change for the recommended behaviours and was this related to adherence and weight change?

ii) What is the strength of association between the Context Habit Measure and Self Report Habit Index measures of habit strength?

iii) Which 'tips' did participants find most useful and do they think the behaviours are now habitual?

METHOD

The methodology of this study was outlined in Chapter 5. Therefore only measures relevant here that were not described in Chapter 5, calculations of composite variables, and the analyses reported in this chapter, are described here.

Measures

Habit Strength

Self Report Habit Index

Habit strength was assessed for 16 different behaviours (all targeted by the 'TenTopTips' and shown in Appendix 7.1) using the Self Report Habit Index (Verplanken & Orbell, 2003) at baseline and 24 weeks from the start (i.e. weeks 8 and 32 for the WL group). A 7-point Likert scale from strongly agree to strongly disagree was used.

The Context Habit Measure

The Context Habit Measure (Wood et al., 2002; Wood et al., 2005) was completed at baseline (the initial meeting for the treatment groups and week 8 for the waiting list group) for eight of the recommended behaviours (shown in Appendix 7.3). Participants answered two questions;

- "Please answer how often you did each of the following things in the past two months", choosing from the options: 'I never perform the behaviour', 'Monthly or less often', 'At least once a week', or 'Just about everyday'.
- "Do you typically perform the following behaviours in the same location?" choosing from 'I never perform the behaviour', 'Rarely or never in the same location', 'Sometimes in the same location', or 'Usually in the same location'.

Responses to each question were coded as 0 to 3 and the two responses multiplied to give a scale score of 0 to 9 for each behaviour.

Adherence

Copies of the weekly tick-sheets were returned either at weighing sessions or by post (freepost envelopes were provided). These were used to estimate rates of adherence.

Final questionnaire

At the end of the study participants completed a final questionnaire which asked: "Which tips were the most useful for you in learning to manage your weight?", and "Do you feel the tips are now habits, and if so how long did this take?".

Calculations of composite variables

Automaticity scores

An automaticity subscale of the SRHI was used to track changes over time. Appendix 7.2 shows which items were used to create this subscale. It excluded behavioural frequency/history of repetition and identity items, therefore focusing on the subjective experience of automaticity alone. It is not known how responses to frequency items change when an individual is beginning to perform a behaviour, but these items would appear to be more appropriate for comparing habit strength across people at one time point. Identity items were excluded because there is still some controversy over whether habits are fundamental to an individual's identity (see Chapter 1).

There was a very high correlation between the full SRHI and the automaticity total; across the 16 behaviours at baseline (just before receiving the tips) correlations ranged from 0.98 to 0.99. Therefore it is unlikely the results would have been different if the full SRHI was used. Changes in automaticity scores over time were calculated. The aim of the tips is to decrease two of the behaviours measured and increase the other 14. A total positive health change in automaticity (positive automaticity change) was

calculated (over 24 weeks of using the tips) by summing the increase in automaticity for the healthy behaviours and the decrease in automaticity for the unhealthy behaviours.[58]

Use of the self-monitoring sheets

A variable was created for the number of tick sheets submitted as a percentage of sheets that could have been returned at the last assessment each participant attended (percentage of tick sheets completed).

Calculating adherence

Adherence to the tips advice was assessed after 24 weeks of using them. For participants who remained in the study and who had completed tick sheets for at least half of these weeks, a mean number of times each tip was ticked in a week was calculated for the tick sheets available. The number of days each week on which participants had recorded their weight was also counted and averaged, giving 11 behaviours with adherence values. The means were summed across behaviours to create a total average adherence score. The range of possible values for total adherence was 0 to 77.

Analysis

In this chapter the analyses focus on findings at 24 weeks from when participants were given the tips and include all participants in the study.[59] For the waiting list group all values were recoded with week 8 as baseline (and week 12 as week 4, and so on). As in Chapters 5 and 6, for all of the analyses, parametric assumptions were checked and where they were not met non-parametric tests were run to confirm the parametric findings and only reported if they differed from the parametric results.

To assess whether the number of tick sheets submitted related to weight loss, the variable 'percentage of tick sheets completed' was correlated (Spearman) with weight loss using the last observation carried forward variable at week 32, which represents the weight each participant lost at the last assessment they attended.

[58] If participants had missing data for one or two of the behaviours the mean of the other behaviours was used as an estimate for automaticity change for the missing behaviours.

[59] The waiting list group were included because the sample of participants from the intervention groups with automaticity scores at week 24 was very small.

Correlations (Pearson/Spearman) were run between both Personal Need for Structure and Impulsivity, and automaticity change at 24 weeks.

Two regressions were performed, predicting weight loss from adherence and automaticity change. The two participants with large weight losses were excluded (as in Chapter 6). A regression was performed with automaticity change as the dependent variable and adherence as an independent variable to assess the relationship between adherence and automaticity change. Group (intervention vs waiting list) was included as a predictor in these regressions to control for differences between groups.

To assess the relationship between different measures of habit strength Pearson (or Spearman) correlations were run between these measures at baseline (the meeting when participants were given the tips), for the eight different behaviours which were assessed with both measures. All participants with data were included in this analysis.

RESULTS

Automaticity change and adherence

Mean automaticity change, and the percentage of participants who increased on self-reported automaticity, across 24 weeks for the 16 different behaviours assessed are shown in Table 7.1. The two shown in bold are behaviours that the tips aim to reduce. This table shows that the majority of participants who provided data at week 24 increased their automaticity for the recommended behaviours over time. The automaticity scale ranges from 7 to 49. The mean baseline scores suggest that for some participants these behaviours were already somewhat automatic.

The variable 'percentage of tick sheets completed' was not normally distributed. The median was 84%, indicating that participants used the sheets for the majority of the time they were in the study. This was not significantly correlated with weight loss at the final assessment point (32 week LOCF): ($r=-0.038$, $p=0.717$, $N=96$), suggesting that completing the tick sheets was unrelated to outcome.

Table 7.1: Changes in automaticity scores over 24 weeks

		Baseline score		Score at 24 weeks		Change over 24 weeks		Participants increased automaticity
	N	Mean	SD	Mean	SD	Mean	SD	
Eating five portions of fruit and veg a day	34	26.8	12.4	38.2	10.5	**+11.3**	12.4	85%
Avoiding large portions (except of fruit and veg)	35	18.1	12.5	29.3	14.3	**+11.1**	14.1	77%
Choosing reduced fat foods	35	20.7	14.3	31.6	12.7	**+10.9**	13.6	89%
Reading labels when buying food	35	25.0	14.6	35.7	12.5	**+10.7**	17.2	74%
Using high fat food only sparingly	35	24.1	13.4	34.7	12.0	**+10.6**	11.5	89%
Eating healthy snacks	34	23.2	13.6	32.8	11.0	**+9.6**	14.2	82%
Keeping to a regular food routine	36	30.2	15.7	38.8	12.9	**+8.6**	13.5	83%
Walking 10,000 steps	35	24.7	15.1	33.1	14.9	**+8.4**	13.7	83%
Avoiding second helpings	35	21.6	12.3	29.5	13.8	**+8.0**	11.8	77%
Reading labels when preparing food	35	23.7	15.2	29.6	14.2	**+5.9**	15.1	74%
Drinking water and sugar free squashes instead of other soft drinks	35	35.6	13.8	40.8	10.6	**+5.3**	12.7	77%
Weighing myself	35	22.6	13.9	27.5	17.0	**+4.9**	13.8	77%
Standing for at least 10 mins every hour	35	26.1	14.3	30.7	14.6	**+4.6**	13.5	71%
Eating at a table	34	31.8	15.7	32.8	15.6	**+1.0**	10.6	71%
Drinking more than 1/2 units of alcohol a day*	34	21.4	13.7	21.1	15.3	**-0.3**	10.8	65%
Eating in front of the TV	35	27.2	13.9	27.0	17.5	**-0.2**	10.7	54%

*different for women and men respectively

Personality and automaticity change

There were no significant associations between Personal Need for Structure (r=0.207, p=0.234, N=35) or Impulsivity (r=-0.053, p=0.760, N=35) [60] and total automaticity change over 24 weeks.

[60] This was very similar to the Spearman correlation even though impulsivity was not normally distributed.

Associations between automaticity change, adherence and weight change

Regressions predicting weight change at 24 weeks showed a medium-to-large effect of automaticity change ($\beta = 0.317$, $p=0.069$, $N=32$) and a similar effect of adherence ($\beta = 0.283$, $p=0.050$, $N=45$). A regression predicting automaticity change from baseline to 24 weeks with the predictors of adherence over these weeks and group showed a small-medium effect of adherence ($\beta=0.249$, $p=0.171$, $N=32$).

Comparing Habit measures

Table 7.2 presents the correlations between the CHM and SRHI scores (both the full scale and the automaticity sub-scale) for each of the eight behaviours for which data was available from both measures. All these correlations were significant at the 0.01 level.

Table 7.2: Correlations between different measures of habit strength*

Behaviour	Correlation between SRHI and CHM	Correlation between Automaticity and CHM	N
Choose reduced fat foods	0.664	0.621	93
Walk 10,000 steps a day	0.698	0.654	93
Eating healthy snacks	0.516	0.442	90
Reading food labels when buying food	0.638	0.615	98
Stand for at least 10 minutes in every hour	0.642	0.612	98
Drinking water and sugar free squashes instead of other soft drinks	0.477	0.475	99
Eat five portions of fruit and vegetables a day	0.657	0.632	94
Weighing yourself	0.743	0.707	97

*Pearson correlations presented as Spearman correlations were very similar when there was doubt regarding normality.

Participants' perceptions at the end of the study

39 participants returned the final questionnaire. In response to the question of which tips were most useful participants gave up to four answers resulting in 53 responses. Table 7.3 shows the number of times each tip was mentioned. Two participants responded that all the tips were useful.

Table 7.3: Recommended behaviours participants found useful

Tip	Meal Routine	Reduce Fat	Walk	Healthy Snack	Labels	Portions	Up on your feet	Drinks	Focus on food	5 a day	Weigh
N	3	2	10	4	6	7	2	3	2	4	8

When asked if the tips were now habits, 17 participants said yes, 14 said some were habits and 8 said none of the recommended behaviours were habits. Of those within these groups who had an automaticity change score at 24 weeks those who responded 'yes' had a change score of 146.0 (N=11), those who said 'some' had a change score of 100.0 (N=10) and those who said 'none' had a change score of 95.0 (N=6). 27 participants gave a length of time that they thought it took for the behaviours to become habitual. The mean was 3.0 months (SD 2.0).

DISCUSSION

Automaticity and adherence

The average subjective automaticity of the behaviours increased during the study, suggesting that for some people at least, the behaviours recommended in the 'TenTopTips' leaflet became more habitual. Eating fruit and vegetables, and avoiding large portions, showed the largest increase in automaticity, and eating at a table the least (of those behaviours the intervention aimed to increase). Automaticity for eating at the table was relatively high at the start of the study although there was scope for it to increase. In the pilot study many participants reported that they did not have a table which may, in part, explain this finding.

The behaviours which the intervention aimed to reduce changed very little in their automaticity scores. This supports the idea that it is harder to break than to create habits (Verplanken & Wood, 2006). However, it is assumed that other unhealthy habits must have been broken because participants did, on average, lose weight. As discussed in Chapter 1, an interesting question is whether recommending new healthy habits results in participants exerting the self-control required to 'break' existing habits and create new ones instead. The results of this study suggest that participants did exert self-control and stop performing unhealthy behaviours and shows that they did develop new habits. Whether the old habits have in effect been broken and would no longer trigger behaviour when self-control is not applied is not known.

As many of the tips involved replacing one behaviour with another, the increase in automaticity for the recommended behaviours suggests that their unhealthy counterparts must have reduced in frequency and automaticity. As was also discussed in Chapter 1,

it is not known whether it is easier to break a habit by repeatedly not performing the behaviour in response to the cue, or through performing an alternative behaviour in these situations. The results of this study showed that the behaviours which participants were told not to perform did not reduce in automaticity, while behaviours they were advised to perform did increase in automaticity. This suggests replacing one behaviour with another may be particularly helpful. However, as the change in automaticity was averaged across participants and the comparison is between behaviours that may have started with different levels of automaticity, and participants may be more or less motivated to change them, the conclusion that replacing a habit with an alternative is more effective in 'breaking' a habit than simply repeatedly *not* performing the habitual response, can only be made tentatively.

Participants used the tick sheets a large percentage of the time throughout the study. It is difficult to know whether this was because it was recommended as part of the intervention or because they were asked to do so as part of the study design. The finding that the percentage of tick sheets completed did not relate to weight loss could be taken to suggest the tick sheets are not an effective component of the intervention. However this is far from conclusive, particularly as there may have been times the sheets were completed but were not returned. It is possible that using the monitoring sheets was important early in the study but once habits have formed, it became less important. Anecdotally, many participants reported that using the sheets was helpful in keeping them 'on track'. It is difficult to separate the effect of self-monitoring from the rest of the intervention. In future research it would be possible to compare groups with and without the daily reports to assess the importance of this component. Considering the evidence that self-monitoring is a significant predictor of weight loss (Boutelle & Kirschenbaum, 1998) it seems probable this aspect of the intervention was important, but as this is the first use of such a simple monitoring tool it is important that future work assesses the additional benefit it gives.

Adherence and automaticity change both neared significance as predictors of weight loss, with medium effect sizes. In addition adherence and automaticity change were associated with one another, although this was not significant in this small sample. Adherence had been predicted to affect weight change. The finding that automaticity change was also associated with weight loss is interesting. In this study it is not possible to assess the hypothesised mediation of adherence in explaining this

relationship, i.e. that when automaticity has increased people are more able to continue performing the behaviour, and this results in weight loss. In future studies it would be useful to assess automaticity change over 6 months and relate this to behaviour and weight maintenance over the following six months.

Personality was not found to relate to habit change. It may be that all people are able to create habits equally well when they are motivated to do so. This suggests that the findings relating impulsivity to weight loss, discussed in Chapter 6, are not operating through hindering habit formation, but are likely due to impulsive people finding it more difficult to avoid eating in tempting situations. Chapter 8 reports on another study which assesses the relationship between personality and habit change.

Different measures of habit strength

This study provided the opportunity to assess the association between two different measures of habit strength which have previously not been used in the same study. Correlations between the Self Report Habit Index and the Context Habit Measure were between 0.5 and 0.7 for the different behaviours, which is considered a large effect (Cohen, 1992). Correlations between the Context Habit Measure and the automaticity sub-scale of the SRHI were slightly lower. As the SRHI includes items that ask about behavioural frequency which were removed in the automaticity subscale, and the CHM is based on behavioural frequency, this slight reduction in association would be expected. What is interesting is that such a strong correlation remains between the CHM, which assesses if a behaviour is performed often and in stable circumstances, and the automaticity subscale of the SRHI, which assesses the subjective experience of automaticity. This gives support to the validity of both measures as an assessment of habit strength. The finding also helps to draw together the literature on habitual behaviour by showing that studies using the two different measures are measuring a very similar construct.

Participant perceptions

The results from participants' reports of their experiences are interesting. No one tip in the intervention stood out as the most useful advice, but walking, portion control and self-monitoring of weight were mentioned more than the other behaviours, suggesting these may be particularly important. This supports Hill's (2003) suggestion that if specific behaviours are going to be targeted, portion control and increasing lifestyle

physical activity would be good choices. The conclusion that participants did form habits during the study is supported by the fact that 80% of participants who completed this questionnaire reported that at least some of the behaviours had become habits. The average length of time participants perceived it took to form habits was 3 months. Chapter 8 reports on a study which focuses on the time it takes to form a habit.

Limitations

As in Chapter 6 the main limitation of the analyses reported in this chapter was the small sample size. This limits the generalisability of the findings and the power to detect significant effects. I have therefore focused on the size of Beta values in regressions rather than focusing on significance alone, but this is not ideal. Participants in this sample are those who remained in the study and provided data on automaticity at 24 weeks. As discussed in Chapter 5, those who remained in the study had been more successful at losing weight during the study and it is also likely that they were more successful at creating habits. Therefore the finding that participants were able to increase their automaticity for the recommended behaviours can not be generalised to all participants who are given the intervention, only those who remained engaged with it over time.

Combining the change in automaticity across 16 behaviours resulted in a loss of precision in the data and potentially reduces the predictive power of the variable 'automaticity change'. I could have investigated the relationship between weight loss and change in automaticity for each behaviour separately, but for this to be valid a much larger sample would be required. The self-monitoring sheets were not an ideal measure of adherence. Ideally, more detailed measures of eating and activity behaviours (e.g. food diaries) would have been used to assess the impact of the intervention. However, this would have greatly increased participant burden.

Conclusions

Habit formation was a goal of this intervention. The positive changes in automaticity suggest that the intervention was successful in achieving this goal, although more so for some behaviours than others. Longer-term follow-up would be required to assess how long new diet and exercise habits are maintained for. Over time, as people's lives change, the cues for these habits may change which would require an individual to form a new healthy habit. Returning to the 'TenTopTips' leaflet and using the tick sheets

would be one way to achieve this. Adherence and automaticity change both had associations with weight loss. The nature of this trial made it difficult to examine in detail the relationship between repetition and automaticity for different behaviours, and whether this is related to personality. The next chapter reports on an experimental study which was able to directly address these relationships.

CHAPTER 8

STUDY 3: MODELLING HABIT FORMATION[61]

INTRODUCTION

All models of habit assume that repetition of a behaviour in a consistent context eventually results in it being automatically triggered by that context. I have used the term Context Dependent Repetition (CDR) for this process. Despite the central position of repetition in habit models, the exact nature of the relationship between repetition and automaticity remains unexplored because the recent literature has paid little attention to the *process* of habit development. This study examines the relationship between repetition and the development of automaticity in individuals who were asked to perform an initially novel behaviour on a daily basis. Hull's (1943; 1951) work has already indicated a relationship between repetition and habit strength, but it was limited to results from laboratory studies where habit strength is inferred from behavioural responses and data pooled across participants. There is a clear need to replicate and extend this work by examining real-world behaviour, and on an individual basis.

Of particular interest both to individuals wanting to acquire healthy habits and behavioural researchers wanting to promote behaviour change is how long it takes to form a habit. At present, we do not know the answer. The aim of the present study was to test the CDR theory by examining the habit formation process in a series of volunteers who were simply asked to repeat a behaviour of their choice, in approximately stable circumstances, in an everyday setting. No rewards were given for performing the behaviour. Participants were asked to choose a situation rather than a time as a cue, because prospective memory research indicates that situation cues permit external cueing of an intended action, whereas time of day cues require monitoring to identify the time to act (McDaniel & Einstein, 2000). In the development of a habit, situations are therefore likely to be better cues than times. In support of this, in Study 1 I found that participants reported many more examples of situation-cued than time-cued habits.

[61] A version of this chapter has been submitted to *Personality and Social Psychology Bulletin.*

Of the three measurements used to assess habit strength, only the SRHI is appropriate to track changes over time because it focuses on the subjective experience of automaticity. In comparison the Context Habit Measure is based on an estimate of behavioural performance. The Response Frequency measure is based on habits generalised across situations and has only been developed and validated to assess travel mode choice. Although using the SRHI repeatedly to track habit development has been recommended (Verplanken et al., 2005), to date no published studies have used it in this way. For the present study I used the automaticity sub-scale of SRHI items. Behavioural frequency/history of repetition items were excluded because repetition of an initially novel behaviour was built into the intervention and questions about how often the behaviour is performed 'in general' are not appropriate when the level of repetition is changing. As discussed in Chapter 7 repetition items are more appropriate for assessing habit strength at one time point. The identity items were also excluded because there is controversy over the relationship between identity and habitual behaviours (Verplanken & Orbell, 2003; Wood et al., 2002).

Hull's (1943; 1951) work suggested the relationship between repetition and habit strength follows an asymptotic curve where automaticity increases steadily, but by a smaller amount with each repetition until it reaches an asymptote (or plateau); however, because outcomes were averaged across the sample, it was not clear whether the curve applies at an individual level. It is unlikely that habits develop through a step-change process, where one day a behaviour is not automatic and the next day it is. Therefore the hypothesis in this study was that repeating a behaviour, would result in increasing subjective automaticity which would follow an asymptotic curve. To test this hypothesis, this curve was fitted to each participant's data.

Some features of individuals could make the development of automaticity easier. Personality traits such as personal need for structure, conscientiousness and impulsiveness seem likely to be associated with being more or less willing - or perhaps more or less able - to create habits. People who prefer a structured life are likely to be better at achieving the contextual stability needed to develop a habit, while those who are impulsive may find this more difficult. Conscientious people are more likely to perform the behaviour as requested once they have committed to doing so. Personality was therefore assessed at baseline in this study to test the idea that conscientiousness,

need for structure, and (lack of) impulsiveness, would be associated with better habit formation.

As suggested in Chapter 1, implementation intentions (plans) have been hypothesised to speed up the habit-formation process by creating a mental association between situation and action that is then strengthened through repetition (Verplanken & Wood, 2006). In the present study, the relevant behaviours were defined in terms of a situation and an action, which could be argued to be similar to forming an implementation intention. Therefore it was not possible to create an experimental condition where people did not use planning. However there may be an impact of additional planning similar to that used by Armitage (2004). It is likely that any impact of this type of planning would operate through increasing the reliability of performing the behaviour rather than enhancing the mental association between situation and action. The impact of extra planning was assessed as part of the study.

One important issue in the habit development field is the role of omissions. James (1890) argued that development of habits requires uninterrupted performance. In the real world, this criterion is unlikely to be met, since there would almost certainly be some occasions when the cue is encountered and the behaviour not performed (a missed opportunity). One question addressed in this study was therefore whether a missed opportunity compromised habit development.

The study addressed the following questions:

- Does subjective automaticity increase when volunteers are given the simple instruction to repeat a behaviour in the same situation each day?
- Can an asymptotic curve be used to model the relationship between repetition and automaticity?
- How many repetitions are needed to reach a plateau of automaticity?
- Are there differences in the parameters of the asymptotic curve for each individual in relation either to the choice of behaviour, personality, or ratings of how difficult the behaviour is to carry out?
- Does forming thorough plans to carry out the repetition speed up the habit formation process?
- Does missing an opportunity to perform the behaviour compromise habit development?

Ethical approval

Ethical approval for this study was granted by the UCL Committee for the Ethics of Non-NHS Human Research. A copy of the confirmation letter is shown in Appendix 8.1.

METHOD

Participants

This study was advertised to university students through an email circular (Appendix 8.2). Interested participants (n=101) attended an individual initial meeting, of whom 96 chose to participate in the study (The Information Sheet and Consent form are shown in Appendix 8.3 and 8.4). A payment of £30 was made for participating in the full 12 weeks of the study, but was not contingent on behaviour change or habit development.

Procedures

At the initial meeting, participants were asked to choose a healthy eating, drinking or exercise behaviour that they would like to make into a habit. The behaviour had to be something that i) they did not already do, ii) could be performed in response to a salient daily event (cue), and iii) where the cue occurred every day and only once a day. Examples of the behaviours chosen were 'eating a piece of fruit with lunch', 'running for 15 minutes before dinner' and 'drinking a glass of water when I get up'.

Participants were randomised to a waiting list (N=22) or immediate start (N=74) group. Those in the waiting group attended an initial meeting where they chose their behaviour and were then asked to wait for four weeks before returning for the baseline meeting after which they started the study. The SRHI was completed at both meetings. For the immediate start group the initial meeting served as the baseline meeting. At the baseline meeting, participants were asked to try to carry out their chosen behaviour every day, starting from the day after the meeting.

Participants were also randomised to being asked to make a plan (N=51) and no specific planning instructions (N=45). At the baseline meeting, those in the planning group were given the following instruction, and then given space to write their plans: "The more you plan how you will do this behaviour, the easier it will be for you to do it.

Please use the space below to plan how you will do this. Consider anything you will need to do in advance in order to prepare to do the behaviour (for example if you are intending to eat a piece of fruit each day you may need to plan where and when to buy this). Try to formulate your plans in as much detail as possible. Focus on the situations in which you will implement these plans"

Participants were asked to log on to the study website every day for 83 days, starting two days after the baseline meeting. On each occasion they reported whether they had performed the behaviour the previous day and completed the SRHI. If they missed days they could report whether or not they had performed the behaviours retrospectively for up to three previous days, but the SRHI was only ever completed for the current day. If participants reported that they had not performed their chosen behaviour, they were asked to state why this was the case choosing from a number of options:

- I was not in the situation/ the cue didn't occur (e.g. I didn't have breakfast if breakfast was the cue)
- I forgot
- I wasn't prepared (e.g. I didn't have any fruit if the behaviour was eating fruit)
- I chose not to do it
- Other

Measures

The automaticity subscale of the SRHI was the primary outcome measure (Verplanken & Orbell, 2003). This used 7 items of the SRHI (shown in Appendix 5.14), answered on a 7-point Likert scale, giving the scale a range from 0 to 42 with higher scores indicating stronger automaticity.[62] Although previous research has summed the items in the measure using Likert scales of 1-7, in this study scales of 0-6 were used. This is because it is simpler to interpret graphs where the lowest possible value is 0. In addition, the analysis involves calculating time to reach 95% of the asymptote (discussed shortly) which makes most sense with a scale which starts at 0.

In order to test predictions about moderation of habit formation by personality factors, participants also completed:

[62] There was no need to allow scale totals to be calculated even if values were missing because this questionnaire was completed online and participants were not able to move to the next page if they had failed to answer any items.

- The Barratt Impulsiveness Scale (BIS-11; (Patton et al., 1995) ($\alpha = 0.84$[63]).
- The Personal Need for Structure (PNS) (Neuberg & Newsom, 1993) ($\alpha = 0.88$[63]).
- The Conscientiousness items from the International Personality Item Pool (IPIP) (Goldberg, Deary, De Fruyt, & Ostendorf, 1999) ($\alpha = 0.79$[63]).

These measures are shown in Appendix 6.2, 6.1 and 8.5 respectively and details of how questionnaire totals were calculated are shown in Appendix 8.6. The BIS and PNS were described in Chapter 5. The International Personality Item Pool is a public domain resource of items on individual differences and includes a Big-5 domain questionnaire which includes a ten-item scale measuring conscientiousness. Respondents are asked to rate the accuracy with which the self-statement items apply to them.

At the baseline meeting participants were asked the following question for their chosen behaviour: "How easy/difficult would it be for you to do this everyday" (please rate from 1(easy) to 5 (difficult)). At the initial and baseline meetings participants were asked; "Over the past four weeks have you done this…", with response options: no times, once, twice, three times, on average once a week, on average twice a week, on average three times a week, on average four times a week, on average five times a week, on average six times a week, or every day. After the 12 weeks of the study, participants completed an evaluation questionnaire (shown in Appendix 8.7).

Analysis

Modelling each individual's change in automaticity using non-linear regressions

Each individual's daily automaticity scores were plotted over 12 weeks to examine the shape of each curve. The ideal would have been to examine the relationship between number of repetitions and automaticity, but because participants failed to log-on to the website every day, there were days when behavioural data were not available. I therefore used day of the study as a proxy for repetitions and later considered consistency of performance.

SPSS Version 14 was used to run nonlinear regressions to fit an asymptotic curve for each individual's data based on Hull's (1943; 1951) model, using Mitscherlich's law of diminishing returns ($y = a - be^{-cx}$), where y is automaticity and x is day of the study

[63] Alpha values are from this study.

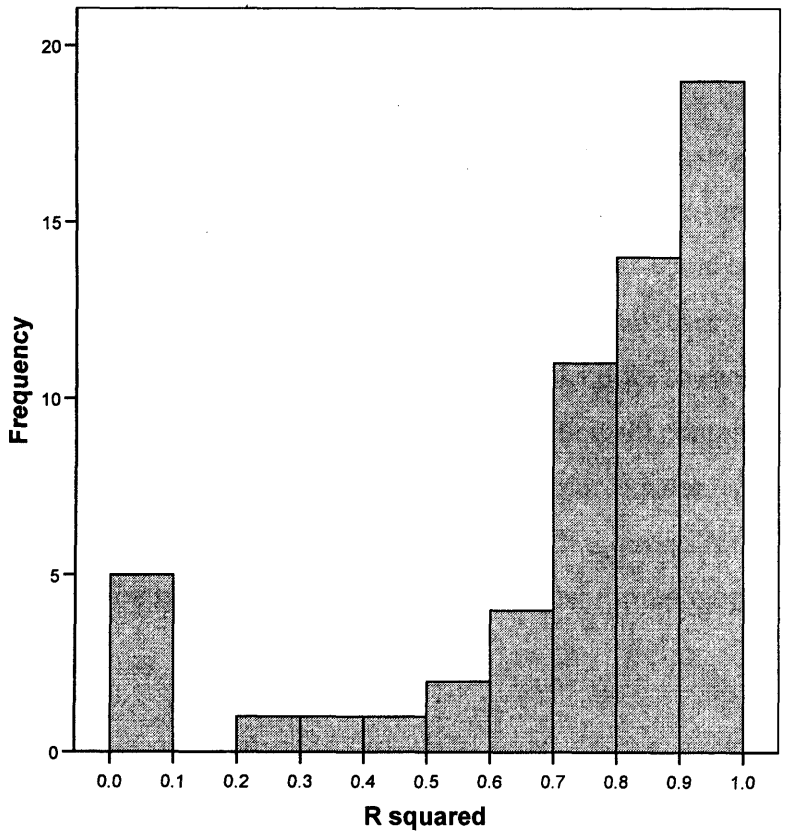
(Mitscherlich, 1919). This equation has the advantage that the constants provide psychologically meaningful results. In this model, *a* represents the asymptote of the curve (the automaticity plateau score), *b* is the difference between the asymptote and the modelled initial value of y (when x = 0), and *c* is the 'rate constant' which represents the rate at which the maximum is reached. All constants are positive numbers. The constants were used to calculate the time taken for the automaticity score to reach 95% of the asymptote using the following equation: time to reach 95% of asymptote = -[ln(a/20b)] / c.

The R^2 value indicates how well the model fitted the data for each participant. Clearly a distribution of curve-fits would be expected when the data are from individuals. The value of 0.7 was chosen as the threshold for 'good' fit on the basis of examining the distribution of curve fit values (Figure 8.1) where a step-change was apparent in the number of participants with R^2 values above 0.7. No cut-off value on the SRHI has been defined as identifying a behaviour as habitual. I chose to consider those with an asymptote score of lower than 21 to not have developed a habit. A score of 21 indicates an average response of "neither agree nor disagree" for all the items in the subscale (a score of 3 on a 0-6 point Likert scale). In order for a behaviour to be considered an eligible candidate for a habit it was decided the average score needed to be at least at this level. This does not mean that scores of 21 and over are necessarily habitual, only that I am confident in defining those below 21 as not habitual.

Performance variables

Participants were not entirely consistent in logging on to the website and therefore there were days for which data on whether the behaviour was carried out were not available. Two variables were created to estimate the number of repetitions of the behaviour during the study period. The first (number of reported repetitions) was calculated by simply summing all the occasions when a participant reported that they had performed the behaviour. The second (percent compliance) was calculated as the percentage of all days for which data were available, showing that the participant had performed the behaviour. These were used to compare participants for whom the model could and could not be fitted, and to examine associations with the curve parameters derived for each individual.

Figure 8.1: Histogram showing the distribution of R^2 values for the 58 participants the model was able to fit.



Parametric assumptions

Many of the variables of interest, based on the regression parameters and estimates of performance, were not normally distributed. Unless otherwise stated, medians and quartiles (Q_1:Q_3) are presented and non-parametric tests used to compare groups or examine correlations between variables.

Comparing participants on performance and curve parameters

Differences in performance variables and curve parameters were analysed in relation to the behaviours chosen, personality, participants' baseline ratings of how easy/difficult it would be perform the behaviour, and assignment to the planning or less planning groups, among the 37 participants with good model fit. Differences in performance variables based on the variables listed above were also analysed among all those with adequate data for analysis (N=82). Where group differences were assessed, Kruskal Wallis ANOVA (and if significant Mann-Whitney Tests to assess where group

differences lie) or Mann Whitney U tests were used. Where the variables of interest were continuous, Spearman correlations were used to assess the associations.

Impact of the study procedure

Two analyses assessed the impact of the study procedure on habit development. The automaticity scores of the waiting list control group at the initial meeting and four weeks later (before starting the study) were compared, using a Wilcoxon signed rank test, to assess whether identifying the behaviour to make into a habit, in itself, had an impact on automaticity. To check if any differences could be attributed to participants performing the behaviours during the four week wait, their ratings of how often they on average performed the behaviour in the 4 weeks prior to each meeting were compared. In addition the total number of times each participant completed the questionnaire for their target behaviour was correlated with the curve parameters among the 37 participants for whom the model was a good fit to assess if the number of times the questionnaire was completed impacted the habit formation process.

RESULTS

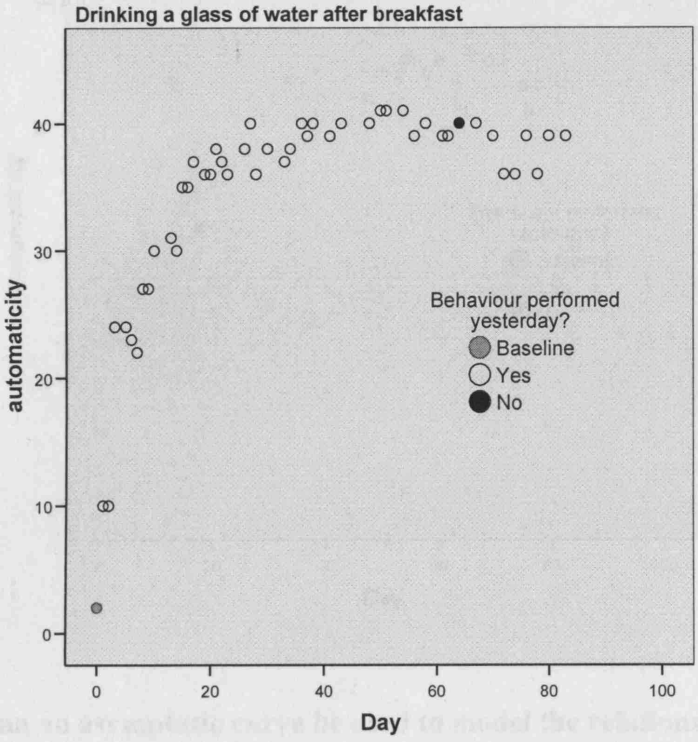
Participants were predominantly postgraduate students (two were undergraduates) and therefore represent a wide range of ethnicities and countries of origin. Participant details are presented in Table 8.1. For the habit task, 27 participants chose an eating behaviour, 31 a drinking behaviour, 34 an exercise behaviour and 4 chose another behaviour (e.g. meditation). These are shown in Appendix 8.8, along with the cues chosen. Participants also specified a quantity for their chosen behaviour, for example 30 minutes running. The median automaticity score at baseline was 3 (Q_1:Q_3 = 0:9). Fourteen participants did not enter data beyond day 60 and were considered to have dropped out of the study. From this point forward these 14 participants are not included in any analyses. The remaining 82 participants logged-on an average (median) of 47 out of 84 days, and in combination with the occasions on which they entered behavioural data retrospectively, this gave an average of 76 days for which data were available. At the start of the study, Cronbach's alpha was 0.94 for the complete SRHI and 0.90 for the automaticity score.

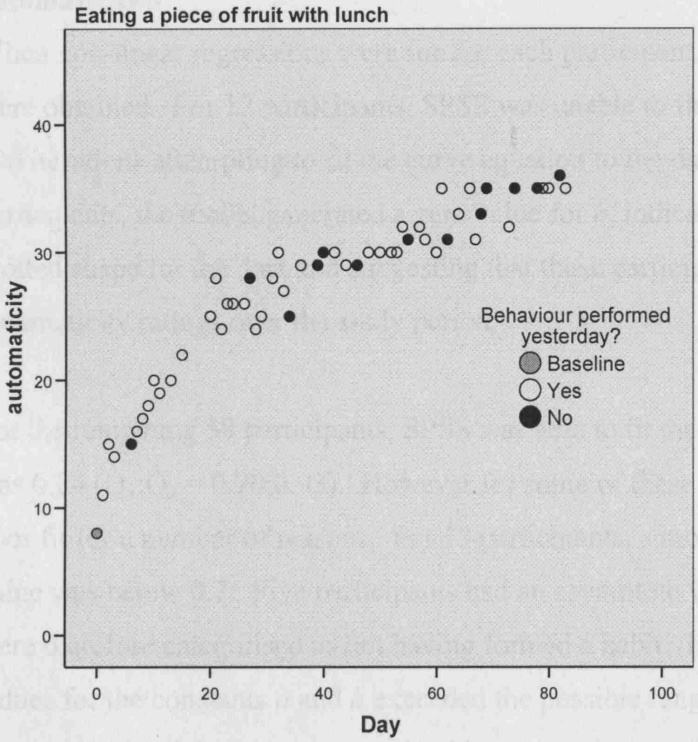
Table 8.1: Participant characteristics (N=96)	
Age	Mean 27 (range 21-45)
Gender	69% Female
Ethnicity (%)	
White	65
Chinese	12
Other Asian	5
Indian	4
Black Caribbean	3
Hispanic	3
Black African	2
Pakistani	1
Bangladeshi	1
Other	3
Chose not to respond	1
Country of Origin (%)	
UK	27
Other Europe	29
East Asian	13
USA or Canada	11
South America	5
Africa	5
Southern Asia	4
Middle East	2
Southeast Asia	2
Caribbean	1

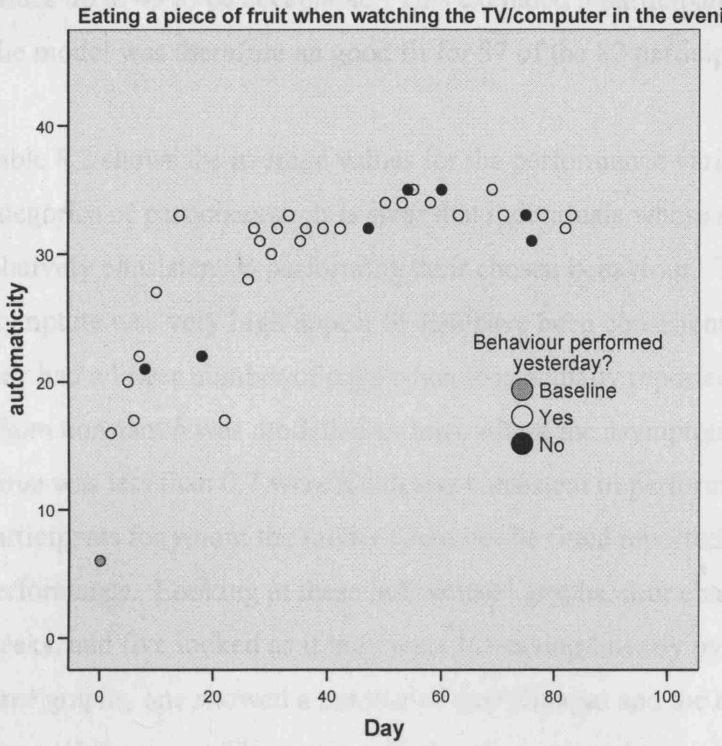
Does subjective automaticity increase when volunteers are given the simple instruction to repeat a behaviour in the same situation each day?

Individual scatter plots of automaticity scores over the days of the study were generated (examples are shown in Figure 8.2). Information on whether or not the behaviour had been completed on each previous day was also indicated. On visual inspection it was clear that many of the graphs showed the expected curve shape, with an increase over time until a final plateau, and that this was most evident in those who had performed the behaviour most consistently during the study. It was therefore appropriate to run the non-linear regressions.

Figure 8.2: Three examples of increases in automaticity scores during the 84 days of the study, showing on which days each participant had performed their chosen behaviour the previous day







Can an asymptotic curve be used to model the relationship between repetition and automaticity?

When non-linear regressions were run for each participant, a number of different results were obtained. For 12 participants, SPSS was unable to find an optimal solution after 100 iterations attempting to fit the curve equation to the data. For another 12 participants, the model generated a zero value for *b*, indicating a horizontal line as the plotted shape for the data and suggesting that these participants did not increase their automaticity ratings over the study period.

For the remaining 58 participants, SPSS was able to fit the model. The median R^2 value was 0.84 (Q_1:Q_3 = 0.70:0.93). However for some of these participants this model was a poor fit for a number of reasons. For 13 participants, a model was fitted but the R^2 value was below 0.7. Five participants had an asymptote value of less than 21, and were therefore categorised as not having formed a habit. In some cases, the modelled values for the constants *a* and *b* exceeded the possible range on the automaticity scale because the model was not constrained by range. I accepted this as a feature of the model except for those for whom the modelled value of the asymptote became unrealistic. The maximum score for automaticity was 42, and I considered asymptote

values up to 49 to be acceptable. This excluded 3 participants from the 'good fit' group. The model was therefore an good fit for 37 of the 82 participants (45%).

Table 8.2 shows the average values for the performance variables across the different categories of participants. It is clear that individuals whose curves had a good fit were relatively consistent in performing their chosen behaviour. Those where the modelled asymptote was very high appear to also have been consistent but this is less certain as they had a lower number of days when they actually reported the repetition. Those for whom constant *b* was modelled as zero, where the asymptote was low, or where the R^2 value was less than 0.7 were much less consistent in performing the behaviour. The 12 participants for whom the model could not be fitted reported a moderately high level of performance. Looking at these individuals' graphs, four changed little over the 84 weeks, and five looked as if they were increasing linearly over time. Of the remaining three graphs, one showed a number of step changes and the others had highly changeable scores. The participant showing a step-change, increased on all items in the questionnaire on the same day then continued responding identically for some time before changing on all items again. This suggests (s)he found it difficult to distinguish between the items and consciously decided when (s)he wanted to represent themselves as more habitual. It is not clear why the other two participants had data which was so varied.

Table 8.2: Performance variables within participant groups

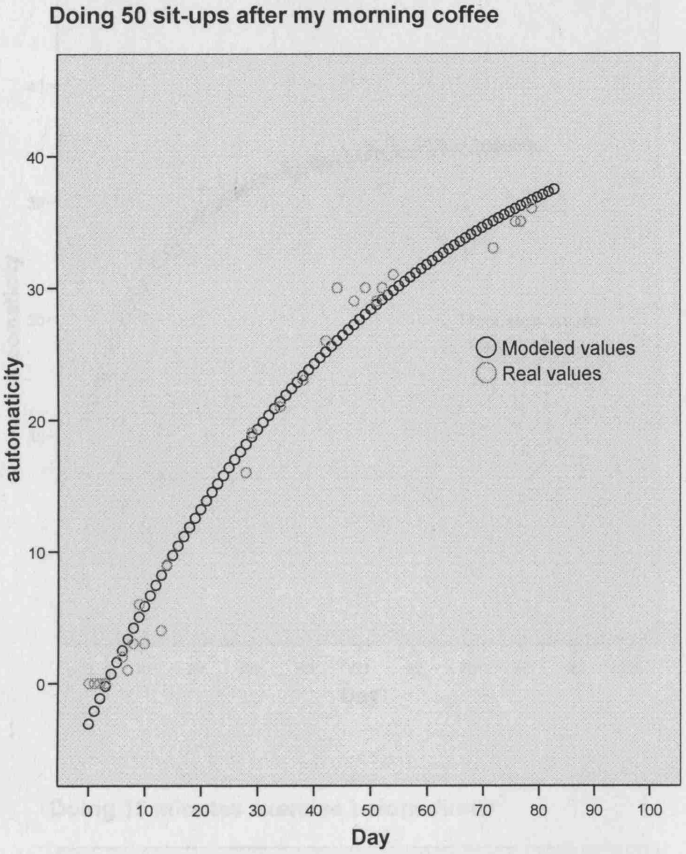
	Good Fit	a > 49	a < 21	$R^2 < 0.7$	b is modelled as 0	Model can't fit
N	37	3	5	13	12	12
Percentage compliance, Median (Quartiles, Q_1:Q_3)	88 [a] (80:94)	82 [ab] (64:94)	65 [b] (44:70)	60 [b] (47:97)	59 [b] (39:73)	80 [ab] (52:95)
Number of reported repetitions, Median (Quartiles, Q_1:Q_3)	63 [a] (58:76)	52 [ac] (51:65)	43 [bc] (30:52)	50 [c] (32:72)	36 [b] (17:43)	59 [c] (36:72)

[ab] Mann-Whitney tests between each pair of groups indicated significant differences between subgroups with different superscripts.

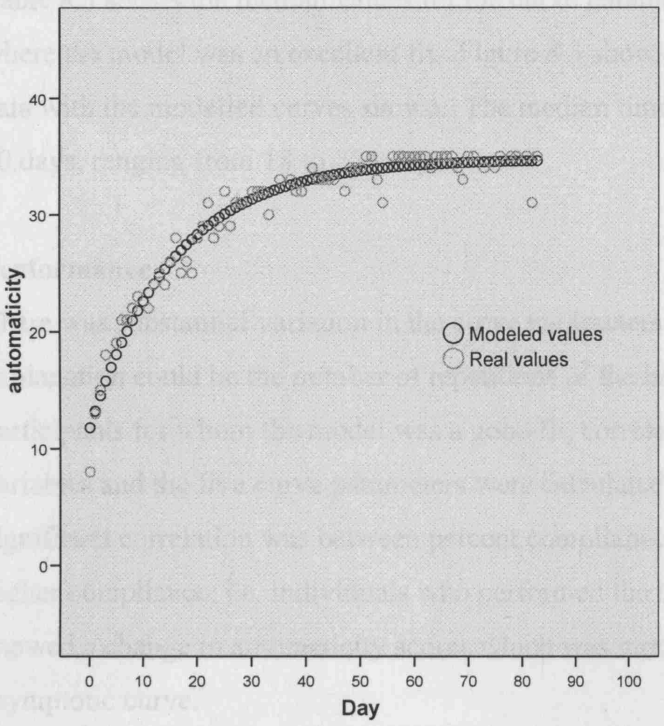
Table 8.3: Median, Quartiles and minimum and maximum values of the curve parameters for those for whom the model was a good fit (N=37)

	Median	Quartiles (Q_1:Q_3)	Minimum	Maximum
R^2	0.89	0.82:0.94	0.72	0.98
a (asymptote)	35	29:43	21	48
b (change in habit strength/automaticity)	31	24:40	13	51
c (rate of change)	0.042	0.028:0.069	0.010	0.170
Time to reach 95% of asymptote (days)	70	39:103	18	254

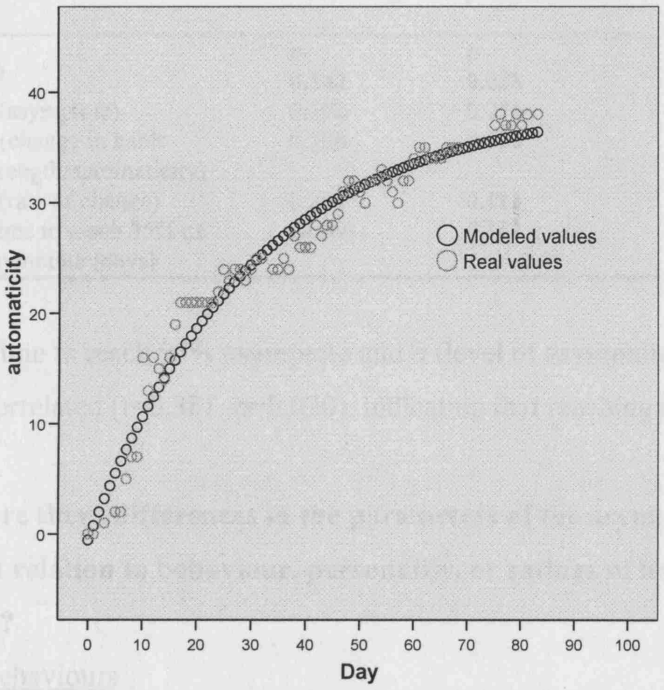
Figure 8.3: Three examples of increases in automaticity scores during the 84 days of the study showing the scores entered and the curve modelled using non-linear regressions.



Walking for ten minutes after breakfast



Doing 15 minutes exercise before dinner



How many repetitions are needed to reach a plateau of automaticity?

Table 8.3 shows the median values for the curve parameters among the 37 participants where the model was an excellent fit. Figure 8.3 shows examples of these participants' data with the modelled curves shown. The median time to reach 95% of asymptote was 70 days, ranging from 18 to 254 days.

Performance

There was substantial variation in the curve parameters across individuals. One explanation could be the number of repetitions of the behaviour. Among the 37 participants for whom the model was a good fit, correlations between the performance variables and the five curve parameters were calculated (Table 8.4). The only significant correlation was between percent compliance and R^2 indicating better fit with higher compliance, i.e. individuals who performed the behaviour more consistently showed a change in automaticity scores which was modelled more closely by an asymptotic curve.

Table 8.4: Correlations between performance variables and curve parameters

	Percentage compliance (N=37)		**Number of reported repetitions (N=37)**	
	r	**p**	**r**	**p**
R^2	**0.342**	**0.038**	0.241	0.150
a (asymptote)	0.192	0.256	0.162	0.338
b (change in habit strength/automaticity)	0.166	0.326	0.174	0.303
c (rate of change)	0.264	0.115	0.113	0.505
Time to reach 95% of asymptote (days)	-0.266	0.111	-0.097	0.568

Time to reach 95% asymptote and *a* (level of asymptote) were also significantly correlated (r=0.381, p=0.020), indicating that reaching a higher asymptote took longer.

Are there differences in the parameters of the asymptotic curve for each individual in relation to behaviour, personality, or ratings of how easy/difficult the behaviour is?

Behaviours

Behaviours chosen by participants were classified as eating (N=22), drinking (N=28) or exercise (N=29) behaviours (3 participants chose behaviours which did not fit into these categories). These groups were compared on the performance variables. Kruskal Wallis ANOVAs showed significant differences between these groups on both percentage compliance (χ^2 =8.893, p=0.012) and number of reported repetitions (χ^2

=6.059, p=0.048). Mann-Whitney tests showed these differences fell between the exercise and drinking groups. Participants who chose exercise behaviours had a lower mean percentage compliance (70, Q_1:Q_3 = 52:88) and number of repetitions (43, Q_1:Q_3 = 35:68) than those who chose eating (80, Q_1:Q_3 = 73: 88 / 59, Q_1:Q_3 = 51:71) or drinking (90, Q_1:Q_3 = 73: 95 / 63, Q_1:Q_3 = 51:74) behaviours.

Among those who had particularly good-fitting curves (n=37), there was a fairly even division into eating, drinking and exercise behaviours (one participant could not be included in this analysis). The analyses shown in Table 8.5 show that the only variable that was significantly different between those who chose different behaviours was percent compliance, with the drinking group performing the behaviour more consistently.

Table 8.5: Performance levels and curve parameters among those who chose different types of behaviours

	Eat (N=10)		Drink(N=14)		Exercise(N=12)		Kruskal Wallis p value
	Median	Quartiles (Q_1:Q_3)	Median	Quartiles (Q_1:Q_3)	Median	Quartiles (Q_1:Q_3)	
Number of reported repetitions	59	53:68	71	63:78	63	50:75	0.135
Percent compliance	80[a]	77:90	93[b]	89:97	86[a]	78:91	0.014
R^2	0.84	0.74:0.94	0.88	0.84:0.95	0.92	0.84:0.96	0.159
a (asymptote)	34	27:44	37	28:43	37	31:45	0.652
b (change in habit strength/automaticity)	27	20:35	32	27:40	34	24:41	0.425
c (rate of change)	0.045	0.031:0.074	0.048	0.039:0.083	0.031	0.022:0.061	0.314
Time to reach 95% of asymptote (days)	65	35:106	61	36:76	96	42:125	0.279

[ab] indicates significant differences identified using Mann Whitney tests between subgroups with different superscripts.

Personality

Personal Need for Structure, Conscientiousness and Impulsivity were assessed at baseline. The average scores in the sample (N=96) matched existing normative data. For the BIS, the mean score in the present sample was 62 (SD 10) compared with an average of 64 (SD 10) (Patton et al., 1995) in other student samples. Previous studies using the PNS have used a midpoint (3.5) on the scale as a cut-off to determine high and low personal need for structure (Neuberg & Newsom, 1993). In the present sample the mean was 3.8 (SD 0.9). A recent study of US undergraduate students averaged the answers to the ten items in the conscientiousness scale and found the mean of these was 3.6 (SD 0.6) (Donnellan, Oswald, Baird, & Lucas, 2006). In the current study the mean was 3.7 (SD 0.7).

The personality factors were not significantly correlated with the amount that the behaviours were performed in this study (Table 8.6).

Table 8.6: Correlations between personality and performance levels, among all those with adequate data

	Personal Need for Structure (N=82)		Impulsivity (N=82)		Conscientiousness (N=79)	
	r	p	r	p	r	p
Number of reported repetitions	0.085	0.447	-0.021	0.848	0.193	0.088
Percent compliance	0.004	0.970	-0.012	0.916	0.134	0.240

None of the personality factors were significantly correlated with any of the regression outcomes or with estimates of the amount the behaviours were performed, in the 37 participants with good fit (Table 8.7).

Table 8.7: Correlations between personality and performance levels and curve parameters

	Personal Need for Structure (N=37)		Impulsivity (N=37)		Conscientiousness (N=35)	
	r	p	r	p	r	p
Number of reported repetitions	0.159	0.437	0.109	0.522	0.108	0.539
Percent compliance	-0.017	0.919	0.063	0.711	-0.041	0.817
R^2	-0.030	0.860	0.038	0.823	-0.098	0.575
a (asymptote)	0.120	0.478	0.041	0.810	0.008	0.964
b (change in habit strength/automaticity)	0.111	0.512	0.126	0.456	-0.007	0.967
c (rate of change)	0.095	0.575	-0.008	0.962	0.079	0.653
Time to reach 95% of asymptote (days)	-0.085	0.619	0.044	0.794	-0.121	0.489

Table 8.8 shows that conscientiousness and impulsivity did not differ significantly between groups of participants, grouped by the outcome of modelling their automaticity scores. However there was one significant effect found where those who had an asymptote value above 49 had significantly lower 'personal need for structure' scores than those in a number of the other groups. This may be a chance finding as there were only three participants in this group.

Table 8.8: Personality within participant groups

	Good Fit	a > 49	a < 21	$R^2 < 0.7$	b is modelled as 0	Model can't fit	Kruskal Wallis p value
N	37	3	5	13	12	12	
Personal Need for Structure, Median (Quartiles, Q_1:Q_3)	3.92[b] (3.21:4.75)	2.50[a] (1.83:2.92)	3.08 (2.83:3.75)	3.58[b] (2.96:4.08)	4.04[b] (3.41:4.90)	3.46[b] (3.12:4.42)	0.037
Impulsivity, Median (Quartiles, Q_1:Q_3)	62.0 (55.0:70.0)	68.0 (63.1:80.4)	66.0 (64.0:69.5)	64.0 (55.5:67.5)	58.4 (47.3:63.8)	65.0 (57.3:68.0)	0.305
Conscientiousness*, Median (Quartiles, Q_1:Q_3)	3.70 (3.30:4.20)	2.90 (2.50:2.90)	2.95 (3.30:4.15)	3.45 (3.03:3.87)	3.95 (3.35:4.55)	3.65 (3.13:4.30)	0.082

[ab] Mann-Whitney tests between each pair of groups indicated significant differences between subgroups with different superscripts.
*Three participants did not complete this measure the N's in the $R^2 < 0.7$ and Good Fit groups were reduced to 12 and 35 respectively.

How easy/difficult it would be to perform the chosen behaviour

81 participants had answered the easy/difficult question. This was correlated with the performance variables. There was no significant correlation with percentage compliance (r=-0.109, p=0.333) or number of reported repetitions (r=-0.050, p=0.655). Within the 37 participants with good fit, correlations were run between responses to the easy/difficult question and the curve parameters and performance variables (Table 8.9). There were significant correlations between ratings of how easy or difficult the behaviour would be and percent compliance and time to reach 95% of asymptote. This significant effect of participants' ratings on percentage compliance within the participants with good fit, which was not found within all participants, will be discussed.

Table 8.9: Correlations between participant's ratings of how easy/difficult it would be to perform a behaviour and curve parameters (N=36)

	Easy/Difficult	
	r	p
Number of reported repetitions	-0.162	0.346
Percent compliance	**-0.337**	**0.044**
R^2	-0.158	0.357
a (asymptote)	-0.009	0.957
b (change in habit strength/automaticity)	0.080	0.642
c (rate of change)	-0.297	0.078
Time to reach 95% of asymptote (days)	**0.339**	**0.043**

Does forming thorough plans speed up the habit formation process?

Although all participants planned in detail when, where and how they would perform their chosen behaviour, it was hypothesised that additional planning could speed the habit formation process through increasing the level of repetition of the target

behaviours. However, across all participants (N=82) there was no significant difference between those in the planning group (N=42) and those in the less planning group (N=40) in terms of the amount they performed the behaviour during the study (Table 8.10).

Table 8.10: Differences on performance variables between those who made plans and those who did not

	Planning (N=42)	Less Planning (N=40)	Mann-Whitney p value
Number of reported repetitions, Median (Quartiles, Q_1:Q_3)	55.0 (43.0:71.0)	60.5 (36.5:72.0)	0.878
Percent compliance, Median (Quartiles, Q_1:Q_3)	78.0 (65.7:90.7)	82.1 (57.3:92.3)	0.952

Among the 37 participants with good fit, there were no differences between the planning (N=19) and the less planning group (N=18) on performance estimates or curve parameters (Table 8.11). However the effect neared significance for R^2 showing that the planning group showed a pattern of change which was better fit by an asymptotic curve. There is also a suggestion, although this does not near significance that those in the planning group took less time to reach their asymptote.

Table 8.11: Performance levels and curve parameters among those who chose different types of behaviours

	Planning (N=19)		Less Planning (N=18)		Mann-Whitney p value
	Median	Quartiles (Q_1:Q_3)	Median	Quartiles (Q_1:Q_3)	
Number of reported repetitions	61.0	51.0:78.0	63.0	59.8:75.0	0.703
Percent compliance	86.0	79.7:97.6	88.5	8.2:92.7	0.638
R^2	0.94	0.84:0.95	0.87	0.79:0.93	0.073
a (asymptote)	35.2	29.0:43.0	35.1	28.1:43.3	0.832
b (change in habit strength/automaticity)	33.5	22.7:39.4	29.6	25.8:40.9	0.855
c (rate of change)	0.047	0.028:0.057	0.041	0.026:0.074	0.796
Time to reach 95% of asymptote (days)	66.3	39.3:100.2	74.8	38.5:117.0	0.584

Does missing an opportunity to perform the behaviour compromise habit development?

To test the hypothesis that missing an opportunity reduces automaticity, I examined automaticity scores the day after a missed opportunity and compared these with the previous day's score. For these analyses, a missed opportunity was defined as an occasion on which the behaviour was reported as not having been performed which was immediately preceded by three occasions when it had been performed. 140 such occasions were identified (across 55 participants). The mean difference between the

last day of action and the first day after omission was a decrease of 0.29 automaticity points. I also looked at whether automaticity increased when the behaviour was performed again after the missed opportunity. On occasions when the missed day was followed by a day on which the participant performed the behaviour again (N=67), the difference between the last action day and the second day after omission (when the behaviour had been performed again) was an increase of 0.55.

In order to compare this to situations where the behaviour was performed, I identified all the occasions when the behaviour was performed on two consecutive days and automaticity scores were available. The mean change was an increase of 0.47 automaticity points. On occasions when the behaviour was performed for three consecutive days and automaticity scores were available for the first and third days the average increase was 0.79 points.[64]

The analysis was also repeated excluding cases where an opportunity was missed but was reported to be due to the participant not being in the relevant situation, or not being prepared, because they had not experienced an opportunity to perform the behaviour. This left 84 occasions and the mean decrease was 0.23 points. There were then 36 occasions when the behaviour was performed again the following day and the average change from the last action day to this day was 0.61 points.[64]

There was no significant correlation between the change in automaticity scores between the last day of action and the first day after omission, and the time in the habit formation process that the omission occurred (i.e. day of the study) ($r=0.099$, $p=0.246$, $N=140$)[64].

The impact of the study design

Further analyses considered the effects of the study procedure on responses to the SRHI. For the 22 participants in the waiting list control group, the automaticity score at the initial meeting was compared with the score after the 4 week delay. There was no significant difference between these scores (Wilcoxon signed rank test $Z=-1.48$, $p=0.14$). The median was 2(Q_1:Q_3 =0:8) at the initial meeting and 3 (Q_1:Q_3 = 0:14) at the baseline meeting, 4 weeks later. This was not due to any large changes in the amount the behaviour was performed during these four weeks. Only 10 of the 22

[64] These results were similar when repeated restricting the analysis to only those whom the model fitted well.

participants reported a higher level of performance in these four weeks than those prior to the initial meeting and none of these rated their performance more than 2 categories higher at baseline than at the initial meeting. There were no significant correlations between the total number of times each participant completed the questionnaire for their chosen behaviour and the curve parameters among the 37 for whom the model was a good fit (Table 8.12). The median number of times the questionnaire was completed for these 37 participants was 50 (Q_1:Q_3 = 35:66).

Table 8.12: Correlations between the number of times participants completed the SRHI and curve parameters (N=37)

	r	p
R^2	0.199	0.237
a (asymptote)	0.082	0.628
b (change in habit strength/automaticity)	0.143	0.400
c (rate of change)	-0.132	0.435
Time to reach 95% of asymptote (days)	0.157	0.352

Participants views on changes during the study

77 participants completed the evaluation questionnaire. Responses are grouped into agree, disagree or neither agree or disagree and presented in Table 8.13.

Table 8.13: Responses to the questionnaire completed at the end of the study

Question	Disagree %(N)		Neither agree or disagree %(N)		Agree %(N)	
	Total sample	**Excellent model fit**	Total sample	**Excellent model fit**	Total sample	**Excellent model fit**
Doing this everyday got easier over time (N= 77/36)	9 (7)	**3(1)**	16 (12)	**17 (6)**	75 (58)	**81 (29)**
During the study my enjoyment of the behaviour increased (N= 76/36)	16 (12)	**6 (2)**	17 (13)	**25 (9)**	67 (51)	**70 (25)**
During the study my desire to do the behaviour increased (N= 76/36)	11(8)	**3 (1)**	14 (11)	**17 (6)**	75 (57)	**81 (29)**
During the study my belief in my ability to do the behaviour increased (N=77/37)	5 (4)	**0 (0)**	23(18)	**19 (7)**	71 (55)	**81 (29)**
This is now a habit (N= 76/36)	17 (13)	**11 (4)**	20 (15)	**8 (3)**	63 (48)	**81 (29)**

DISCUSSION

Modelling the habit formation process

This study is a novel application of habit formation research in a real-world setting. The most important finding was that for the majority of participants, automaticity increased steadily during the study. These findings support the theory of Context Dependent

Repetition (CDR), by showing that simply repeating a behaviour in a consistent setting resulted in increasing automaticity. I was able to model the habit formation process and generate parameters for each individual's habit-formation curve. An asymptotic model was a good fit for 45% of the participants who provided enough data for analysis. Those for whom the fit was poor had typically carried out the behaviour fewer times during the study, except for three participants for whom the poor fit was due to the modelled asymptote reaching a level that was not plausible in relation to the scale. This was because they showed a continuing increase in automaticity throughout the study with no asymptote. Five other participants, in the group that the model did not fit, on visual inspection also showed a steady linear increase but no asymptote. It seems likely that the individuals whose automaticity score appears to increase linearly over the 84 days of the study were just slower than others in forming a habit and would have reached a plateau if recording had continued for longer. Because the model fitted so many participants, and those it did not fit were performing the behaviour less consistently, the findings support the idea that the model reflects a generalised habit formation process. This model could be a useful tool for researchers interested in differences in the habit formation process between people and behaviours, for example differences in the time it takes to form a habit and the level of automaticity reached, because it provides parameters for each individual which are easily interpreted. I examined a number of potential explanatory variables, but the scope for further research using this model is considerable.

The typical asymptotic pattern was a decelerating increase to a plateau but individuals varied in both the speed at which they reached the plateau and the final level. Variations in the values of the asymptote suggest differences in the degree of automaticity that people experienced for their chosen behaviour, although I cannot rule out the possibility that people responded differently to the questionnaire items. Time to plateau - operationalised here as time to reach 95% of asymptote – was an interesting outcome. An often-asked question is 'how long does it take to form a habit'. In this study I addressed the question of how long it takes for a behaviour to reach its maximum automaticity. An alternative would have been to define a score on the automaticity scale which was indicative of a habitual behaviour and investigate how long it took participants to reach this level. However, as already suggested, people may respond differently to the questionnaire, or it may apply differently to different behaviours, so defining such a level was not possible. The average modelled time to

plateau in this sample was 70 days with individual participants' values in the model ranging from 18 to 254 days. This average is considerably larger than the ten repetitions Ronis et al. (1988) proposed; the only statement I found in the literature discussing how long it takes to form a habit.

The value of the asymptote was significantly correlated with time to reach 95% of asymptote, suggesting that it takes longer to form stronger habits. This is not the same as saying that more repetitions will necessarily increase habit strength, because each person had their own individual plateau height. Something about either the individual or the behaviour may limit the level of automaticity that can be reached. However it appears that behaviours that are 'destined' to become strongly automatic require more repetitions for this to happen.

Ideally this analysis would have considered the relationship between number of repetitions, rather than day of the study, and habit strength. However, because there were days when performance was not recorded, this was not possible. Therefore it was important to consider whether being more consistent was related to faster habit development or a higher final level of automaticity. I calculated two alternative estimates of the amount the behaviour was performed to examine this. Assuming that an individual has to perform a behaviour a specific number of times in order to develop a habit, not performing the behaviour on days during the study would result in the total number of days to plateau being increased. I therefore expected those who performed the behaviour less during the study to take longer to reach a plateau. In this study neither of the performance variables was related to time to plateau. However the percentage compliance estimate (the amount the behaviour was reportedly performed as a percentage of data that participants provided) showed a trend towards those with higher compliance taking less time to reach a plateau. With more participants this relationship could potentially have been significant. Future work will need to reduce missing data to examine this more precisely. However, the lack of significant relationship suggests that the average time to plateau of 70 days would not have been greatly decreased if participants had been more consistent. As the level of performance reported was high (88%) even if a significant relationship had been found the reduction in time to reach asymptote produced by more consistency would likely not be large.

Within the 37 participants with a 'good fit' model, there was no relationship between the performance estimates and plateau height. However, the five participants for whom the model fitted well, but who had a low automaticity score considered to not be indicative of a habit, had performed the behaviour significantly less than those with higher plateau scores. There may therefore be a threshold value of performance below which the level of habit strength is curtailed. Above this threshold, it would appear that something other than mere number of repetitions determines the final level of habit strength.

Type of behaviour

Verplanken (2006) has suggested that more complex behaviours achieve lower levels of automaticity. However in his study the number of repetitions was restricted, leaving it possible that the complex task could become as habitual as the simple task with more repetitions. Nevertheless, Wood et al (2002) found that complex tasks were associated with more thoughts during their performance than less complex tasks, suggesting they may be less automatic. It has also been suggested that the complexity of a task can determine the 'type' of automaticity which can develop. Wood and Neal (2007) proposed that complex tasks are more likely to be goal-directed and therefore do not fall under their definition of habits. The suggestion that different behaviours have the potential to reach different levels of automaticity and that the mechanisms through which this automaticity operates may vary, means it is important to compare the habit formation process for different types of behaviours.

In the current study participants who chose exercise behaviours were less likely to perform them than if they chose eating or drinking behaviours, although this was only significant between the exercise and drinking behaviours. Among those who successfully formed a habit, those who chose drinking behaviours performed these more often than who chose exercise behaviours and these in turn were performed more than eating behaviours. It seems clear that it is easier for participants to perform drinking behaviours than eating or exercise behaviours, but future work with more participants is needed to examine this further. The proportion of participants who had a good model fit was very similar within the three types of behaviour, suggesting that it is equally possible to form habits for all of these. There were no differences between groups on the curve parameters. However, because the study was not powered for sub-group analyses, this negative finding should not be considered to be definitive. The exercise

group did take one and a half times longer to reach their asymptote than the other two behaviour groups and as exercising can be considered more complex than eating or drinking this supports the proposal that complexity of the behaviour impacts habit formation. In future, differences could be examined by pre-selecting different behaviours for study.

How easy or difficult the participants thought performing the behaviour would be

Participants who reported that performing the behaviour everyday would be more difficult performed the behaviour less and took longer to reach their asymptote. As discussed above, although the relationship between performance and time to reach asymptote was non-significant the p value was low, and as the sample size was small there may be a relationship which failed to reach significance due to low power. It is therefore not possible to establish whether the relationship between ratings of difficulty and time to reach asymptote is mediated by performance consistency or not. It is possible that more complex behaviours may be considered to be more difficult and it may be this complexity which causes habit formation to take more time, but equally likely it could be that due to the behaviours being performed less often habit formation takes longer.

The finding that those who thought that performing the behaviour would be difficult had lower levels of performance was only found among those with good model fit, and not within the total sample. One explanation for this is that the levels of motivation to perform the behaviour were lower among the whole sample, as compared to only those with good model fit. This is supported by the finding that the levels of performance were lower in the total sample. If motivation is low then how difficult a behaviour would be to perform is less likely to determine compliance.

Personality

Contrary to expectations, none of the three personality variables were related to compliance (performance). The only personality variable that approached significance was conscientiousness. However, this was only when using the variable which summed the number of times a participant had entered that they performed the behaviour, and not when the percentage compliance variable was used, therefore it probably reflects the association between conscientiousness and compliance with study demands. Personality variables were also unrelated to the shape of the habit formation curve.

Although there were significant differences in personal need for structure between groups of participants with different outcomes from the model-fitting process, this appeared to be due to outliers (the three participants who had a very high modelled asymptote value had very low need for structure scores). It could be that when people are motivated to create a habit they are able to do so irrespective of personality but the evidence provided in this study is not conclusive because of the small sample size. One alternative way that personality could impact on habit formation is that some people have more consistent cues in their days around which to create habits, and therefore if asked to consistently perform a behaviour may do so in a routine way. In the present study, participants specifically chose a cue which reliably occurred every day, so this could not be tested.

Planning

All participants in this study could be considered to have formed an implementation intention concerning how, when and where they would perform their chosen behaviour, but half the participants were specifically asked to form additional plans focusing on the situation in which they would perform the behaviour. However this did not impact on performance. In addition there were no significant differences in curve parameters between those who were asked to form additional plans and those who were not. Once people have formed implementation intentions there may be no additional benefit from forming further plans. Future research should focus on the impact of forming implementation intentions on habit formation. Habits may take longer to form when implementation intentions have not been used, and this also warrants investigation.

Missed opportunities

The effect of errors of omission was highlighted as crucial by James (1890), but has never been tested formally. I examined specific missed opportunities and found that they reduced the automaticity score on the subsequent day by less than half a point. In the instances where the behaviour was performed again the following day and automaticity data were available, scores increased from the day before the missed opportunity. Comparing the increase in automaticity score over two days when the behaviour was performed on both days and over two days when there was a missed opportunity shows a missed opportunity did not materially affect the habit formation process. There was also no relationship found between the timing of a missed opportunity and the change in habit score, but there were relatively few such

opportunities to evaluate and therefore there is potential for more work on this question. The hypothesis that missed opportunities earlier in the habit formation process will be more detrimental than when automaticity is more fully developed warrants further investigation. Future work also needs to examine the impact of more than one missed opportunity to assess at what point automaticity begins to reduce.

An interesting issue is whether a missed opportunity results in people giving up on the attempt to form a habit. For individuals in the group where the model fitted well, the average percentage of days the behaviour was performed (out of those where data was entered) was 88% i.e. these individuals manifestly did not give up and stop performing the behaviour. However there may be a minimum frequency of repetitions needed for a behaviour to become a habit, as was suggested above. The percentage compliance value was significantly correlated with how well the model fitted the data. This would fit with the idea that those who were less consistent in performing the behaviour had data which were 'messy' due to brief reductions in automaticity when the behaviour was not performed, but this did not preclude habit development at the levels of performance in this group.

Participants' perceptions of change during the study

The evaluation questionnaire assessed participants' perceptions of changes over the course of the study. The majority of participants in the total sample, and an even larger majority among those who had good model fit, reported that performing the behaviour became easier over time. They also reported that their enjoyment of performing the behaviour, their desire to do it, and their belief in their ability to do so, increased over time and they now viewed the behaviour as a habit. This gives a positive view of habit formation. Future work should examine this in more detail by measuring how these factors change longitudinally during the habit formation process.

Rewards

This study involved participants trying to establish habits for healthy behaviours, and explicit rewards were not provided for performing the behaviours. Some of these behaviours may have been inherently rewarding when they were performed, for example an eating behaviour may be associated with a hedonic reward. However many others may not have been directly rewarding. One of the main challenges in behaviour change research is that the healthy behaviours we aim to promote are often less

rewarding to people than unhealthy alternatives. The finding that it was not necessary to provide people with rewards to enable them to form habits is encouraging in terms of including advice on habit formation in behaviour change interventions, as in the 'TenTopTips'. However it does not clearly distinguish between the alternative models of habits outlined in Chapter 1. If the behaviours are inherently rewarding then these results are able to support the Motivational Contexts Model of habit operation, which is based on the transfer of the motivational properties of a reward onto a cue when the reward is regularly received after a behavioural response to the cue. If the behaviours were not immediately rewarding then the results of this study would challenge this model. Because it is not possible to know if the behaviours were rewarding, these results do not provide clear evidence for or against this model. It is not clear whether if rewards had been provided, this would have altered the habit formation process. This is a topic which could be assessed in future research using the modelling procedure from this study.

Limitations

There were a number of limitations to this study. The size of the sample of individuals with good curve fit was relatively small, so power to examine differences between participants was low. There were also – not unexpectedly given the 3 month duration of data collection - days when participants did not enter behavioural data, which was a limitation in interpreting the results. I assessed the impact of the study procedure on automaticity score. This analysis suggests that the identification of a specific behaviour to make into a habit, did not in itself change the self-reported automaticity score over 4 weeks. The SRHI is a self-report measure, and has never previously been used repeatedly as it was in this study. It is difficult to assess the extent to which completing the same questions every day impacts on people's responses. However, there was no relationship between the number of times the questionnaire was completed and automaticity scores, suggesting that completing the questionnaire on multiple occasions did not impact these reports of automaticity. There was a large range in the number of times the questionnaire was completed, therefore this finding was not due to lack of variation in this variable. Nevertheless, as this analysis was conducted within a small number of participants I can not rule out the possibility that completing the questionnaire had a small influence on changes in automaticity score.

In this study, the alpha values for the SRHI and the automaticity sub-scale were very high. This shows that participants were responding in a very similar way across items in the scale and therefore it may not be necessary to use all the items. Anecdotally, participants had most difficulty with the double negative questions, for example that 'it would require effort not to do'. It may be possible to adapt the measure, making it shorter and easier to use, which would be helpful for longitudinal studies.

As discussed, the SRHI does not have a cut-off value to define habitual behaviour and clearly a plateau at a very low level could not be used as indication of a habit. I used as the cut-off a total automaticity score that on average indicated disagreement with the items. Arguments for different cut-offs could be proposed.

This study was as controlled as possible while investigating real-world behaviour. As a result of this, I cannot know how consistent the context where the behaviour occurred was. Participants chose a cue - for example after lunch – but if they eat lunch at very different times, in very different circumstances, then the context in which they perform the behaviour will be variable. This could explain why some participants failed to form habits and warrants further investigation. Different features of performance context have been considered as cues to action (Wood et al., 2005) but no research has investigated the level of consistency that is required. It is possible this varies across habits, i.e. some habits may be cued by 'after lunch' and others only by 'after lunch when at home'. This may depend on the level of variability experienced during the habit formation process.

Conclusions

In conclusion, the instruction to repeat a behaviour in response to a cue appeared to be enough instruction to enable the majority of people to develop a habit for a behaviour, that they had been motivated to perform. Although consistency in repetition is required, the precise level of consistency is not yet known. It is possible to model the habit formation process in individuals on the basis of subjective reports of automaticity, and to generate parameters that can be interpreted and compared. There was variation both in the level of automaticity and the time taken to reach a plateau. Although no relationships were found between different types of behaviours or personality types and the curve parameters, there is potential to replicate and extend this work. Future

research can use the model outlined here to investigate these and other factors that might explain the differences in curve parameters.

CHAPTER 9
GENERAL DISCUSSION

AIMS

The aim of the research presented in this thesis was to investigate the utility of a theory of habit formation in designing simple weight loss advice. Part of the reason for the interest in using the theory of habit formation was the potential to give this advice with little or no health professional contact. A review of the literature on habitual behaviour identified a number of models describing the operation of habits. Central to all of these is the assumption that habits develop through repetition of behaviour in consistent contexts (Context Dependent Repetition). Advice based on this idea can easily be given in written form and therefore, if shown to be effective in promoting habit formation, has the potential to be used as the basis of brief behaviour change advice. A review of low-intensity weight loss interventions revealed that, despite considerable interest in these approaches, only a small number involved little or no contact from health professionals, and many lack a theoretical basis for why they should facilitate behaviour change. In this thesis, I focused on using the theory of Context Dependent Repetition as the basis of a very low-intensity weight loss intervention, which presented advice in a leaflet and involved no contact with health professionals. I also tested this theory in an experimental study and examined the relationship between repetition and automaticity.

SUMMARY OF MAIN FINDINGS AND CONTRIBUTIONS TO THE LITERATURE

This thesis has addressed a series of questions, a number of which I set out to examine, and others that emerged during the process. I will outline these questions, discuss how the results presented help to answer them and review the contribution this makes to the literature. Although the studies in this thesis did not intend to provide evidence for or against the alternative models of habits identified in Chapter 1, where the findings are relevant to the models this is discussed.

Does Context Dependent Repetition result in habit formation?

A review of the literature on habitual behaviour revealed that all the models assume that habits develop through repetition in consistent contexts (Context Dependent Repetition). The intervention tested in this thesis (the 'TenTopTips') recommends ten simple behaviours and advises participants to incorporate the tips into their daily routines, and monitor their progress on a simple monitoring sheet. The advice is intended to encourage participants to perform the behaviours regularly in consistent contexts (Context Dependent Repetition) to promote habit formation. Qualitative interviews in the pilot study of the 'TenTopTips' (Study 1) showed that participants experienced the behaviours as becoming 'automatic', in line with the concept of habit acquisition. Most participants reported that by the end of the 8 week period at least some of the behaviours had become automatic, and that it would be easy to continue with them. In the randomised controlled trial of the 'TenTopTips' (Study 2), participants completed the SRHI at baseline and after 6 months, and automaticity scores had increased substantially. Study 3 examined the habit formation process for eating and activity behaviours in more detail using items from the Self Report Habit Index to track changes in automaticity over time as participants repeated a behaviour. Results showed increasing automaticity for the majority of participants. As far as I know, this is the first study to focus on the habit formation process for 'real world' behaviours. These results provide evidence that giving explicit advice on Context Dependent Repetition is sufficient to promote habit formation.

Is it necessary to provide explicit rewards each time a behaviour is performed in order to create a habit?

In the behaviourist tradition habits were considered to be a function of the rewards received for performance of a behaviour in response to a cue (Hull, 1943; Hull, 1951). However, the review of recent models of habitual behaviour suggested a lack of agreement about whether it is necessary to provide explicit rewards on each occasion a behaviour is performed, in order for it to become habitual. I hypothesised that in free-living humans it would be possible to create habits without providing explicit rewards if the behaviour was one an individual wanted to do. In all three studies, advising participants to perform behaviours in consistent situations was sufficient to promote habit formation. Rewards were not provided each time the target behaviours were performed and no explicit identification of goals was required. This could be taken as evidence against the Motivational Contexts Model (Neal et al., 2006; Wood & Neal,

2007) of habits, which argues that habits are formed when a cue is associated with a reward received after a specific response to the cue and the motivating properties of the reward are transferred onto the cue. However, it is possible that performing the behaviours was inherently rewarding and therefore, although not explicitly rewarded, the behaviour was reinforced at each repetition. Therefore although the results presented here cannot resolve debates on the role of reward in the operation of habits, it seems safe to conclude that habits can be formed without provision of explicit external rewards.

Does the relationship between repetition and automaticity plot an asymptotic curve?

Hull's (1943; 1951) research provides a model (an asymptotic curve) for the relationship between repetition and habit strength. However his work was limited to results from laboratory studies where habit strength is inferred from behavioural responses and data pooled across participants. There was a clear need to replicate and extend this work by examining real-world behaviour, and on an individual basis. In Study 3 an asymptotic curve was a good fit for many individuals' pattern of automaticity change over 12 weeks. For those whom the curve did not fit, the results showed that they often performed the behaviour less consistently. This supports the hypothesis that this model reflects a generalised habit formation process.

Does missing an opportunity to perform a target behaviour hinder the habit formation process?

James (1890) argued that development of habits requires uninterrupted performance, and no exceptions must occur while the habit is developing. The results presented in this thesis provide evidence against this idea. In Study 1 and 2 nearly all participants reported missing opportunities to perform the behaviours recommended in the 'TenTopTips' and this had not precluded habit acquisition. Study 3 provided more direct evidence that missing an opportunity to perform the target behaviour did not affect the habit formation process. There was no significant reduction in automaticity between two occasions when the intermediate opportunity had been missed, compared to when the behaviour had been performed on all three occasions. However individuals who were less successful in forming habits during the study (indicated by low automaticity scores) performed the behaviour less consistently, suggesting that some

degree of consistency in repetition is required to form habits, but the precise level of consistency is not yet known.

How long does it take to form a habit?

Although this is an important question, both to individuals wanting to acquire healthy habits and behavioural researchers wanting to promote behaviour change, the only statement I could find in the literature was that of Ronis et al (1988); that a behaviour is habitual once it has been "performed frequently (at least twice a month) and extensively (at least 10 times)" (p213). The results of the pilot study of the 'TenTopTips' (Study 1) suggested that the time it takes to form a habit is variable, across both individuals and behaviours. In the 'TenTopTips' pilot one participant reported that all the behaviours felt automatic after two weeks, but others felt that some were not fully automatic even after 8 weeks. A lack of automaticity for the behaviours was indicated for some participants who reverted to their old ways when the study finished. In the trial of the 'TenTopTips'(Study 2) participants were asked if they thought the recommended behaviours had become habitual, and if so how long this took. Among those who thought that some or all of the behaviours had become habitual, the average time stated was three months. This fits with the finding from Study 3 that the median length of time it took for participants to form a habit (operationalised as time to reach 95% of their asymptote) was 70 days. This is longer than might be expected, and significantly longer than suggested by Ronis et al (1988). Further work is needed to assess the time it takes different people to form habits for different types of behaviours. Providing information on how long it takes to form habits, in habit-based interventions may help to encourage participants to continue to exert self-control for a sufficient length of time to establish habits.

Is the habit formation process different for people with different personalities?

The hypothesis that personality might impact on the speed of habit formation was assessed in Study 2 (the trial of the 'TenTopTips) and Study 3 (the habit forming study), and in both studies no effect was found. This suggests that when people are motivated to form habits they are able to do so irrespective of their natural preference for stability in their lives, impulsivity or conscientiousness. The non-significant results could be due to lack of power, but there was no hint of an association. However, as these are the first studies to assess the relationship between personality and habit formation, it is

important that future studies assess additional aspects of personality and in larger samples.

Can people form multiple habits simultaneously?

Study 3 focused on the habit formation process, but only in one behaviour. In comparison, participants using the 'TenTopTips' were encouraged to develop habits for multiple behaviours simultaneously. Given the increase in automaticity found across many of the behaviours in the trial of the 'TenTopTips' (Study 2), it appears to be possible to create a number of habits at the same time. The limit on the number of new habits which can be established at one time is likely to lie in the individual's capacity to remember to perform many new behaviours at the relevant times during their lives to result in the required consistency in repetition for the behaviours to increase in automaticity.

Is it easier to break habits by not performing the behaviour or by performing an alternative behaviour?

While the focus of this thesis was on creating rather than breaking habits, the results from the trial of the 'TenTopTips' (Study 2) are relevant to the topic of breaking habits. Participants increased their automaticity for many behaviours, but their automaticity for the two behaviours which the intervention aimed to reduce remained stable. This supports the proposal that it is easier to make than to break habits (Verplanken and Wood, 2006).

Although the learning processes in extinction and counter-conditioning have been argued to be similar (Bouton, 2000), whether learning a link for a new behaviour is easier than learning a link for non-behaviour is an empirical question that we do not currently have an answer to. The results described are relevant to the question of whether it is easier to break a habit by repeatedly not performing the behaviour in response to the cue, or through performing an alternative behaviour when the cue is encountered. A number of the healthy behaviours that increased in automaticity are likely to have replaced unhealthy alternatives (e.g. choosing the low-fat option which precludes choosing the high fat option). This suggests that participants exerted self-control in order to stop performing the unhealthy behaviours and, as automaticity for performing the new behaviours increased, it is assumed that automaticity for performing the alternative decreased. Given that the habits participants were trying to 'break',

without replacing them with alternatives, did not reduce in automaticity, this suggests replacing one behaviour with another may be particularly helpful. However, it could be that some participants chose not to try to 'break' the two habits in question (eating in front of the TV and drinking alcohol) or that these are particularly difficult habits to change, so the results are only suggestive.

Can we compare individuals on their habit formation process?

In Study 3 it was possible to model the habit formation process in individuals on the basis of subjective reports of automaticity, and to generate parameters that could be interpreted and compared. There was variation both in the level of automaticity reached and the time taken to form a habit (operationalised as time to reach 95% of their asymptote). In this thesis I was unable to explain this variability between individuals performing different behaviours. Nevertheless, the methodology could be applied in future research to examine these differences. Understanding more about the factors which impact how quickly a habit is formed and the strength of the habit once developed may be able to inform future interventions based on habit theory.

Do the Self Report Habit Index and the Context Habit Measure measure the same construct?

A useful contribution to the literature on habitual behaviour was made by comparing two measures of habitual behaviour which have not previously been used in the same study. This showed the two measures, one assessing frequency of performance and performance stability (the Context Habit Measure (Wood et al., 2002; Wood et al., 2005; Ji & Wood, 2007)) and one assessing self-reports of the features of habits (the Self Report Habit Index (Verplanken and Orbell, 2003)) were highly correlated. This is consistent with the idea that they are measuring that same construct and that research using the two measures can be considered as a whole.

Can advice on creating habits for simple weight control behaviours help people to lose weight?

As discussed, a review of low-intensity weight loss interventions revealed that, despite high levels of interest in these approaches, only a small number have involved little or no contact from health professionals, and many lack a theoretical basis for why they should facilitate behaviour change. Studies 1 and 2 provided evidence that it is possible to generate simple advice about behaviour based on habit theory that is straightforward

to follow, easy to remember, undemanding to carry out, and compatible with normal everyday life. The 'TenTopTips' recommends ten simple behaviours and advises participants to incorporate the tips into their daily routines and monitor their progress on a simple monitoring sheet. A randomised controlled trial of this intervention (Study 2) found that giving motivated overweight and obese adults the 'TenTopTips' leaflet resulted in clinically significant weight loss over 8 months (3.8 kg in completers), which was significantly higher in the intervention groups than a control group over an 8 week trial phase. Psychological well-being also improved over the 32 weeks of the study. The finding that participants showed positive changes in automaticity for the recommended behaviours during the study suggests participants may be able to maintain the behaviours, although longer follow-up would be required to assess this.

Although behaviour change interventions often implicitly aim to create habits, few have had any theoretical underpinning related to habit formation. As far as I am aware, the 'TenTopTips' was the first to explicitly target habit formation and the results show that it is possible to promote weight loss with a simple leaflet based on habit theory. This makes an important contribution to the literature because the intervention is very simple compared to those previously used and involves no support from health professionals. The weight loss results are comparable to those found with many other low-intensity interventions, for example the LEARN self-help manual for weight loss (Poston et al., 2006; Gardner et al., 2007; Foster et al., 2003; Womble et al., 2004). These results therefore suggest that this approach has the potential to result in significant benefits relative to the low cost of delivery, particularly if the results can be replicated in a study with no 'official' weighing. Even with monthly weighing, which can be conducted by a lay person, the cost of implementation would be much lower than many other interventions and considering the potential health benefits would be worth the expense.

LIMITATIONS

The quantitative results of Study 1 (the pilot of the 'TenTopTips') were useful in designing the subsequent studies, and were encouraging regarding the potential of the intervention, but had little scope beyond this. I will not reiterate the limitations of the pilot study here. The qualitative outcomes were of more interest and the limitations, inherent in this type of research, were discussed in Chapter 4. In this discussion I focus

on the limitations of the two larger studies. Limitations of these studies were discussed in earlier chapters but the most important issues are reviewed here.

Power

Both studies had limited power to detect differences between groups and associations within subgroups. This was partly due to reduction in the samples, in Study 2 due to drop-out, and in Study 3 due to the model only providing a good fit for 37 participants. In Study 2 this was addressed by calculating effect sizes and focusing on these rather than statistical significance alone, but this limited the conclusions which could be drawn. In Study 3 an examination of effect sizes for group differences was not possible because the majority of variables were not normally distributed. However the sample sizes were adequate to answer the central questions in both studies, and analyses within the reduced samples provide interesting results which warrant further investigation in future research.

Participant characteristics

The participant samples used in the studies were not ideal. In Study 2 participants were predominantly white, well-educated women. This is a limitation of many weight loss studies (Weinstein, 2006), even when they are advertised widely (Jeffery et al., 2003). This study did involve 34% men, which is higher than many other weight loss studies, and was sufficient for significant differences in weight loss to be detected between men and women. The recruitment method did not allow for an analysis of response rates to the advertisement, so it is not possible to assess whether this was a high or a low percentage of the men who saw the advertisement. Because men lost more weight than women in this study it would be worth investigating if men can be encouraged to engage with this intervention. The results suggest that any ethnic differences identified in weight loss may be due to differences between the ethnic groups on other predictors, but because the numbers of participants from ethnic groups other than white was small, and a higher percentage of these participants dropped-out of the study, more work is needed to assess if this intervention is useful for those from ethnic groups other than white. Although participants in this study had relatively high levels of education, weight loss was unrelated to education, suggesting that the results are not specific to those with a high level of education. In Study 3 participants were students, and although there is no reason to think that the habit formation process should be different

among students than other people, it will be important to use alternative samples in future research.

Study Designs

Both studies were longitudinal, one with a 12 week follow-up and one with a 32 week follow-up. In both cases, it would have been beneficial to have continued for longer, but this was not practical. Study 3 was the first study to investigate the habit formation process and it was therefore impossible to predict in advance how long it would take for participants to form a habit. The length of time to form a habit identified in this study was surprisingly long and suggests that any future study following a similar design should continue for at least 15 weeks in order for the majority of participants (more than 75% of participants in this study) to have reached an asymptote. In Study 2 participants who remained in the study continued to lose weight over the 32 week trial and it would be interesting to assess the weight change over a longer period of time, to assess the average total weight loss achieved and maintenance of this loss. Despite this, both studies were able to make valuable contributions to the literature with the length of follow-up used.

Ideally in Study 2, a control group would have been used for the full 32 weeks of the study. This was not practical because participants were recruited through an advertisement asking for volunteers who wanted to lose weight and therefore asking them to wait for 8 months before they received this could have potentially resulted in a large drop-out rate within this group. This limits the conclusions that can be drawn about the long-term outcomes of the study, however the significant difference between the intervention and control groups at 8 weeks shows that the intervention does have an effect on weight loss independent of the effect of participating in the study and attending regular weighing sessions.

FUTURE RESEARCH

Whilst some important findings have emerged from the studies in this thesis, this remains a new area of research and many questions have been raised which warrant further research. As I have mentioned throughout the thesis, a useful next step in testing the 'TenTopTips' intervention would be an effectiveness trial where all overweight and

obese patients in GP surgeries were randomised to receive the leaflet or not. This could have a longer follow-up than was used in the trial presented here, and the control group could be given the intervention after the end of this follow-up. It would be interesting to include one treatment group who were only weighed at the start and the end of the study, and one with more frequent weighing to assess the impact of the intervention without the 'official' weighing included in the exploratory trial. With a large sample, this would allow for analyses of predictors of outcome, to assess whether those identified here (for example gender and number of previous weight loss attempts) were important.

The 'TenTopTips' was presented as a weight loss intervention for those who are overweight or obese. However, it could potentially also be used as a weight gain prevention intervention for adults of normal weight. Thus far low-intensity weight gain prevention interventions have had limited success, yet those which have been most successful have focused on recommending small behavioural changes, similar to those in the 'TenTopTips'. However, people are often more interested in weight loss than weight gain prevention, and therefore there could be less interest in the intervention if it was presented in this way (Levine et al., 2007). As weight gain prevention is an important public health goal more work on how to interest the public in this is important, and a focus on whether the 'TenTopTips' could be used in this way could be informative.

Research on habitual behaviour is growing within social psychology but has not focused on habit formation. There are many unanswered questions relating to the habit formation process that have emerged from the research reported here. I found that the average time to form a habit was 70 days but this was only within 37 people, and there was substantial variation among participants. More research is needed to assess the time to reach asymptote in a larger sample with a variety of different behaviours. A useful first step would be to conduct a larger study, similar in design to Study 3 and using the same method of analysis. Ideally this would reduce missing data to allow for a direct analysis between number of repetitions and automaticity. An important question to address is what level of consistency is required to form habits, or in other words how many missed opportunities would result in a reduction in automaticity. Whether the impact of missed opportunities is more important earlier in the habit formation process would also be of interest.

Whether more complex behaviours are able to become as automatic as simple behaviours, and whether this takes longer, remains unresolved. In order to adequately investigate this it will first be important to identify a way of measuring the complexity of everyday behaviours and to carefully consider exactly which aspect of the behaviour is considered to be the habit, for example if going for a 30 minute run is the behaviour of interest, is it the whole 30 minutes of running which is habitual, or the initiation of the behaviour. Including assessments of motivation and perceived ease of performing the behaviours would also be informative. Although personality was not found to be predictive in the studies in this thesis, as these were the first studies to address this question further assessments of differences in the habit formation process by personality would be useful. Information on individual differences which predict success in forming habits could be useful in identifying people for whom habit-based interventions are most appropriate.

Implementation intentions have been shown to speed the habit formation process in one study (Orbell and Verplanken, 2005[65]), and therefore there is scope to investigate this further. Designing a study specifically to address whether forming an implementation intention speeds habit formation through creating a mental association between situation and action will require careful thought, because it would need to compare participants who were all performing a behaviour in a stable situation but where one group had formed an implementation intention to do this and one group had not. Another unresolved question is whether habits can be 'broken' by replacing the habitual response to a cue with an alternative response, and whether this is more effective than simply repeatedly *not* performing the behaviour in response to the cue. Using implementation intentions to plan to perform the replacement behaviour or to plan not to perform a habitual behaviour are two possible strategies to 'break' habits which warrant further attention.

The role of rewards in the habit formation process and in the operation of habits remains unresolved, although I found that it is not necessary to provide explicit rewards in order for habits to develop. There is scope for many different studies on this topic. One option would be to conduct a study similar to Study 3 and to provide explicit rewards, to investigate how this affects the habit formation process i.e. whether habits are formed

[65] Cited in Gollwitzer and Sheeran (2006) as manuscript under review.

more quickly and whether they reach a higher level of automaticity when rewards are provided, and if when these rewards are later removed the habit is broken.

One limitation of Study 3 was that it was difficult to draw conclusions about differences between people on their final automaticity score because these differences could reflect variation in how individuals respond to the items in the questionnaire rather than actual differences in automaticity. Ideally a more objective measure of the association between cue and action would be used. In studies of implementation intentions cue-response links are assessed using response times in lexical decision tasks (Webb & Sheeran, 2007a). This approach could possibly be used to assess the cue-response links hypothesised to be the basis of habitual responses. Similar measures could also potentially be used to differentiate between alternative models of habits.

FINAL REMARKS

The research in this thesis aimed to investigate the utility of a theory of habit formation in designing weight loss advice that has the potential to be effective at a population level. I hope that I have succeeded in demonstrating the promise of using a theory of habit formation in behaviour change interventions, provided some insight into the habit formation process, developed a methodology which can be used to investigate this further, and highlighted the importance of conducting more research into this process that can inform interventions for a variety of behaviours.

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APPENDICES

Appendix 1.1: The Context Habit Measure

How often do you perform 'behaviour X'?

never (score 0)

monthly or less (score 1)

at least once a week (score 2)

just about every day (score3)

Multiplied by

Do you typically perform 'behaviour X' in the same location?

never (score 0)

rarely (score 1)

sometimes (score 2)

usually (score3)

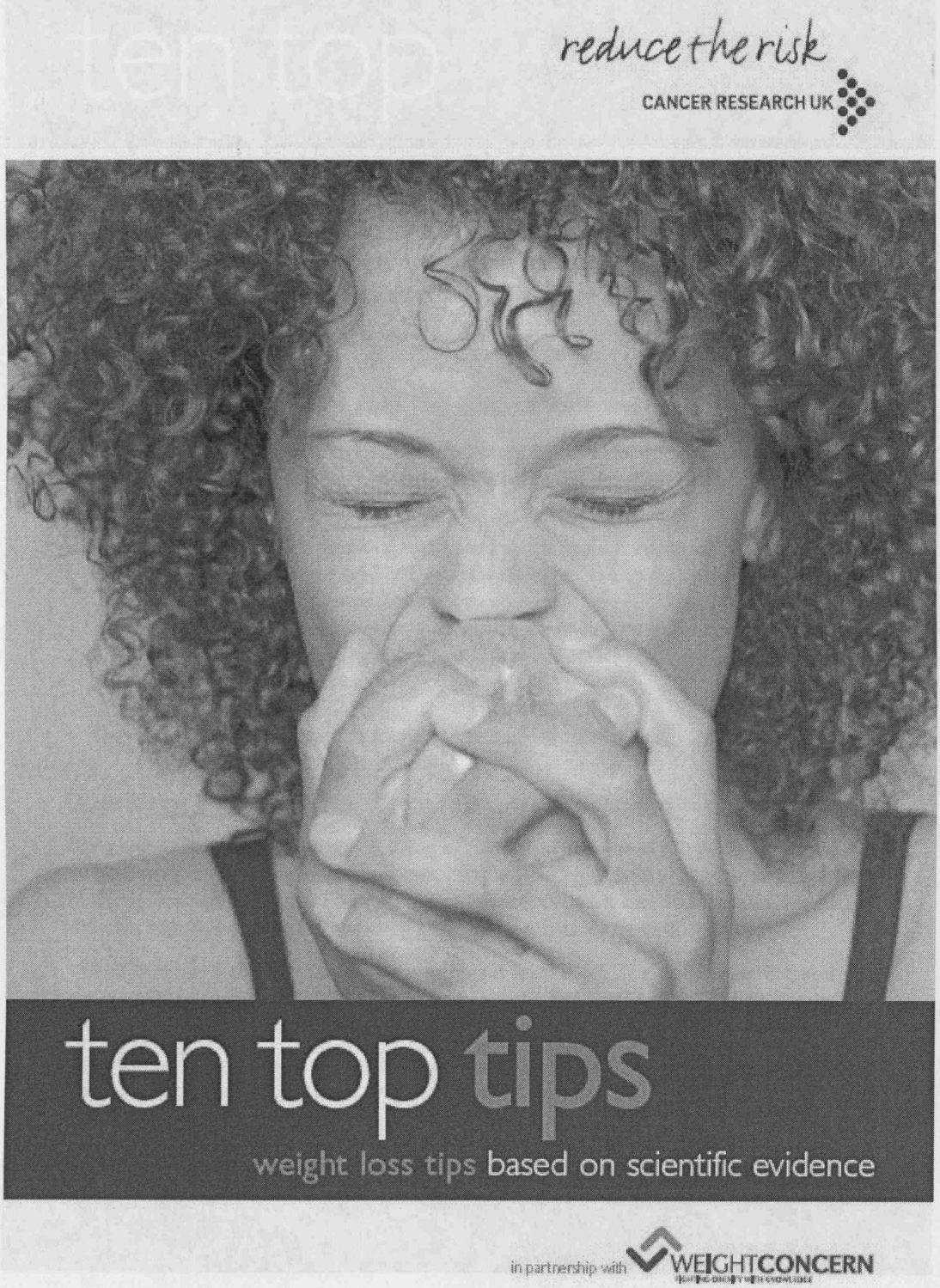
Appendix 1.2: The Self Report Habit Index

'Behaviour X' is something:

1. I do frequently
2. I do automatically
3. I do without having to consciously remember
4. That makes me feel weird not to do it
5. I do without thinking
6. That would require effort not to do
7. That belongs to my (daily, weekly, monthly) routine
8. I start doing it before I realise I'm doing it
9. I would find hard not to do
10. I have no need to think about doing
11. That's typically "me"
12. I have been doing for a long time

Rated on a Likert Scale (either 7 or 11 point) from strongly disagree to strongly agree

Appendix 4.1: The Ten Top Tips Leaflet



ten top tips

This leaflet contains a programme of weight loss tips, all based on scientific evidence. They will help you take in fewer calories and burn more energy through activity. Ten Top Tips are simple habits that everyone can fit into their daily routines and doing all ten over the longer-term will help you lose weight and keep it off.

How can the Ten Top Tips help you control your weight?

The Ten Top Tips programme helps you incorporate lifestyle changes into your daily routine so that they become automatic and easy to maintain. To develop new healthy habits you need to:

- **Plan ahead:** In the first week or two, spend a little time working out in advance how you are going to do the tips. For example work out how to fit five servings of fruit and vegetables and the extra walking into your day.
- **Tracking your progress:** Use tick sheets each day to record if you do each of the tips. Keep this up until the tips have become automatic. Record-keeping increases success in developing healthy habits.

A tear off tick sheet can be found at the back of this leaflet.

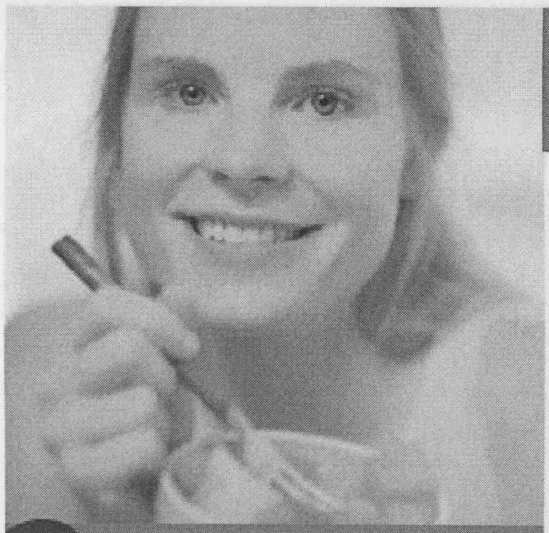
Does being overweight matter?

Being overweight affects your health. It can increase the risk of several types of cancer. These include cancers of the bowel, kidney, oesophagus (foodpipe) and womb, as well as breast cancer in women who have been through the menopause. It can also increase the risk of diabetes, high blood pressure, coronary heart disease, osteoarthritis and stroke.

We all know how difficult it is to lose weight and keep it off. The good news is that if you are overweight losing just 5-10% of your body weight and keeping it off will have a positive effect on your health. For most people this will be around 3-10kg or $^1/_2$ - $1^1/_2$ stone.

(NB If you are seriously overweight and have other health problems, it may be advisable to seek advice from your Doctor before beginning a weight management programme).

Visit www.reducetherisk.org.uk for further information on all of these tips.



2 Go reduced fat

Choose reduced fat versions of foods such as dairy products, spreads and salad dressings where you can. Use them sparingly as some can still be high in fat.

Handy Hint:

- Change to semi-skimmed milk and save 60 calories/day, amounting to 420 calories over a week (based on consuming 300mls milk/day).

Keep to your meal routine

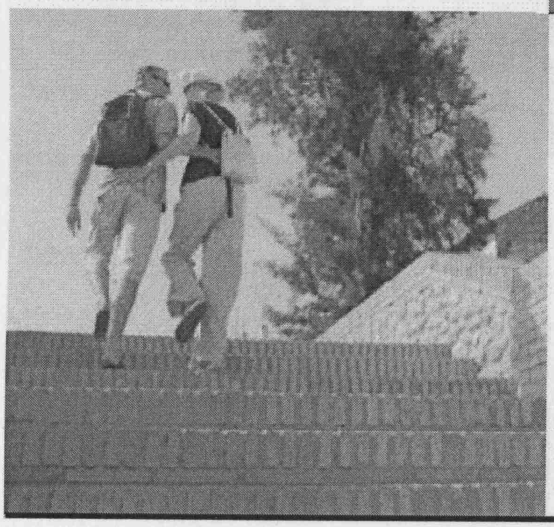
Try to eat at roughly the same times each day, whether this is two or five times a day.

Handy Hints:

- Pick a pattern that fits in with your own daily routine and stick to it.
- If you are someone who needs snacks, try to snack around the same time each day.
- Try planning when you intend to eat and check at the end of the day if you have achieved this.

Keeping a record has been shown to increase people's success in developing healthy habits

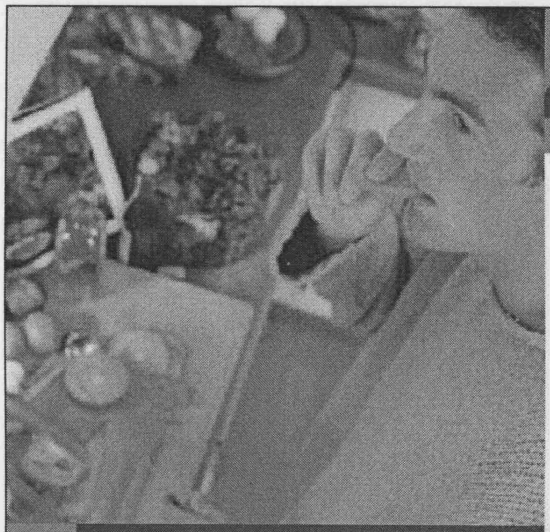
3 Walk off the weight



Walk 10,000 steps (equivalent to 60-90 minutes moderate activity) each day. You can use a pedometer to help count the steps. You can break up your walking throughout the day.

Handy Hints:

- 5000 steps a day extra (40mins walking at a brisk pace), will burn 1240 calories over a week.
- Take the stairs rather than the lift.



4 Pack a healthy snack

If you snack, choose a healthy option such as fresh fruit or low calorie yogurts instead of chocolate or crisps.

Handy Hints:

- Have a banana instead of a snack-size chocolate bar and save 225 calories.
- Take a piece of fruit to work in your bag so that you have it with you for a snack.
- Choose yogurts with less than 100 calories per pot. The calcium will also keep your bones healthy.

5 Look at the labels

Be careful about food claims. Check the fat and sugar content on food labels when shopping and preparing food.

Handy Hints:

- A low fat digestive biscuit has the same number of calories as the standard digestive biscuit at 70 calories. Check the fat and sugar content.
- Order our shopping guide from the Reduce the Risk website: www.reducetherisk.org.uk

Creating a daily routine, keeping track of your progress and planning ahead are key to developing healthier habits to last a lifetime.

6 Caution with your portions

Don't heap food on your plate (except vegetables). Think twice before having second helpings.

Handy Hint:

- Fill your plate up with lots of vegetables. They are low in calories and will help satisfy your hunger.

7 Up on your feet

Break up your sitting time. Stand up for ten minutes out of every hour.

Handy Hints:

- Standing up on the bus or train burns an extra 70 calories an hour.
- When watching TV try to stand up during the ad breaks and do a few chores (e.g wash the dishes or put the rubbish out).

8 Think about your drinks

Choose water or sugar-free squashes. Unsweetened fruit juice is high in natural sugar so limit it to 1 glass per day (200ml / $^1/_3$ pint). Alcohol is high in calories so try to limit the amount you drink.

Handy Hint:

- A pint of standard beer has 2 units of alcohol and 182 calories.

9 Focus on your food

Slow down. Don't eat on the go or while watching TV. Eat at a table if possible.

Handy Hints:

- Eating meals at the table will help you to focus on the amount of food you eat.
- Don't eat while walking, wait until you get there and take time to concentrate on what you are eating.

10 Don't forget your 5 a day

Eat at least 5 portions of fruit and vegetables a day (400g in total).

Handy Hints:

- A medium sized apple or banana or 3 serving spoonfuls of peas is 1 portion.
- Try having fruit or vegetables with every meal. This makes it easier to reach the five a day.

frequently asked questions

Should I choose 'diet' foods?

Low calorie foods can be useful for reducing your energy intake but be careful of misleading claims and check the labels. For example low fat biscuits and other sweet foods may be lower in fat but not in calories.

I don't eat any fruit and vegetables. Do I have to start eating five all at once?

It may work better for you to start eating a smaller number and build up over time. Make sure your plan is clear so you can judge if you achieve it or not each day.

Do I have to make all these changes at once?

The sooner you can build the tips into your life the quicker you'll start to lose weight. But it can be difficult to make all these changes at once. If you prefer you could try a smaller number until you feel confident enough to move on to others. The end goal is to fit all of the tips into your lifestyle.

Should I avoid occasional opportunities to exercise if not part of my normal routine?

It is fine to do more but keep doing your routines as well. This applies to all the tips.

What do I do on days when I am doing something different to my normal routine? for example: when I am away on business or at weekends.

You can develop different routines for the doing the tips during the week and at weekends. If you are away on a trip, do your best to stick to most of the tips and then get back to your normal routine as soon as you return.

What if I lose interest in the tips?

Changing habits of a lifetime is hard work but once the tips become part of your normal routine you will hardly notice doing them. Just like brushing your teeth.

The sooner you can **incorporate all the tips** into your life the quicker you'll start to lose weight.

Guide to shopping

The following information provides you with some simple advice for understanding food labels.

	per 100g	
	a lot	a little
Sugars	10g	2g
Fat	20g	3g
Saturated fat	5g	1g
Fibre	3g	0.5g
Salt	1.25g	0.25g
Sodium	0.5g	0.1g

Reproduced with permission from the Foods Standards Agency

Look for the following information on food labels to make healthy choices:

Snacks
Less than 3g fat
and less than 8g sugar per serving

Breakfast cereals
Less than 5g fat
and less than 10g sugar per 100g

Ready meals
Less than 10g fat
and less than 350kcal per portion

Pre-packed sandwiches
Less than 6g fat
and less than 280kcal per sandwich pack

further information

Visit www.reducetherisk.org.uk for further information about the Ten Top Tips and more about the healthy choices that could reduce your risk of cancer.

Visit Weight Concern's website www.weightconcern.org.uk for further information about obesity and weight loss.

For more about cancer visit Cancer Research UK's patient information website www.cancerhelp.org.uk.

About Cancer Research UK

Cancer Research UK is the leading charity dedicated to research on the causes, treatment and prevention of cancer. If you would like to support our work please call 020 7121 6699 or visit our website.

Cancer Research UK
PO Box 123
London
WC2A 3PX
020 7242 0200
www.cancerresearchuk.org

Reg charity no. 1089464 2006 Ref: rtr400

About Weight Concern

Weight Concern is a UK charity committed to researching and developing more effective treatments for obesity. We also train health professionals in techniques to help support people who want to control their weight.

Weight Concern
Brook House
2-16 Torrington Place
London
WC1E 7HN
enquiries@weightconcern.org.uk
www.weightconcern.org.uk

ten top tips tick sheet: Keeping track of your progress

Fill in this tick sheet every day to record whether or not you managed each tip.
Keeping a record has been shown to increase people's success in developing healthy habits.
Keeping track of your weight is also very useful. Daily weighing has been shown to increase successful weight control. In the notes column you can write details of how you are achieving the tips, and anything that particularly helps you use them. This information will help you plan for the next week.

ten top tips	m	t	w	t	f	s	s	done on 5 days or more?	notes
1. Keep to your meal routine									
2. Go reduced fat									
3. Walk off the weight (No. of steps)									
4. Pack a healthy snack									
5. Learn the labels									
6. Caution with your portions									
7. Up on your feet									
8. Think about your drinks									
9. Focus on your food									
10. Don't forget your 5 a day									
Your weight									

What do you plan to do next week? (e.g. I will write a shopping list to remind myself to buy fruit)

Appendix 4.2: Additional information on the 'TenTopTips'

Ten Top Tips: Additional Information

Sticking to the Tips

Weight loss does not have to involve huge changes, or take up too much time or money. Small changes, like Ten Top Tips, can help you to work towards a healthier body weight, but require a long-term commitment. To help the Ten Top Tips become habits so that they are automatic things you do on a day-to-day basis, you need to **plan, be prepared**, and **build the tips into your daily routine.** Without doing these things, it is extremely difficult to make healthier changes that will carry on into the future. These pages have lots of helpful ideas to make the Ten Top Tips part of your daily life.

Sticking to a Daily Routine

To make a tip part of your daily routine, you need to do it again and again, in a similar situation or at a similar time. This way, things should get easier over time.

Make a plan

To help make these tips part of your routine, try to plan ahead.

- In the first week or two, spend time working out in advance how you are going to stick to the tips
- Focus on what you actually plan to do, not just the result you are hoping for
- Concentrate on the tips that you think will be most difficult for you
- Modify your plans over time as some things work better than others

For example rather than: "I'm going to try hard to eat five fruit and vegetable portions a day", a better plan would be: "I will have a piece of fruit at breakfast, or after lunch and dinner to increase my fruit intake".

Be prepared

Being prepared will make it easier for you to keep to the tips. For example:

- If you plan to walk to the train station, allocate extra time for your journey
- If you plan to eat fruit at home, make sure you buy fruit when you go shopping
- Write a list before you shop, even if it's just for a few items, and stick to the list. You can use the shopping card that will help you to understand the labels on food products and make healthier choices.

Keep track of your tips

Research shows that people who keep track of what they are doing are more successful at developing healthy habits. You can use the tick sheets provided to do this. Fill in your tick sheet on a daily basis and make a note of anything that is helping you to achieve each tip. Use a new tick sheet every week and keep them as a record of your progress. Continue doing this until the tips have become automatic. You can look at the example tick sheet to show you how to fill one in.

Using the tick sheet will:

- help you identify which tips you are already following
- identify if you have achieved any of the tips on 5 or more days in the week
- highlight the tips you may need to focus your plan on
- help you to check if your plan has worked and make any necessary changes
- help you keep a record to look back on, tracking improvements and difficulties you may have had in doing the tips

Record your weight
It is important to keep a record of your weight on a regular basis. This will show you what effect your healthy changes are having on your weight and help you to adapt your plans accordingly. You can also weigh yourself on a daily basis if you want to. Studies have shown that daily weighing increases the chances of successfully controlling your weight. Some people find daily weighing is less worrying than weighing less often once you get used to it. Tracking your weight daily allows you to see if it is going gradually up, staying stable, or going down. There is a space for you to record your weight on the tick sheet.

1. Keep to your meal routine
Try to eat at roughly the same times each day, whether this is two or five times a day. If you create a regular routine it will help your body to learn when your next meal is due and prevent you from getting too hungry between meals.

- Keep to the same pattern of eating every day.
- Pick a pattern that fits in with your own daily routine and stick to it. If you haven't eaten like this for some time, or if you never have, it will require effort.
- If you are someone who snacks, try to snack at around the same time each day.
- Try planning when you intend to eat and check at the end of the day if you have achieved this.

2. Go reduced fat
It is easy to overeat on foods like butter or spreads, salad dressings, mayonnaise, cheese, pastries, chips, biscuits and crisps. This is because high fat foods contain a lot of energy, even in small portions. So without actually eating large amounts of food, you could be eating more calories than you can burn every day. And because you've not eaten that much, you may still feel hungry.

- Eating less high fat food and choosing reduced fat food where possible will help to reduce your calorie intake. This will also benefit your heart health.
- Go for semi-skimmed or skimmed milk and choose reduced fat versions of dairy products like spreads, yogurts, cheese, fromage frais, and custard. Changing to semi-skimmed milk could save you 60 calories a day or 420 calories a week.
- Use a minimum amount of oil when cooking. Spread margarine or butter thinly on your bread, even low fat versions. If possible stop using them entirely.
- Try to cut down on food that has been cooked in lots of oil or batter. For example, try steamed fish instead of fried fish, bruschetta instead of garlic bread and steamed rice instead of egg fried rice.
- Cut back on, or better still, cut out pastries, chips, pork pies, sausage rolls, cakes and puddings except for special treats.
- Try to avoid sauces based on cream or coconut milk. For example, you could have tandoori instead of a korma, a stir-fry or steamed Thai dish instead of a green curry, or a marinara instead of a carbonara.
- Try to avoid salads with high fat, creamy dressings, or ones that contain fatty ingredients like bacon, cheese or croutons. And cut down on vegetarian food that includes high fat ingredients like coconut milk, batter, and full fat dairy products like cheese or butter.

3. Walk off the weight
Walking is so flexible that you can fit it into your daily routine. You don't need to buy special walking shoes or join a gym – just try to walk a little bit more throughout the day.

- If you can, walk to or from work. If you take public transport, try getting off a stop earlier and walk from there. After all, most of us would like to spend as little time as possible in the rush hour crush!.

- Take the stairs instead of the lift. If you work on a high floor, try getting off the lift a floor earlier and walk up. You can then increase the number of floors you climb, as you get fitter.
- Go for a short walk at lunch-time rather than sitting for the whole break.
- Walk to the shops instead of taking the car or bus.
- Take a walk with friends or family - enjoy the countryside, local parks or a trip to the shops on foot.

You don't have to walk for a long time - every little bit adds up. And don't worry if you think you're unfit. Build up the amount you walk gradually. Try using a pedometer. A pedometer is a small step counter that you clip to your belt or waistband. It contains a pendulum that registers every step you take so that you can see how much walking you do each day. Some pedometers also work out the distance you have walked and the calories you have used. But these measurements tend to be inaccurate. So you only really need a pedometer that counts the number of steps you take. Set yourself a target of 10,000 steps. Some people find targets helpful when they are trying to increase their walking. Aiming for 10,000 steps a day is a good target. This is not a magic number and you may want to try for more or less steps. But taking around 10,000 steps a day is a useful guide if you want to become physically active and maintain a healthy body weight. Find out the number of steps you take on a 'normal' day before you try to increase your walking. This will give you some idea of how many more steps you need to do. Keeping a log of the steps you do each day can help you monitor your progress.

4. Pack a healthy snack

- Snacking need not be unhealthy. Ditch the fatty crisps, chocolate or biscuits – they are very high in fat and calories. Instead try some portions of fresh fruit, tinned fruit in natural juice, dried fruit or strips of raw vegetables, like carrots, cucumber or peppers. Having a banana instead of a chocolate bar could save you 225 calories.
- Drink a delicious home-made fruit smoothie – they can count as a portion of fruit and vegetables a day. But be careful of shop varieties, which can have added milk, yogurt or sugar.
- Healthy savoury snacks include whole-meal scones, oat cakes, crackers, rice cakes, crumpets, muffins or slices of toast. All are suitable with a low-fat spread. Or try some breadsticks with a cup of low-calorie soup.
- Sweeter healthy snacks include low fat yogurts (under 100 calories a pot) or fromage frais, a small bowl of whole-grain cereal with semi-skimmed or skimmed milk, a small slice of malt loaf or a fruit scone.

5. Learn the labels

It is not always possible to tell how nutritious a food is by its appearance. Looking at food labels can guide you to make better food choices. The nutrition information box lists the amounts of calories and nutrients, such as fat, in different foods. But it can be difficult working out whether the values in these boxes are good or bad. To help you, the Food Standards Agency has produced a set of guidelines for the most common nutrients:

	A lot	A little
Sugars	10g	2g
Total fat	20g	3g
Saturated fat	5g	1g
Fibre	3g	0.5g
Salt	1.5g	0.3g
Sodium	0.6g	0.1g

Look at the fat, sugar and calorie content per 100g. How do they compare to the guidelines in the table above? You should be aiming for more products that fall into the 'little' category. And only eat products that fall into the 'a lot' category sparingly.

Check the ingredients list. The ingredients in a product are listed in order of weight. The first ingredient on the list is present in the greatest amounts and the last ingredient in present in the smallest amounts. If fatty ingredients or sugars are fourth in the list or lower, the product is likely to be a lower fat/low sugar option. Fats and sugars can go by many different names; for a full list, go to Weight Concern's page on understanding food labels. Nutritional food claims can be misleading. 'Light', 'diet' or 'reduced fat' food may have less fat than a similar product but they can still be very high in calories, fat or sugar.

For example 'low fat' spreads have about half the fat content of butter or margarine but are still 40% fat. So while they have less fat than so-called ordinary spread, they are still high fat foods - use them sparingly. 'Low fat' crisps, biscuits, cakes and sausages can still be high in fat, sugar or both. Many supermarkets have introduced 'healthy eating' ranges. These may have reduced levels of fat, sugar, salt or calories, but different places will use different criteria. So even for these products, it is worth checking the label to make sure you're actually making a healthy choice.

6. Caution with your portions

Research has shown that people eat more if they are given a larger portion of food than they would normally have. You can't always rely on your body to register all those extra calories and adjust your appetite throughout the day. So to stop yourself putting more weight on and maybe lose some weight, you will need to keep an eye on the amount of food you eat, and think about cutting it down. Here are our ideas for being portion-savvy.

At home

- Eat off a smaller plate – you are more likely to eat less food.
- Fill your plate up with lots of vegetables (except for potatoes). They are low in calories, good for you, and will help to fill you up.
- Be careful when you read . A 'portion' of food as defined by the manufacturer may not be the same as a healthy-sized portion.
- Cook smaller quantities of food. This will reduce the temptation for second-helpings.
- After you've served yourself, refrigerate or freeze leftovers so that you're not tempted to have seconds.
- Don't eat from the bag – place foods in a bowl so you can see how much you're eating.

Eating out

- If you're eating out at night, think about what you eat during the rest of the day. Don't skip meals – this might make you overeat later. Instead, plan to eat lighter meals earlier on in the day so you don't take in too many calories.
- Have a salad as a starter. And don't commit yourself to ordering a dessert until you've finished your main course.
- If you're eating a meal with lots of dishes, like tapas or dim sum, be careful how many you order.
- If you have a choice, order regular portion sizes instead of large ones.
- Try splitting a starter or side dishes with a friend – it's sociable and will cut down on your calorie intake.
- Do not feel you have to clear your plate. It can help to decide in advance what you're going to eat and push the rest to the side of the plate.

7. Up on your feet

Spending long periods of time sitting down can contribute to weight gain. But breaking up the time you spend sitting will help you control your weight. Even small bits of activity are good for you. You can be more active each day by doing bits of housework like cleaning or washing, doing chores like putting the rubbish out, changing your working day so you spend less time sitting down, or even fidgeting. When it comes to activity, every little bit counts if it means you

are sitting less. Incorporating small changes into your lifestyle will increase the amount of movement and activity you do each day. If you lead a very inactive lifestyle, your first goal should be to reduce the amount of time you spend sitting down. Try and seize the small opportunities to work a bit more activity into your schedule. Here are some tips for doing this:

At home

- Don't use the remote control, get up and turn the channel over using the TV set.
- Stand up for 10mins in every hour of watching TV, do the ironing or put the washing away. This will burn extra calories each hour than just sitting.
- Stand and wash the dishes after each meal, rather than letting a day's worth build up.
- Break up your sitting time by doing your chores like putting the rubbish out or doing the washing up.
- Some activities can be done in front of a TV, including lifting free weights, stretching or rope skipping. Try learning how to juggle – it's both light exercise and a nice party trick.

At work

- At work, break from sitting at your desk; collect work from the printer, or deliver a message, rather than sending an email or phoning.
- In morning breaks at work, take the post to the post box rather than waiting until the end of the day.

Getting around

- Stand on the bus or train, rather than sitting. This burns an extra 70 calories for every hour of travelling.

8. Think about your drinks

Drinks are not calorie-free. Many soft drinks (including fizzy and sweetened soft drinks) contain a lot of sugar. These drinks are said to have lots of 'empty calories' – they can contribute to weight gain but don't have much nutritional value. You could aim to cut down on these types of drink. Unsweetened fruit juice contains lots of vitamins and minerals, and can count towards your five daily portions of fruit and vegetables. But they are low in fibre and high in natural sugar, so they should only count for one of these portions on any one day.

High street coffee shops are becoming more popular, and offer a wide choice of drinks. Large drinks with lots of cream, milk or sugar can be loaded with fat and calories. Try buying smaller sizes, and asking for 'skinny' drinks that use skimmed milk. Try to avoid cream, flavoured syrup or sugary toppings. Use skimmed or semi-skimmed milk if you're making hot drinks at home too.

Alcoholic drinks are very high in calories. So if you want to lose weight, you'll need to consider reducing the amount you drink. Alcohol also increases your appetite - some people notice that they tend to eat more when they drink alcohol. In terms of overall health, women can have up to 2 units of alcohol a day and men can have up to 3 units a day. However to help you lose weight, we recommend that women should have no more than 1 unit of alcohol each day and men should have no more than 2 units of alcohol each day.

Choose dry versions of all alcoholic drinks – for example dry cider or dry white wine – as these are lower in calories than sweet versions. Opt for low-calorie mixers where you can.
Use the information below to guide you on how many calories and units of alcohol there are in your drinks.

Drinks	kcal
1 pint strong cider (8.5% ABV)	574
1 pint strong ale	409
1 pint draft beer (3.5%)	182
1 alcopop (275ml bottle)	180
1 glass (50ml) cream liqueur e.g. Baileys	165
1 alcoholic cocktail (e.g. a bloody Mary)	120
1/2 pint sweet cider	119
1 small glass (125ml) sweet white wine	118
1/2 pint dry cider (5%)	102
1 flute (125ml) of champagne (12.5%)	95
1/2 pint of lager	90
1 small glass (125ml) red wine	85
1 gin and tonic (25ml gin)	85
1 small glass (125ml) dry white wine (12%)	83
1 vodka and diet mixer (25ml vodka)	56

1 unit of alcohol =
1 small glass wine(100ml) of 10% ABV – N.B most wines will be stronger than this
half a pint (284ml) of ordinary strength beer, lager or cider
¼ of a pint of strong lager, beer or cider
1 single measure of spirits (25ml)
1 single measure of vermouth or sherry (50ml)

9. Focusing on your food
Focusing on your food will help you to control your portion sizes. Research has found that you are more likely to eat more calories while watching television. And if you eat while doing something else, such as walking, it is easy to eat much more than you realise. The following tips may help you focus on your food and help you to eat less:

- Eat your meals at the table it will help you focus on the amount of food you eat.
- Eat slowly. It takes time for your body to register how much food you've eaten and how full you are.
- Don't eat while walking, wait until you get there and take time to concentrate on what you are eating.

10. Don't forget your five a day
Eating at least five portions of fruit and vegetables a day is an essential part of a healthy, balanced diet. By following the 5-a-day guidelines, you could reduce your risk of cancer, heart disease and other conditions.

What is a portion?
A portion is about 80g of fruit or vegetables.

Fruit
• 1 large slice of melon or pineapple, or ½ grapefruit
• 1 whole apple, banana or orange
• 2 whole plums or kiwis
• 1 cupful of raspberries or grapes
• 7 strawberries
• 3 tablespoons of stewed apple or canned peaches in juice
• 1 heaped tablespoon of sultanas or raisins, or 3 dried apricots

• a glass (150-200ml) of 100% juice (fruit or vegetable juice or smoothie), max 1 per day
Vegetables
• 3 tablespoons of broccoli or spinach
• 3 tablespoons of carrots, swede, or parsnips
• 3 tablespoons of peas or sweetcorn
• 1 small corn on the cob
Salads
• 1 side salad (the size of a cereal bowl)
• 1 medium tomato, or 7 cherry tomatoes

Fruit juice can also only count towards one portion a day. This is because they are high in nutrients but low in fibre. And extracting the juice releases sugars which are bad for your teeth. Mushrooms can also count towards your portions. But try not to fry them in lots of oil as they will readily soak it up. Dried or tinned fruit, and tinned or frozen vegetables can all count towards your daily portions. But try to eat tinned fruit kept in natural fruit juice rather than syrup. And check the salt content of tinned foods, as it can sometimes be high. The fruit and vegetables in ready meals or takeaways can also count towards your portions. But these foods are often high in fat and added salt and sugar, so try to eat them in moderation.

Potatoes are nutritious but are classified as starchy foods, so for these purposes, don't count towards your portions. And chips certainly don't count either!

Variety is the spice of life. Different types of fruit and vegetables contain different combinations of fibre, vitamins, minerals and other nutrients. Eating a variety of fruit and vegetables will ensure that you get a good mix. A good rule of thumb is to eat fruit and vegetables of different colours. Often the chemicals that are responsible for the colours are the same ones that are good for health.

Appendix 4.3: An example interview transcript: Participant

		Shared themes
1		
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3		
4		Simple and easy to remember (opposite)
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8		Initial thought and effort required
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10		
11		Behaviours are habits
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14		Time to form a habit
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16		
17		Confidence in continuing with tips
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24		Initially performing some of the tips
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Initial thought and effort required
Behaviours are habits
Context cues
Developing a routine is important
Planning

Feel 'strange' if don't do it

Success in developing routines

Strict compliance not critical

Initial thought and effort

Became easier with repetition

Trial and error

Planning

Success in developing routines

Success in developing routines

Behaviours are habits

Required little thought after some time

Confidence in continuing with tips

Trial and error

Planning

Initially performing some tips

206
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Appendix 4.4: Table of themes across participants

Themes	KW	RH	PW	SC	RS	GC	HM	LK	AL	EM
Attitudes towards the tips										
Overall positive	✓	✓	✓	✓	✓			✓	✓	✓
Simple and easy to remember	✓		✓	✓	✓	✓	x	✓		✓
Flexible	✓	✓								✓
Not restricted	✓				✓			✓		
Initially performing some tips			✓	✓	✓	✓	✓	✓	✓	
Strict compliance not critical	✓	✓	✓	✓			✓	✓		✓
Tricks	✓	✓							✓	✓
Developing a Routine										
Developing a routine is important		✓		✓			✓	✓	✓	
Planning	✓	✓		✓	✓	✓	✓	✓	✓	✓
Trial and error	✓	✓	✓		✓	✓	✓		✓	
A wish to have planned more	✓	✓							✓	
Success in developing routines	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Automaticity development										
Initial thought and effort required	✓	✓	✓			✓	✓		✓	
Became easier with repetition	✓	✓		✓	✓	✓	✓			
Required little thought after some time	✓	✓	✓	✓	✓		✓			✓
Cues										
Context	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Time	✓							✓		
Internal stimuli	✓									
Habits										
Behaviours are habits	✓	✓	✓	✓			✓		✓	
Feel 'strange' if don't do it	✓						✓			
Time to form a habit	✓	✓					✓			
Confidence in continuing with tips		✓	x	✓		✓	✓	✓	✓	

x shows where a participant expressed the opposite of the theme

Appendix 4.5: Final list of themes with example quotes (the quotes used in the chapter)

Theme	Quotes	Participant
Attitudes towards the tips		
Overall positive	*'Yeah I think most of us have enjoyed doing it'*	
Simple and easy to remember	*'I found them just simple to understand'* *'I just think they are kind of pretty easy to remember, they're quite straightforward and don't really take much memorising'* *'I just found that quite difficult because well just because I kept forgetting you know' (opposite)*	
Flexible	*'I'm trying to make it work in my own way rather than sticking to it very rigidly'*	
Not restricted	*'I'm going to continue because it isn't like I stopped eating something that I have to go back to that's what usually happens when you go on a diet you are eating soup or toast and then you are watching your calories, I didn't watch my calories at all and yet I felt healthier and I still lost weight and I feel good as well*	
Initially performing some tips	*'I think a number of us found that it was quite good that there were one or two on here that weren't difficult for us to do ... like so for me, the drinking one was not a problem at all because I don't drink it anyway and that's quite nice because you feel oh I've got that under my belt'*	
Strict compliance not critical	*'we are usually still watching TV and eating food, it's not that I just go to the dining table always, I still eat there but I will just not take any more food'.* *'When I did break it I knew I was breaking it and I felt it was my, sort of my choice if you like so it wasn't a bad thing and since I've been back from holiday I've gone straight back onto it'*	
Tricks	*'the caution with your portions....I mainly did that by having smaller plates'* *'I found that have my supper, brush my teeth, and I won't eat again, I think I won't eat again because I'm too lazy to go and brush them again'*	
Developing a Routine		
Developing a routine is important	*'some things have to be routine otherwise it won't work'* *'I have to just to name a routine of how I am going to watch what I eat'*	
Planning	*'I thought about the walking and how I would achieve that'*	
Trial and error	*'that first week it was all just sort of a whole heap of things, and you're – like - oh I'm on to this one now, and oh have I done that,.. sort of thing'*	
A wish to have planned more	*maybe if I had planned around it, it might have helped'*	
Success in developing routines	*'Just following them from one week to the next, they just become sort of one routine the more it goes on'*	

Automaticity development	
Initial thought and effort required	*more thought at the beginning was required* *'week 1 I think it was the case that I felt that I had to do all ten all in one go and I just found that quite difficult because well just because I kept forgetting you know'*
Became easier with repetition	*'initially it was sort of difficult because obviously you've got to change your eating habits, your drinking habits and your exercise habits and it was good that it covered all three bases ... but it got easier, it did get easier over time'*
Required little thought after some time	*I don't really think too much about it'* *'I think that some of them just worm their way into your brain'*
Cues	
Contest	*'every lunchtime since I started I've been out for a walk regardless of how short or long'* *'first thing in the morning .. prepare carrots or radishes o whatever'* *'I tend to automatically think - oh I'll walk somewhere to add a few more steps on rather than to catch a bus or whatever and things'*
Time	*'I will have it 1 o'clock or half past one'* *(talking about lunch)*
Internal stimuli	*'in the evenings when I've had the munchies sitting there watching telly, I'm just opening a packet of raisins and eaten them or an apple and stuff'*
Habits	
Behaviours are habits	*'I think in the eight weeks ... I don't think all of these are still ingrained behavior but I think that a good - say - 7 or 8 of them actually are, so I think that's a good outcome'*
Feel 'strange' if don't do it	*'it's easy to have a salad and now I actually feel quite strange if I haven't done that'*
Time to form a habit	*'I think after the first couple of weeks all of them became sort of second nature'* *'they are quite easy to do and I'd say after the third or fourth week you sort of fall into a routine'*
Confidence in continuing with tips	*'It was fine, I'm going to continue'* *'they are ingrained'* *'I've slipped up a bit actually in the four or five days since it finished, but not too much' (opposite)*

Appendix 5.1: Confirmation of ethical approval for Study 2

UCL GRADUATE SCHOOL

Professor Jane Wardle
Health Behaviour Unit
Department of Epidemiology and Public Health
UCL
2-16 Torrington Place
London
WC1E 6BT

28 November 2005

Dear Professor Wardle

Re: Notification of Ethical Approval

Re: Ethics Application: 0531/002: Efficacy of a brief behavioural intervention for weight control

The above research has been given ethical approval following review by the Chair of the UCL Research Ethics Committee for the duration of the project (January 2006 – January 2007) subject to the following conditions:

1. You must seek Chair's approval for proposed amendments to the research for which this approval has been given. Ethical approval is specific to this project and must not be treated as applicable to research of a similar nature. Each research project is reviewed separately and if there are significant changes to the research protocol you should seek confirmation of continued ethical approval by completing the 'Amendment Approval Request Form'.

The form identified above can be accessed by logging on to the ethics website homepage: http://www.grad.ucl.ac.uk/ethics/ and clicking on the button marked 'Key Responsibilities of the Researcher Following Approval'.

3. It is your responsibility to report to the Committee any unanticipated problems or adverse events involving risks to participants or others. Both non-serious and serious adverse events must be reported.

   Reporting Non-Serious Adverse Events
   For non-serious adverse events you will need to inform Ms Helen Dougal, Ethics Committee Administrator (h.dougal@ucl.ac.uk), within ten days of an adverse incident occurring and provide a full written report that should include any amendments to the participant information sheet and study protocol. The Chair or Vice-Chair of the Ethics Committee will confirm that the incident is non-serious and report to the Committee at the next meeting. The final view of the Committee will be communicated to you.

   Reporting Serious Adverse Events
   The Ethics Committee should be notified of all serious adverse events via the Ethics Committee Administrator immediately the incident occurs. Where the adverse incident is unexpected and serious, the Chair or Vice-Chair will decide whether the study should be terminated pending the opinion of an independent expert. The adverse event will be considered at the next Committee meeting and a decision will be made on the need to change the information leaflet and/or study protocol.

UCL Graduate School. North Cloisters, Wilkins Building
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www.ucl.ac.uk/gradschool

Letter to Professor Wardle 28/11/2005

On completion of the research you must submit a brief report (a maximum of two sides of A4) of your findings/concluding comments to the Committee, which includes in particular issues relating to the ethical implications of the research.

Yours sincerely

Sir John Birch
Chair of the UCL Research Ethics Committee

Cc: Phillippa Goodwin, Health Behaviour Unit, Department of Epidemiology and Public Health, UCL

Appendix 5.2 Email advertisement for Study 2

Dear Colleague

Would you like to change your eating and exercise habits? Would you like to have more control over your weight? Would you like to work towards losing weight?

Researchers at University College London (UCL) are conducting research into how best to help people lose weight. They have designed a simple programme (the ten top tips) to help people make changes to their lifestyle that will help with weight loss.

UCL are conducting a trial to evaluate the ten top tips over the next few months. To participate you need to be over 18 and be overweight (have a Body Mass Index (BMI) over 25). If you don't know your BMI go to http://www.shape-up.org/weightcon/bmi.html where you will find a BMI Calculator.

Participation would involve attending an initial meeting at University College London (based in Torrington Place (WC1E 7HB)) and then brief follow-up appointments every one to four weeks. At the meetings, participants will be weighed, have their waist measurements taken and be asked to complete questionnaires.

If you are interested in participating please email Pippa Goodwin at If you leave your postal address you will be sent some more information. You can contact her with any questions you may have.

All information you provide will be kept in accordance with the 1998 Data Protection Act. The information will remain confidential, be held securely and not divulged to any third parties. Your information will be used for research purposes only and you will be free to withdraw from the study at any time.

Thank you,

THE NAME OF THE PERSON AT THE COMPANY WHO SENT THE EMAIL

Appendix 5.3 Information Sheet for Study 2

Royal Free and University College Medical School
Department of Epidemiology and Public Health
University College London
Gower Street Campus

HEALTH BEHAVIOUR UNIT
2-16 Torrington Place
London WC1E 6BT

Researcher *Pippa Goodwin*
Director *Professor Jane Wardle*

CONFIDENTIAL
Efficacy of a brief behavioural intervention for weight control
Participant Information Sheet

You are being invited to take part in a research study. Before you decide, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

The purpose of this research is to investigate what effect a brief weight control intervention (the ten top tips) will have on weight loss and quality of life in a group of employees from workplaces in the Bloomsbury area. We are recruiting 145 people to take part in this study. You have been chosen because you have responded to an advertisement for the study and we hope this means you would like to work towards losing weight by using the ten top tips. The tips are all things that relate to improved weight control and can be integrated into your daily life. Using the tips involves trying to make the suggested changes and then using a tick sheet to note each day which tips you achieve.

Your participation is voluntary and you may choose to withdraw from the study at any time. The study will run for 32 weeks in total. If you choose to participate you will be invited to attend a meeting at University College London (UCL) (Torrington Place). At this meeting you will be asked to complete questionnaires and will be weighed and your waist measurement will be taken. People will be randomly allocated either to start immediately or to wait for eight weeks before using the tips. Everyone will be asked to attend weighing sessions at UCL every four weeks where participants will be asked to complete brief questionnaires and will be weighed.

We hope that by the end of the study you will have gained better control over your weight management and will have lost some weight. This research has the potential to give us information on the impact of a simple new weight control programme so that this can be made available more widely to help others with weight management.

All information you provide will be kept confidential in accordance with the 1998 Data Protection Act. Data you provide in paper form will be kept locked in a secure cabinet and will only be linked to you via a participant code. The data will only be used for research purposes and will not be disclosed to any third parties. It is intended that this data will be used to draw conclusions about the benefits of using the ten top tips and that the results will be written up for publication. If in the future this data helps to answer further research questions it may be used in this way. If you would like to be informed of the findings of this study when the data has been analyzed and written up please inform the researcher and she will send you this.

Thank you for considering taking part in this study. In you have any questions about the research please contact Pippa Goodwin (details above).

If you choose to participate in this research you will be given a copy of the Information Sheet and the signed Consent Form to keep prior to taking part in the research.

Approved by University College London's Committee on the Ethics of Non-NHS Human Research

The Health Behaviour Unit is an external unit of *Cancer Research UK*, charity no 1089464

CANCER RESEARCH UK

Appendix 5.4 Consent Form for Study 2

Royal Free and University College Medical School
Department of Epidemiology and Public Health
University College London
Gower Street Campus

HEALTH BEHAVIOUR UNIT
2-16 Torrington Place
London WC1E 6BT

Researcher *Pippa Goodwin*
Director *Professor Jane Wardle*

CONFIDENTIAL

Informed Consent Form
Efficacy of a brief behavioural intervention for weight control

To be completed independently by the participant

Project Title: Tracking Habit Formation

Please circle the appropriate answer

Have you read the Participant Information Sheet?	Yes	No
Have you had the opportunity to ask questions and discuss the study?	Yes	No
Have you received satisfactory answers to all your questions?	Yes	No
Have you received enough information about the study?	Yes	No
Do you understand that once you start the study you may be asked to wait for eight weeks before using the ten top tips?	Yes	No
Do you understand that you are free to withdraw from the study without penalty at any stage?	Yes	No
Do you agree with the publication of the results of this study in an appropriate outlet/s?	Yes	No

Signed:.....

Date:.....

Full Name in Capitals:.....

The Health Behaviour Unit is an external unit of *Cancer Research UK*, charity no 1089464

CANCER RESEARCH UK

Appendix 5.5 Timescale of questionnaires completed in Study 2*

	Waiting List	Intervention + weekly weighing[1]	Intervention + 4 weekly weighing
Initial meeting	Height, weight and percentage body fat Demographics Body Satisfaction Quality of Life Weight Efficacy Personal Need for Structure Impulsivity Eating Behaviours	Height, weight and percentage body fat Demographics Body Satisfaction Quality of Life Weight Efficacy Personal Need for Structure Impulsivity Eating Behaviours Self Report Habit Index Context Habit Measure	Height, weight and percentage body fat Demographics Body Satisfaction Quality of Life Weight Efficacy Personal Need for Structure Impulsivity Eating Behaviours Self Report Habit Index Context Habit Measure
4 weeks	Weight	Weight	Weight
8 weeks	Weight and percentage body fat Body Satisfaction Quality of Life Weight Efficacy Eating Behaviours Self Report Habit Index Context Habit Measure	Weight and percentage body fat Number of previous weight loss attempts Body Satisfaction Quality of Life Weight Efficacy	Weight and percentage body fat Number of previous weight loss attempts Body Satisfaction Quality of Life Weight Efficacy
12 weeks	Weight	Weight	Weight
16 weeks	Weight	Weight Body Satisfaction Quality of Life Weight Efficacy	Weight Body Satisfaction Quality of Life Weight Efficacy
20 weeks	Weight	Weight	Weight
24 weeks	Weight	Weight Self Report Habit Index	Weight Self Report Habit Index
28 weeks	Weight	Weight	Weight
32 weeks	Weight and percentage body fat Self Report Habit Index Final Questionnaire	Weight and percentage body fat Body Satisfaction Quality of Life Weight Efficacy Final Questionnaire	Weight and percentage body fat Body Satisfaction Quality of Life Weight Efficacy Final Questionnaire

* All participants also submitted weekly tick-sheets when using the intervention.
[1]This group were also weighed weekly.

Appendix 5.6: Calculating questionnaire totals

Questionnaire totals were calculated for each questionnaire. Different numbers of missing values were accepted for each questionnaire, and the mean of all other items used to replace them, and calculate a total score. The details of this process are summarised in the table below. The internal reliability at baseline is presented for each questionnaire. As the SRHI was completed for 16 different behaviours, the range of values is presented.

Questionnaire	Number of items	Scoring of items	Number of missings accepted	Method of calculating score	Scale score range	Higher score indicates more:	Baseline Cronbach's alpha
BIS	30	1-4	6	Sum	30-120	impulsivity	0.79
PNS	12	1-6	3	Average	1-6	need for structure	0.84
BSS	16	1-7	4	Sum	16-112	body satisfaction	0.83
WEL	20	0-9	5	Sum	0-180	weight-efficacy	0.85
ESWLS	22	1-5	5	Sum	22-110	life satisfaction	0.88
Automaticity sub-scale	7	1-7	2	Sum	7-49	automaticity	0.94-0.98
SRHI	12	1-7	3	Sum	12-84	habit strength	0.93-0.99

Appendix 5.7: Demographics questionnaire

Ten Top Tips Demographics

1. Gender: **Male ☐**
Female ☐

2. Age _____

3. What is the highest level of educational or professional qualification you have obtained?

GCSE ☐
Vocational qualifications ☐ Please specify _____
A-level ☐
Bachelor Degree ☐
Masters ☐
PhD ☐
Other ☐ Please specify _____
No formal qualifications ☐

4. What is your marital status?

Single ☐
Married ☐
Cohabiting/Living with partner ☐
Divorced/separated ☐
Widowed ☐

5. What is your ethnic group?

White☐
Black or Black British ☐
Chinese ☐
Asian or Asian British ☐
Other ☐ Please specify _____

Appendix 5.8: Body Satisfaction Scale

Please rate how satisfied you are with the following parts of your body. Please circle your answer:

	1 Very unsatisfied	**2 Moderately unsatisfied**	**3 Slightly unsatisfied**	**4 Undecided**	**5 Slightly satisfied**	**6 Moderately satisfied**	**7 Very satisfied**
Head	1	2	3	4	5	6	7
Face	1	2	3	4	5	6	7
Jaw	1	2	3	4	5	6	7
Teeth	1	2	3	4	5	6	7
Nose	1	2	3	4	5	6	7
Mouth	1	2	3	4	5	6	7
Eyes	1	2	3	4	5	6	7
Ears	1	2	3	4	5	6	7
Shoulders	1	2	3	4	5	6	7
Neck	1	2	3	4	5	6	7
Chest	1	2	3	4	5	6	7
Tummy	1	2	3	4	5	6	7
Arms	1	2	3	4	5	6	7
Hands	1	2	3	4	5	6	7
Legs	1	2	3	4	5	6	7
Feet	1	2	3	4	5	6	7

Appendix 5.9: Weight Efficacy Lifestyle Questionnaire

This form describes some typical eating situations. Everyone has situations which make it very hard for them to keep their weight down. The following are a number of situations relating to eating patterns and attitudes. This will help you to identify the eating situations which you find the hardest to manage.

Read each situation listed and decide how confident (or certain) you are that you will be able to resist eating in each of the difficult situations. In other words, pretend that you are in the eating situation right now. On a scale from 0 (not confident) to 9 (very confident), choose ONE number that reflects how confident you feel now about being able to successfully resist the desire to eat. Write this number down next to each item.

Not confident at all that you can resist the desire to eat									Very confident that you can resist the desire to eat
0	1	2	3	4	5	6	7	8	9

EXAMPLES:

I AM CONFIDENT THAT:	CONFIDENCE NUMBER
1. I can control me eating on weekends	8
2. I can say "no" to snacks	6

I AM CONFIDENT THAT:

1. I can resist eating when I am anxious (nervous)	___
2. I can control my eating on the weekends	___
3. I can resist eating even when I have to say "no" to others	___
4. I can resist eating when I feel physically run down	___
5. I can resist eating when I am watching TV	___
6. I can resist eating when I am depressed (or down)	___
7. I can resist eating when there are many different kinds of food available	___
8. I can resist eating even when I feel I is impolite to refuse a second helping	___
9. I can resist eating even when I have a headache	___
10. I can resist eating when I am reading	___
11. I can resist eating when I am angry (or irritable)	___
12. I can resist eating even when I am at a party	___
13. I can resist eating even when others are pressuring me to eat	___
14. I can resist eating when I am in pain	___
15. I can resist eating just before going to bed	___
16. I can resist eating when I have experienced failure	___
17. I can resist eating even when high-calorie foods are available	___
18. I can resist eating even when I think others will be upset if I don't eat	___
19. I can resist eating when I feel uncomfortable	___
20. I can resist eating when I am happy	___

Appendix 5.10 Extended Satisfaction with Life Scale

Read each of the following statements and decide how much you agree with each. Please circle your answer for each statement.

	1 (Strongly Disagree)	**2 (Disagree)**	**3 (Neither Disagree nor Agree)**	**4 (Agree)**	**5 (Strongly Agree)**
I am satisfied with my life	1	2	3	4	5
In most ways my sex life is close to ideal	1	2	3	4	5
I am satisfied with my social life	1	2	3	4	5
I am generally pleased with the quality of my family life	1	2	3	4	5
The conditions important to my safety are excellent	1	2	3	4	5
I am satisfied with my relationship/marriage	1	2	3	4	5
The condition of my health is excellent	1	2	3	4	5
I am satisfied with my person or self as an individual	1	2	3	4	5
The conditions of my sex life are excellent	1	2	3	4	5
I am satisfied with my health	1	2	3	4	5
I am satisfied with my family life	1	2	3	4	5
So far, I have gotten the important things I need with my current personal income	1	2	3	4	5
I am generally pleased with the quality of my relationship/marriage	1	2	3	4	5
I consider my physical appearance excellent	1	2	3	4	5
I am generally pleased with the quality of my work	1	2	3	4	5
I am generally pleased with the life that I lead	1	2	3	4	5
I am satisfied with my physical appearance	1	2	3	4	5
I am generally pleased with the social life I lead	1	2	3	4	5
I am satisfied with my safety	1	2	3	4	5
I am generally pleased with myself as an individual	1	2	3	4	5
I am satisfied with my job	1	2	3	4	5
I am satisfied with the amount of my personal income (from all sources)	1	2	3	4	5

Appendix 5.11: Behaviour Questionnaire

The following questions ask about the choices you make about food. Please tick one of the boxes to show whether statements are true for you or not:

1. I usually avoid eating fried foods
☐ True
☐ False

2. I usually eat five fruit and vegetables a day
☐ True
☐ False

3. I usually choose low-fat options of food such as dairy foods, spreads and salad dressings
☐ True
☐ False

4. I often eat sweet snacks in between meals
☐ True
☐ False

5. I rarely have second helpings
☐ True
☐ False

6. If I eat high fat foods e.g. butter or oil, but I use as little as possible.
☐ True
☐ False
☐ I never eat high fat foods

7. When I have a soft drink I usually choose water or sugar-free squashes
☐ True
☐ False

8. When I have a snack between meals I often choose fruit, vegetables or another low-calorie option
☐ True
☐ False
☐ I never snack

9. I eat at roughly the same times everyday
☐ True
☐ False

10. I usually walk approximately 10,000 steps a day (60-90 minutes)
☐ True
☐ False

11. I usually read the food labels before buying food, to check that fat, sugar and calorie content of the food

☐ True
☐ False

12. I avoid large portions (except for vegetables)
☐ True
☐ False

13. I stand up for about ten minutes in every hour during the day
☐ True
☐ False

14. I usually drink no more than two units of alcohol a day
☐ True
☐ False

15. I usually eat my dinner at a table
☐ True
☐ False

16. I often eat while on the go and when watching TV
☐ True
☐ False

Appendix 5.12: The numbers of missing values imputed at each time point

The table below shows the number of weight values replaced at each stage of the imputing process for each assessment point. This was for all participants at each 'real time' assessment point.

Week	Original Missing	Number replaced						Final Missing
		Mean T+1 &T-1	T+1	T-1	Mean T+2 & T-2	T+2	T+3	
4	39	2	12	7	0			18
8	45	2	10	2	0			31
12	64	2	14	0	0			48
16	66	6	7	1	0			52
20	80	2	12	1	0			65
24	84	9	2	3	2			68
28	86	2	5	3	1			75
32	100	1	16	0	2	3	2	76

Appendix 5.13: Number of participants at each assessment point

The table below shows the number of participants that remained in the study at each assessment point (participants are considered to remain in the study until their last recorded weight), as well as the number of participants with weight data at each time point (in brackets). Both of these assessments are based on the imputed weights. The figures are different because participants could miss one assessment session but remain in the study and return to the next session.

Number of Participants remaining in the study and the number of participants with weight data at each time point

		Baseline	**4 weeks**	**8 weeks**	**12 weeks**	**16 weeks**	**20 weeks**	**24 weeks**	**28 weeks**	**32 weeks**
Group1	Waiting List	35 (35)	35 (35)	33 (33)	27 (25)	23 (22)	21 (18)	19 (16)	17 (15)	16 (16)
Group2	4 weekly weighing	44 (44)	33 (32)	27 (26)	24 (20)	21 (20)	18 (16)	16 (14)	12 (11)	10 (10)
Group3	Weekly weighing	41 (41)	36 (35)	32 (30)	29 (27)	27 (26)	25 (21)	24 (22)	21 (19)	18 (18)

Appendix 5.14: Data used in Figure 5.2

	Intervention Completers			Intervention ITT		Control ITT	
Week	**N**	**Weight Loss (kg)**	**SEM**	**Weight Loss (kg)**	**SEM**	**Weight Loss (kg)**	**SEM**
0	69	0	0	0	0	0	0
4	67	-1.15	0.16	-1.14	0.15	-0.38	0.21
8	56	-1.99	0.26	-1.74	0.22	-0.44	0.26
12	47	-2.28	0.38	-1.86	0.29		
16	46	-2.87	0.37	-2.16	0.29		
20	37	-2.85	0.49	-2.42	0.35		
24	36	-4	0.58	-2.62	0.38		
28	30	-3.45	0.53	-2.62	0.37		
32	28	-3.81	0.67	-2.64	0.39		

Appendix 6.1: Personal Need for Structure

Read each of the following statements and decide how much you agree with each according to your attitude, beliefs, and experiences. It is important for you to realize that there are no "right" or "wrong" answers to these questions. People are different, and we are interested in how you feel.

	1 (strongly disagree)	**2 (moderately disagree)**	**3 (slightly disagree)**	**4 (slightly agree)**	**5 (moderately agree)**	**6 (strongly agree)**
It upsets me to go into a situation without knowing what I can expect from it	1	2	3	4	5	6
I'm not bothered by things that interrupt my daily routine	1	2	3	4	5	6
I enjoy having a clear and structured mode of life	1	2	3	4	5	6
I like to have a place for everything and everything in its place	1	2	3	4	5	6
I enjoy being spontaneous	1	2	3	4	5	6
I find that a well-ordered life with regular hours makes my life tedious	1	2	3	4	5	6
I don't like situations that are uncertain	1	2	3	4	5	6
I hate to change plans at the last minute	1	2	3	4	5	6
I hate to be with people who are unpredictable	1	2	3	4	5	6
I find that a consistent routine enables we to enjoy life more	1	2	3	4	5	6
I enjoy the exhilaration of being in unpredictable situations	1	2	3	4	5	6
I become uncomfortable when the rules in a situation are not clear	1	2	3	4	5	6

Appendix 6.2: Barratt Impulsiveness Scale

People differ in the ways they act and think in different situations. This is a test to measure some of the ways in which you act and think. Read each statement and check the appropriate space on the right side of the page. Do not spend too much tine on any statement. Answer quickly and honestly.

	1 (Rarely/never)	**2 (Occasionally)**	**3 (Often)**	**4 (Almost always/always)**
I plan tasks carefully	1	2	3	4
I do things without thinking	1	2	3	4
I make up my mind quickly	1	2	3	4
I am happy-go-lucky	1	2	3	4
I don't "pay attention"	1	2	3	4
I have "racing" thoughts	1	2	3	4
I plan trips well ahead of time	1	2	3	4
I am self-controlled	1	2	3	4
I concentrate easily	1	2	3	4
I save regularly	1	2	3	4
I "squirm" at plays or lectures	1	2	3	4
I am a careful thinker	1	2	3	4
I plan for job security	1	2	3	4
I say things without thinking	1	2	3	4
I like to think about complex problems	1	2	3	4
I change jobs	1	2	3	4
I act "on impulse"	1	2	3	4
I get easily bored when solving thought problems	1	2	3	4
I act on the spur of the moment	1	2	3	4
I am a steady thinker	1	2	3	4
I change residences	1	2	3	4
I buy things on impulse	1	2	3	4
I can only think about one problem at a time	1	2	3	4
I change hobbies	1	2	3	4
I spend or charge more than I earn	1	2	3	4
I often have extraneous thoughts when thinking	1	2	3	4
I am more interested in the present than the future	1	2	3	4
I am restless at the theatre or lectures	1	2	3	4
I like puzzles	1	2	3	4
I am future orientated	1	2	3	4

Appendix 7.1: Sixteen behaviours SRHI completed for

Keeping to a regular meal routine

Choosing reduced fat foods

Using high fat foods only sparingly

Walking 10,000 steps a day

Eating healthy snacks

Reading the labels when buying food

Reading the labels when preparing food

Avoiding large portions (except of fruit and vegetables)

Avoiding second helpings

Standing for at least ten minutes every hour

Drinking water and sugar free squashes instead of other soft drinks

Drinking more than one/two units of alcohol a day *(different for women and men respectively)*

Eating in front of the TV

Eating at a table

Eating five portions of fruit and vegetables a day

Weighing myself

Appendix 7.2: Self Report Habit Index items displayed to show which were used to calculate an automaticity sub-scale.

Item Number	Item	Used to create a Automaticity score
1	I do frequently	
2	I do automatically	✓
3	I do without having to consciously remember	✓
4	That makes me feel weird not to do it	
5	I do without thinking	✓
6	That would require effort not to do	✓
7	That belongs to my (daily, weekly, monthly) routine	
8	I start doing before I realise I'm doing it	✓
9	I would find hard not to do	✓
10	I have no need to think about doing	✓
11	That's typically 'me'	
12	I have been doing for a long time	

Appendix 7.3: Behaviours assessed using the Context Habit Measure

Choose reduced fat foods

Walk 10,000 steps a day

Have a healthy snack

Read the labels when buying food

Stand for at least 10 mins every hour

Choose water or sugar free squashed instead of alternative drinks

Eat five portions of fruit and vegetables a day

Weighing yourself

Appendix 8.1: Confirmation of ethical approval for Study 3

UCL GRADUATE SCHOOL

Professor Jane Wardle
Health Behaviour Unit
Department of Epidemiology and Public Health
University College London
2-16 Torrington Place
London
WC1E 6BT

14 September 2005

Dear Professor Wardle

Re: Notification of Ethical Approval

Re: Ethics Application: 0531/001: Tracking Habit Formation

The above research has been given ethical approval following review by the UCL Committee for the Ethics of non-NHS Human Research for the duration of the project subject to the following conditions:

1. You must seek Chair's approval for proposed amendments to the research for which this approval has been given. Ethical approval is specific to this project and must not be treated as applicable to research of a similar nature. Each research project is reviewed separately and if there are significant changes to the research protocol you should seek confirmation of continued ethical approval by completing the 'Amendment Approval Request Form'.

The form identified above can be accessed by logging on to the ethics website homepage: http://www.grad.ucl.ac.uk/ethics/ and clicking on the button marked 'Key Responsibilities of the Researcher Following Approval'.

2. It is your responsibility to report to the Committee any unanticipated problems or adverse events involving risks to participants or others. Both non-serious and serious adverse events must be reported.

   Reporting Non-Serious Adverse Events.
   For non-serious adverse events you will need to inform Ms Helen Dougal, Ethics Committee Administrator within ten days of an adverse incident occurring and provide a full written report that should include any amendments to the participant information sheet and study protocol. The Chair or Vice-Chair of the Ethics Committee will confirm that the incident is non-serious and report to the Committee at the next meeting. The final view of the Committee will be communicated to you.

   Reporting Serious Adverse Events
   The Ethics Committee should be notified of all serious adverse events via the Ethics Committee Administrator immediately the incident occurs. Where the adverse incident is unexpected and serious, the Chair or Vice-Chair will decide whether the study should be terminated pending the opinion of an independent expert. The adverse event will be considered at the next Committee meeting and a decision will be made on the need to change the information leaflet and/or study protocol.

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h.dougal@ucl.ac.uk
www.ucl.ac.uk/gradschool

Letter to Professor Wardle 14/9/2005

On completion of the research you must submit a brief report (a maximum of two sides of A4) of your findings/concluding comments to the Committee, which includes in particular issues relating to the ethical implications of the research.

Yours sincerely

Sir John Birch
Chair of the UCL Committee for the Ethics of Non-NHS Human Research

Cc: Phillippa Goodwin, Research Student, Health Behaviour Unit

Appendix 8.2: Email advertisement for Study 3

Subject: Research Participants needed

Would you like to have a healthier lifestyle? Are there any things you would like to add into your daily routines, for example eating more fruit or doing more exercise?

We are conducting research into how people develop healthy eating and exercise habits (for example eating one more portion of fruit or vegetables a day, drinking more water or walking more). We are looking for students to participate in this research and try to create a healthy habit.

This will involve choosing two specific behaviours you would like to make into a habit, and then trying to do one of these every day. You will also be asked to complete on-line questionnaires frequently throughout the study.

You would need to come to meet with the researcher at UCL to start the study. There will be two different starting points in the study so at this meeting some participants will be asked to wait for up to 4 weeks before starting to do their chosen behaviour, while others will be able to start sooner.

The first part of the study is 4 weeks long and the second part is eight weeks long. After completing the first part you will be asked to come to UCL again to meet with the researcher and you will be given the opportunity to decide if you would like to continue on to the second part. Participants will be paid £15 after the first 4 weeks and £15 after the next 8 weeks.

If you would be interested in participating in this research please contact Pippa on

All information you provide will be kept in accordance with the 1998 Data Protection Act. The information will remain confidential, be held securely and not divulged to any third parties. Your information will be used for research purposes only and you will be free to withdraw from the study at any time.

Appendix 8.3: Information Sheet for Study 3

Royal Free and University College Medical School
Department of Epidemiology and Public Health
University College London
Gower Street Campus

HEALTH BEHAVIOUR UNIT
2-16 Torrington Place
London WC1E 6BT

Telephone +44 (0)20 7679 6644
Fax +44 (0)20 7813 2848
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Researcher *Pippa Goodwin*
Director *Professor Jane Wardle*

CONFIDENTIAL
Tracking Habit Formation
Participant Information Sheet

You are being invited to take part in a research study. Before you decide, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

The purpose of this research is to investigate how people form habits. We are interested in how long it takes for a behaviour to become habitual if you do it everyday over a period of time. We are also interested in what happens if you miss an opportunity to do the behaviour during this time. Your participation will enable us to look at the relationship between repetition of behaviour and habit strength. This research has the potential to inform future interventions aimed at helping people to develop healthy habits that have the potential to impact on their health.

We are hoping to recruit 100 students to take part in this study. You have been chosen because you have responded to an advertisement for the study and we hope this means you would like to try to develop a healthy habit.

Your participation is voluntary and you may choose to withdraw from the study at any time. If you choose to participate the study will run as follows.

1. Initially you will be asked to choose two behaviours that you would like to make into habits and will be asked to answer some questions about these on the computer and on paper.
2. You will then be randomly assigned to either start the study immediately or to wait for four weeks. If you are asked to wait then when you start the study in four weeks you will be asked to answer the same questions again and then start the study.
3. When you start the study one of the behaviours you chose will be randomly selected as the behaviour we are going to ask you to try to do everyday (your target behaviour), and the other we will not be asking you to do for now.
4. During the study you will be asked to log on to a website and answer questions about the two behaviours you chose, so before you leave the meeting you will be given a log-in name and password and shown how these questions will be presented.
5. You will be asked to start doing the behaviour the day after the meeting where you have been told which behaviour is your target and will then be asked to log on to the website everyday starting the day after you first do the behaviour.
6. You will then be asked to return and meet with the researcher again (4 weeks from when you started). You will be paid £15 for your participation so far and will be invited to continue the study for another 8 weeks.
7. After this second part of the study you will be asked to come again to meet with the researcher and to answer some brief interview questions. You will be paid another £15 for your participation.

We hope that by the end of the study you will have developed a healthy habit that you wanted to incorporate into your lifestyle. This research has the potential to inform future interventions to help people integrate desired behaviours into their daily lives.

All information you provide will be kept confidential in accordance with the 1998 Data Protection Act. Data you provide in paper form will be kept locked in a secure cabinet and will only be linked to you via a participant code. Data you enter on the website will be stored in a database which will be password protected. The data will only be used for research purposes and will not be disclosed to any third parties. It is intended that this data will be used to investigate how people form habits and that the results will be written up for publication in a peer reviewed journal. If in the future this data may be able to help answer further research questions it may be used in this way.

If you would like to be informed of the findings of this study when the data has been analyzed and written up please inform the researcher and she will send you this.

Thank you for considering taking part in this study. In you have any questions about the research please contact Pippa Goodwin (details above).

If you choose to participate in this research you will be given a copy of the Information Sheet and the signed Consent Form to keep prior to taking part in the research.

Approved by University College London's Committee on the Ethics of Non-NHS Human Research

Appendix 8.4: Consent Form for Study 3

Royal Free and University College Medical School
Department of Epidemiology and Public Health
University College London
Gower Street Campus

HEALTH BEHAVIOUR UNIT
2-16 Torrington Place
London WC1E 6BT

Researcher *Pippa Goodwin*
Director *Professor June Wardle*

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Informed Consent Form
To be completed independently by the participant

Project Title: Tracking Habit Formation

Please circle the appropriate answer

Have you read the Participant Information Sheet?	Yes	No
Has the project been explained to you orally?	Yes	No
Have you had the opportunity to ask questions and discuss the study?	Yes	No
Have you received satisfactory answers to all your questions?	Yes	No
Have you received enough information about the study?	Yes	No
Do you understand that you are free to withdraw from the study without penalty at any stage?	Yes	No
Do you agree with the publication of the results of this study in an appropriate outlet/s?	Yes	No
Who have you spoken to?		

At the end of the study you will be asked to participate in a brief interview about the study. This will be tape-recorded and transcribed and used to understand more about habit formation. The tapes will be kept in a locked cabinet and destroyed once they have been transcribed.

Are you happy to be tape-recorded and the information used in the above way?	Yes	No

Signed:.....

Date:.....

Full Name in Capitals:.....

The Health Behaviour Unit is an external unit of *Cancer Research UK*, charity no 1089464

CANCER RESEARCH UK

Appendix 8.5: Conscientiousness (IPIP questions)

Below are phrases describing people's behaviours. Please use the rating scale below to describe how accurately each statement describes you. Describe yourself as you generally are now, not as you wish to be in the future. Describe yourself as you honestly see yourself, in relation to other people you know of the same sex as you are, and roughly your same age. So that you can describe yourself in an honest manner, your responses will be kept in absolute confidence. Please read each statement carefully, and then circle the appropriate number on the scale shown.

	1 (Very Inaccurate)	**2 (Moderately inaccurate)**	**3 (Neither inaccurate or accurate)**	**4 (Moderately Accurate)**	**5 (Very accurate)**
I am always prepared	1	2	3	4	5
I leave my belongings around	1	2	3	4	5
I pay attention to details	1	2	3	4	5
I make a mess of things	1	2	3	4	5
I get chores done right away	1	2	3	4	5
I often forget to put things back in their proper places	1	2	3	4	5
I like order	1	2	3	4	5
I shirk my duties	1	2	3	4	5
I follow a schedule	1	2	3	4	5
I am exacting in my work	1	2	3	4	5

Appendix 8.6: Calculating questionnaire totals

Questionnaire totals were calculated for each questionnaire. Different numbers of missing values were accepted for each questionnaire, and the mean of all other items used to replace them, and calculate a total score. The details of this process are summarised in the table below. The internal reliability is presented for each questionnaire.

Questionnaire	Number of items	Scoring of items	Number of missings accepted	Method of calculating score	Scale score range	Higher score indicates more:	Cronbach's alpha
BIS	30	1-4	6	Sum	30-120	impulsivity	0.84
PNS	12	1-6	3	Average	1-6	need for structure	0.88
Conscientious-ness	10	1-5	3	Average	1-5	Conscientious-ness	0.79

Appendix 8.7: Evaluation Questionnaire

Please rate how much you agree or disagree with the following statements (they refer to your target behaviour):

	1: Strongly disagree	2: Disagree	3: Neither agree nor disagree	4: Agree	5: Strongly agree
Doing this everyday got easier over time	1	2	3	4	5
During the study my enjoyment of the behaviour increased	1	2	3	4	5
During the study my desire to do the behaviour increased	1	2	3	4	5
During the study my belief in my ability to do the behaviour increased	1	2	3	4	5
This is now a habit	1	2	3	4	5

Appendix 8.8: Behaviours and Cues chosen by participants

Behaviours	
Behaviour	**Number of participants**
Chewing every bite of dinner 15 times	1
Sit-ups	10
Unspecified exercise	4
Lifting weights	2
Yoga/Pilates	2
Meditation	2
Press-ups	2
Kegel exercises	1
Drinking water	29
Drinking fruit Juice	2
Eating dried fruit	2
Eating fruit	18
Eating Vegetables	6
Eating breakfast	1
Flossing	1
Walking	7
Running	6

Cues	
Cue	**Number of participants**
after breakfast	8
after brushing teeth at night	1
after dinner	7
when or just after getting up	17
after showering	2
after lunch	9
after morning coffee	1
at dinner	1
before bed	6
before breakfast	2
before dinner	13
before lunch	3
before having a shower	1
when watching the TV	2
with breakfast	7
with dinner	6
with lunch	10