Designing, delivering, and evaluating novel interventions to support dietary change for weight management

Submitted by Samantha Barbara van Beurden to the University of Exeter as a thesis for the degree of Doctor of Philosophy in Medical Studies, April 2018.

I certify that all material in this thesis which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other University.

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Abstract

Background: Recent empirical research and theoretical models acknowledge that impulsive processes, can often undermine peoples' attempts to lose weight despite currently available and effective support (Chapter 2).

Aim: To develop, deliver, and evaluate an impulse management intervention to support weight loss in adults.

Methods: A systematic review was conducted to identify available impulse management techniques for influencing eating behaviour (Chapter 3). Intervention Mapping was used to develop the intervention (Chapter 4) which drew on various sources including the findings from the systematic review, stakeholder consultations, existing guidance, and qualitative interviews. A two-arm randomised controlled feasibility trial (Chapter 5), with nested mixed-methods process evaluation and two cycles of intervention delivery and data collection (Chapter 6), was conducted. This assessed the feasibility and acceptability of, and informed refinements to, both the intervention and trial procedures in preparation for a full-scale effectiveness evaluation. Weight was measured as the proposed primary outcome for a full-scale trial at baseline, one-month, and three-months of follow-up, app usage data were collected at both follow-up time points, and semi-structured interviews were conducted at one-month with a subsample of intervention group participants only.

Results: The systematic review critically appraised and synthesised evidence on 17 identified techniques which were categorised as Impulse-focused or Reflective techniques. Promising changes in eating behaviour and craving were found for the techniques of visuospatial loading, physical activity, and implementation intentions. Intervention Mapping resulted in development of a novel smartphone app-based intervention (ImpulsePal) aimed to reduce unhealthy snacking, overeating, and alcoholic and sugary drink consumption using impulse management techniques identified in the systematic review. Eighty-eight adults with a Body Mass Index of ≥25kg/m^2 and wishing to lose weight, were recruited and randomised in a 2:1 ratio to use ImpulsePal (n=58) or to a waiting list control (n=30) group. Data were available for 74 participants (84%) at one-month and 67 (76%) at three months. Exploratory analyses suggest that the ImpulsePal group (n=43) lost 1.03kg (95% CI 0.33 to 1.74) more than controls (n=26) at one-month, and 1.01kg (95% CI -0.45 to 2.47) more at three months. Participants reported high satisfaction with the intervention and trial procedures. The process evaluation suggests that ImpulsePal and the impulse management techniques are feasible to deliver and acceptable to users. Interviews with twenty-two participants suggest that they valued having access to in-the-moment support, felt more aware of their own eating behaviour and influences on it, and felt an increased ability to resist temptations.

Conclusions: This work has developed a novel, theory- and evidence-informed, person-centred app which showed potential to improve impulse management, promote healthier eating, and support weight loss. ImpulsePal is acceptable to overweight and obese adults who want to lose weight and is now ready for evaluation in a full-scale trial. The thesis discusses theoretical, methodological, and practical implications for the future development, evaluation, and implementation of digital behaviour change interventions.

Acknowledgements

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Author’s Declaration

There are four chapters in this thesis which report work that has been written up as manuscripts for publication or are in preparation. At the time of submitting this thesis, one had been published, one had been submitted and two are in preparation for submission to peer-reviewed journals. All four are co-authored but all are primarily the result of the candidate’s own work. Throughout the PhD, supervisory guidance was mainly provided by the primary co-supervisors Prof Colin Greaves (CG), Dr Jane Smith (JS), with some additional support from the third supervisor Prof Charles Abraham (CA). The candidate wrote all manuscripts included in the four chapters. Chapters presenting empirical work are largely based on these manuscripts, but efforts have been made to reduce repetition and highlight the narrative of this thesis. Within each chapter, text based on the corresponding manuscript will be clearly indicated. Detailed below is the candidate’s substantial contribution to each of the co-authored manuscripts.

Manuscript 1: Chapter 3 *Modifying or managing impulsive processes to facilitate eating behaviour change for weight loss.*

The first empirical chapter in this thesis, Chapter 3, was submitted to a call for papers (December 2014) for a special issue in *Health Psychology* which focused on non-conscious processes and behaviour change. The paper was accepted for full submission and published in the special issue in 2016. The candidate developed the protocol, screened and selected all articles, extracted the data from the included papers, synthesised the data, and wrote the manuscript. The double screening process was supported by fellow PhD candidate Jeff Lambert at Title and abstract stage, and by supervisors CG and JS at the full-text stage, CA advised on the categorisation, and the narrative synthesis was conducted under guidance of CG. All supervisors commented on the manuscript.

Manuscript 2: *Chapter 4 Development of a weight loss intervention supporting impulse management.*

The development chapter presents work for which the manuscript is currently in preparation. The candidate, convened the intervention development group, developed the materials used in the service user and expert consultations, ran the consultations, gathered and collated the needs assessment data from all described sources (See Chapter 4), developed the intervention map, designed the programme content, voiced the audio-material, conducted the prototype usability testing process, liaised with the app developers at Psynovigo Ltd., and wrote the manuscript. CG, JS, and CA critically reviewed the intervention map. Natalia Lawrence provided expert advice on current evidence for, and operationalisation of inhibition training. All authors participated in at least one of the intervention development group discussions and provided comments on the manuscript

Manuscript 3: *Chapter 5 The feasibility randomised controlled trial of ImpulsePal*

The manuscript relating to the feasibility trial of ImpulsePal presented in Chapter 5 is under review for publication in JMIR mHealth uHealth. The candidate developed the study protocol, approached relevant partners to be included as identification and recruitment routes, applied for appropriate permissions, conducted data collection, analysis, and interpretation and drafted the manuscript. CG and JS critically reviewed the design of the study, provided advice on the analysis and interpretation of the data. Natalia Lawrence and CA advised on the interpretation of data and all commented on the manuscript and approved submission.

Manuscript 4: *Chapter 6 Process evaluation of the ImpulsePal intervention*

The process evaluation is currently being prepared for publication. Much of the candidate’s contributions are similar as described for Manuscript 3 as the process evaluation was nested within the feasibility trial. The candidate developed the topic guide, selected the questionnaires, recruited and collected the data (including conducting all semi-structured interviews), analysed and interpreted the data, and wrote the manuscript. CG and JS critically reviewed the topic guide and questionnaires selected and provided advice on the analysis and interpretation of the data. CG reviewed the final themes and quotes and the Statists Clinic at the University of Exeter provided guidance on quantitative analysis.

Publications relating to this Thesis

The thesis produced four papers for publication. A version of each paper is presented in Chapters 3 to 6.

Chapter 3 has been published as:

van Beurden, S. B., Greaves, C. J., Smith, J. R., & Abraham, C. (2016). Techniques for modifying impulsive processes associated with unhealthy eating: A systematic review. *Health Psychology*, *35*(8), 793–806. https://doi.org/10.1037/hea0000337

Chapter 4 is in preparation for submission as:

van Beurden, S. B., Greaves, C. J., Lawrence, N. S., Abraham, C., & Smith, J. R. (*in preparation*). ImpulsePal: Developing a Smartphone App to Manage Food Temptations using Intervention Mapping.

Chapter 5 has been submitted and is under review:

van Beurden, S. B., Smith, J. R., Lawrence, N. S., Abraham, C., & Greaves, C. J. (*under review*). Randomised controlled feasibility trial of ImpulsePal: A smartphone app-based weight management intervention to reduce impulsive eating in overweight adults. *JMIR mHealth and uHealth*

Chapter 6 (a shortened version) is in preparation for submission as:

van Beurden, S. B., Greaves, C. J., Abraham, C. & Smith, J. R. (*in preparation*). Mixed-methods feasibility process evaluation of the ImpulsePal app intervention for dietary change and weight loss.

Abbreviations

BMI	Body Mass Index
CI	Confidence Interval
CONSORT	Consolidated Standards of Reporting Trials
ExTend	Exeter 10 000 project
HPD	Health Promotion Devon
ITT	Intention-to-treat
MRC	Medical Research Council
MD	Mean Difference
NHS	UK National Health Service
PABAK	Prevalence and Bias Adjusted Kappa
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RCT	Randomised Controlled Trial
TIDieR	Template for Intervention Description and Replication
WHO	World Health Organization

Chapter 1. Introduction

1.1. Brief problem statement

Obesity remains a major global problem (Butland et al., 2007; World Health Organization, 2016). Excess weight has adverse consequences for health and wellbeing which have a substantial impact on health services costs. With two in three adults in the UK and western world currently overweight or obese, obesity is one of the most costly preventable social burdens alongside smoking and excessive alcohol consumption (McKinsey Global Institute, 2014). This obesity epidemic is generated by preventable lifestyle factors, largely driven by overeating which in turn is driven by environmental, social and psychological factors. Health psychology research and weight management interventions have mainly focused on deliberative precursors of behaviour, such as change in explicit attitudes and beliefs, planning and problem-solving (Tang, Abraham, Greaves, & Yates, 2014). Yet even when strong intentions are established, people still struggle to lose weight or maintain change over time (Elfhag & Rössner, 2005; Jeffery et al., 2000; Mann et al., 2007). This discrepancy has led to much recent interest in dual-process models (e.g., (Hofmann, Friese, & Strack, 2009; Strack & Deutsch, 2004) which include "non-conscious" impulsive mechanisms affecting eating behaviour. The need for techniques that can prevent, or modify such impulsive processes to achieve better health outcomes is increasingly recognised (Marteau, Hollands, & Fletcher, 2012; Sheeran, Gollwitzer, & Bargh, 2013) and the development and investigation of such techniques has proliferated in the past decade. Despite this, several questions relating to their mechanisms of action, effectiveness, and mode of delivery remain unanswered. Given the increasing need to reduce the prevalence of overweight and obesity, establishing effectiveness of such strategies as well as the feasibility and acceptability of their use by people who are clinically overweight or obese is imperative.

1.2. Aims and scope

The overarching research question this thesis aims to answer is as follows: "Can we develop, deliver, and evaluate an intervention that helps modify or otherwise manage impulsive processes related to unhealthy eating behaviour to facilitate weight loss".

Using a multi-methods approach, the specific aims are to: (1) identify the range of existing theoretically-driven impulse management techniques and evaluate the evidence for their effectiveness, (2) develop a digital behaviour change intervention for weight management incorporating service user views, as well as theory and evidence through inclusion of promising techniques identified in the review, (3) determine whether the delivery of these techniques via a smartphone app and intervention evaluation procedures are acceptable and feasible, and (4) whether there are refinements to be made to the intervention to improve the delivery of, and/or engagement with, the intervention.

1.3. Overview of thesis

Following this brief introduction, Chapter 2 provides an overview of: (a) the negative health consequences of obesity, (b) eating behaviour as a risk factor for obesity, (c) the health benefits of weight loss and prevention of weight (re)gain, (d) current practices for weight management and related evidence on their effectiveness, and (e) the use of theory, evidence, and user perspectives in intervention development. This chapter provides a rationale and evidence base for the rest of the thesis. The chapter introduces the role of impulsive processes in the regulation of eating behaviour and the potential utility of digital behaviour change interventions.

Chapters 3-6 present a series of empirical studies. Chapter 3 aims to address the specific research question: *How can impulsive processes be modified or otherwise managed to support healthier eating and/or weight loss?*

This chapter describes a systematic review of the evidence of the modification or management of impulsive processes related to eating behaviour. This systematic review aimed to (a) identify and categorise available change techniques that have been used to modify or help manage impulsive processes associated with unhealthy eating, (b) describe their underlying mechanisms of action, and (c) summarise and systematically categorise the available effectiveness evidence to identify potentially promising techniques.

Chapter 4 addresses the following research question: “*How can people be supported to manage impulsive processes to facilitate eating behaviour change and weight management, using a self-delivered intervention”.*

This chapter focuses on the systematic development of a smartphone app-based weight management intervention focused on dietary change by improving impulse management using change techniques identified as potentially promising in Chapter 3. This chapter describes the development process following the 6 steps of Intervention Mapping including the involvement of appropriate users and discusses the strengths and limitations of the Intervention Mapping protocol.

Chapter 5 and Chapter 6 describe the assessment of the feasibility and acceptability of the developed intervention (ImpulsePal) and potential assessment procedures in a randomised controlled feasibility trial with nested process evaluation in two cycles of intervention delivery and evaluation.

Chapter 5 specifically addresses the question: “*Is an effectiveness evaluation of ImpulsePal using a randomised controlled trial design with objective measurement of weight, completion of questionnaires, and semi-structured interviews feasible?”*

This chapter includes the assessment of recruitment rates, study uptake, outcome completion, retention, intervention use, and feedback on procedure acceptability and feasibility.

Chapter 6 addresses the question: “*Is the intervention feasible and acceptable to overweight and obese individuals?”*

This chapter reports on the analysis of usage statistics of specific intervention components, exploratory mediation and moderation analyses, and the analysis of qualitative data gathered via semi-structured interviews during Cycle 1 and Cycle 2 of the feasibility study to elicit further user perspectives on the usability of the intervention and its techniques, as well as potential mechanisms of the intervention. Chapter 6 helped to inform refinements to the development of the intervention and therefore adds to data presented in Chapter 4. Thus, although presented sequentially, the development of the ImpulsePal intervention was an iterative process.

Finally, Chapter 7 summarises and integrates the findings from the work presented in this thesis in an overall discussion, the strengths and weaknesses of the research are addressed, and the possible contributions to theory and implications for practice are described.

Chapter 2. Background.

2.1. The burden of obesity

2.1.1. Prevalence

Excess weight continues to be global health concerns, with about two in three adults in the United Kingdom (UK) and the remainder of the western world currently classed as being overweight or obese. The Health Survey for England (Health and Social Care Information Centre, 2013) reported that although being overweight is still more common than being obese (41% of adult men and 33% of women) the proportion of overweight adults has not changed much since 1993. However, in these past two decades the proportion of obese adults in England has seen a steep increase from 13 to 26% among men and from 16 to 24% among women. This trend is projected to continue with predictions suggesting that by 2050 more than 50% of the UK population will be obese (Butland et al., 2007). Yet, a more recent report (Wang, McPherson, Marsh, Gortmaker, & Brown, 2011) suggested that this prevalence will be reached by 2030; twenty years earlier than originally predicted.

2.1.2. Definition

The World Health Organisation defines overweight and obesity as excessive fat accumulation that may impair health (World Health Organization, 2016). A person's weight status is still commonly classified using the Body Mass Index (BMI) which is defined as a person's weight in kilograms divided by their height in meters squared (kg/m^2). The BMI scale has been divided into several clinical categories which can be seen in Figure 2.1. BMI categories are considered to be age- and gender-independent. However, cut-off points for use in clinical practice may vary by ethnic groups. This relates to ethnicity driven variations in the relationship between BMI and health risk. For example, African-Caribbean/ Black Caribbean people are at an equivalent risk of Type II diabetes or other conditions at a lower BMI than the white European population (NICE, 2013). Waist circumference can be a marker for increases in health risk in addition to BMI classification.

	BMI (kg/m^2)	Obesity Class	Disease Risk* Relative to Normal Weight and Waist Circumference	
			Men 102 cm or less Women 88cm or less	Men > 102 cm Women > 88cm
Underweight	< 18.5	-	-	-
Normal/Healthy	18.5 - 24.9	-	-	-
Overweight	25.0 - 29.9	-	Increased	High
Obesity	30.0 - 34.9	I	High	Very High
	35.0 - 39.9	II	Very High	Very High
Extreme Obesity	40.0 +	III	Extremely HIgh	Extremely HIgh

* Disease risk for type 2 diabetes, hypertension, and CVD.
\+ Increased waist circumference can also be a marker for increased risk, even in persons of normal weight.

Figure 2.1 BMI classifications, waist circumference, and associated disease risk adapted from National Heart, Lung, and Blood Institute.

2.1.3. Health Risk

Obesity is associated with substantially lowered life expectancy, especially among younger adults (20-30 years of age). More specifically, data from the United States (US) suggest that a BMI of over 45kg/m2 during these years may reduce life expectancy by up to 8 and 13 years (for women and men respectively; Fontaine, Redden, Wang, Westfall, & Allison, 2003). Increases in BMI are associated with increased risk for developing a wide range of comorbidities as well as increasing all-cause mortality (Aune et al., 2016). Such comorbidities include cardiovascular disease (Poirier et al., 2006; Prospective Studies Collaboration et al., 2009), Type 2 Diabetes (Abdullah, Peeters, de Courten, & Stoelwinder, 2010), cancer (Aune et al., 2012; Renehan, Tyson, Egger, Heller, & Zwahlen, 2008; World Cancer Research Fund & American Institute for Cancer Research, 2007), and stroke (Strazzullo et al., 2010) ultimately lowering quality of life (Field, Coakley, Must, & et al, 2001; Fontaine, Bartlett, & Barofsky, 2000). People with a BMI of 35- 45kg/m2 have a relative risk of type 2 diabetes that is 8 to 11 times higher than for people of normal healthy weight (Must et al., 1999). However, much of the death and chronic conditions that result from overweight or obesity is preventable.

2.1.4. Cost

Being overweight or obese is associated with health care costs that are 12% and 36% higher than for people of healthy weight (Kent et al., 2017; Sturm, 2002). The cost of overweight and obesity to the UK economy was estimated at £15.8 billion pound per year in 2007, which included £4.2 billion in costs to the NHS for treating overweight and obesity and related morbidity. By 2050 the NHS cost attributable to overweight and obesity are predicted to rise to £9.7 billion with a total societal cost of £49.9 billion (Butland et al., 2007). Public Health England has suggested that local authorities in the UK spend an extra £352 million per year on providing formal care for severely obese people compared to those of healthy weight (Morgan & Dent, 2010). Obesity and its attributable comorbidities have the highest overall impact on the NHS budget when compared to other lifestyle-related risks such as alcohol consumption, smoking, and physical inactivity (Scarborough et al., 2011). Obesity has a global economic impact of roughly $2 trillion per year (McKinsey Global Institute, 2014). At a global level, this makes obesity one of the top three most costly self-generated social problems, alongside smoking and armed violence, war, and terrorism. Curbing the rising trend of overweight and obesity by preventing and treating obesity effectively would lighten the direct and indirect burden on the NHS and global economy, freeing up resources that might be better spent elsewhere. The health service landscape in England is changing greatly due to cuts to local authority public health grants which have already resulted in a 5% reduction in spending on obesity treatment and further cuts have been announced (Department for Communities and Local Government, 2016, 2017). Thus, making the need for more cost-effective solutions more pressing.

2.1.5. Eating behaviour

While there are various factors that contribute to being overweight or obese, a crucial contributor has been the consumption of excess energy without a response in energy expenditure (World Health Organisation, 2003). Many people fail to meet the daily recommendations for healthy dietary intake (Bates et al., 2016) and one major risk factor contributing to the increased energy intake in the population, is the frequent consumption of energy-dense food and drink items (i.e., those high in fat and sugar; French, Story, & Jeffery, 2001;

Poppitt & Prentice, 1996; Stubbs & Whybrow, 2004; Swinburn, Caterson, Seidell, & James, 2004; World Health Organisation, 2003). Energy-dense food and drinks that have been shown to be associated with energy intake include fast food (Prentice & Jebb, 2003), snacks and sweets (Whybrow, Mayer, Kirk, Mazlan, & Stubbs, 2007; Zizza, Siega-Riz, & Popkin, 2001) and sugary soft-drinks (Morenga, Mallard, & Mann, 2013). In addition, the recent rise in obesity prevalence has been paralleled by increases in the amount eaten in one sitting (i.e., portion size; Ledikwe, Ello-Martin, & Rolls, 2005). Moreover, experimental studies have shown that eating rate and energy density have independent yet additive effects on overeating (e.g., Karl, Young, Rood, & Montain, 2013). Thus, food items that are consumed quickly such as fast food, snacks, sugary drinks, which are generally consumed in between meals while “on-the-go”, are considered key contributors to excess energy intake.

2.2. Weight loss and prevention of weight (re)gain.

The goal of obesity treatment is to increase the health and quality of life of the individual by helping them reach and stay at a healthy BMI. If someone is overweight or obese, this requires losing weight.

2.2.1. Health benefits

For people who are overweight or obese, losing weight is associated with numerous health benefits. Evidence from randomised controlled trials has shown that modest weight loss (5-10%) is associated with changes in key cardiovascular disease risk factors, such as cholesterol and blood pressure, with greater improvements seen at greater weight loss (e.g., Brown, Buscemi, Milsom, Malcolm, & O’Neil, 2016; Stevens et al., 2001; Vidal, 2002). For example, in a multi-centred-trial of a lifestyle-based intervention with more than 5000 participants with Type 2 diabetes, of 5% or more was associated with reductions in medicine use and cardiovascular disease risk factors (Look AHEAD Research Group et al., 2007). Weight loss has also been associated with reductions in insulin resistance and the incidence of progression to type 2 diabetes (Knowler et al., 2002; Tuomilehto et al., 2001). For example, in the Finnish Diabetes Prevention Study, a mean 3.4Kg of weight loss in people with impaired glucose regulation, reduced the incidence of type 2 diabetes at 4 years of follow-up by 58% (Tuomilehto et al., 2001). This has led to the generally accepted definition of clinically meaningful weight loss, as a loss of ≥5% of one's initial body weight that is maintained over at least 12-months (Williamson, Bray, & Ryan, 2015).

2.3. Current weight loss interventions

The array of obesity treatments currently spans pharmacotherapy, bariatric surgery, and lifestyle interventions focused on educating, raising awareness, and promoting behaviour change. Each are described in greater detail in the subsequent sections.

2.3.1. Pharmacotherapy

Pharmacological treatment for obesity involves the use of drugs to induce weight loss. These types of drugs tend to reduce appetite, reduce the absorption of fat, or increase the energy expenditure through thermogenesis (i.e., increasing the metabolic rate). Due to the relatively little personal effort required, patients are likely to adhere to this form of treatment (Hsu, Chu, Ku, Liou, & Chou, 2010). A systematic and clinical review of currently approved medications (orlistat, lorcaserin, and topiramate) in the US for long-term obesity treatment in adults included 20 RCTs and 1 meta-analyses highlighted that these medications, when used in addition to lifestyle intervention, produce additional weight loss (3% orlistat and lorcaserin and 9% for phentermine plus topiramate) and an increased likelihood of achieving clinically meaningful weight loss (at least 5%) at 1-year follow-up relative to placebo (Yanovski & Yanovski, 2014).

2.3.1.1. Issues with pharmacotherapy

A UK based study evaluating the effects or orlistat used by 100 701 patients or sibutramine used by 15 355 patients, using routinely collected clinical practice data, saw weight loss at four-months compared to 508 140 matched individuals who were not using either drug. However, this was not sustained over a period of 3-years (Douglas, Bhaskaran, Batterham, & Smeeth, 2015). Thus, results found in randomised controlled trials may not necessarily translate to clinical practice. Moreover, obesity medication is associated with a variety of risks. Depending on which medication is used, pharmacotherapy can have minor adverse side effects such as headaches, dizziness, insomnia, gastrointestinal issues due to limited fat absorption (Yanovski & Yanovski, 2014). For some medications side effects are more severe. A meta-analysis of four high quality randomised placebo-controlled, double-blinded trials including showed that although Rimonabant resulted in greater weight loss (4.7kg) at 1-year of follow-up than the placebo group. Participants using Rimonabant also reported 1.4 times more serious adverse events and were more likely to stop treatment due to depressive mood disorder (2.5 times) and anxiety (Christensen, Kristensen, Bartels, Bliddal, & Astrup, 2007). Rimonabant has since been withdrawn (post approval) by the European Medicines Agency. A systematic review of withdrawn obesity pharmacotherapy after they had received regulatory approval, found 25 medications that were withdrawn between 1964 and 2009. These medications were withdrawn due to serious adverse effects becoming apparent following trial, including psychiatric disturbances, cardiotoxicity, drug abuse, and deaths. Withdrawal occurred within 2-years since release for almost half of the medications which may indicate a lack of rigorous risk assessment during trials (Onakpoya, Heneghan, & Aronson, 2016). Although, obesity itself poses a risk to the individual and warrants long-term treatment, the objective of obesity treatment is to increase the health and quality of life of the individual. Therefore, it is imperative that the risks of the treatment do not outweigh its benefits.

2.3.2. Bariatric surgery

Bariatric surgery is a more generic term for a variety of weight loss surgeries and requires instant and drastic lifestyle changes following surgery to avoid weight regain, as well as to avoid severe physiological reactions to fat intake following surgery. These changes include adopting a healthy well-balanced diet, regular exercise, and taking vitamin supplements. The most commonly performed operations in the UK are: (1) adjustable gastric banding, which reduces the amount of food that can be held in the stomach and reduces the feeling of hunger by placing an adjustable silicone band around the upper stomach; (2) gastric bypass, which reduces the amount of nutrients that can be absorbed by the stomach by redirecting the food from a small section of the stomach straight to the intestine therefore bypassing the rest of the stomach; and (3) open sleeve gastrectomy, which divides the stomach vertically, reducing it in size and therefore reducing the amount of food the stomach can hold as well as reducing the feeling of hunger. Although the first procedure is relatively non-invasive, the latter two are irreversible and are accompanied by lifelong monitoring and a need for vitamin supplements (Dent, Chrisopoulos, Mulhall, & Ridler, 2010).

Randomised controlled trials and meta-analyses have demonstrated the effectiveness of bariatric surgeries in reducing severe obesity and associated comorbidities (Adams et al., 2007; Buchwald et al., 2004; Sjöström et al., 2004). For example, a systematic review and meta-analysis of 11 randomised controlled trials reported that bariatric surgery produces greater body weight loss (26kg) compared with non-surgical treatment of obesity (Gloy et al., 2013). Although these results are based on a small number of studies and individuals (n=796) and blinding during data analysis was only clear for three of the included studies, they are supported by previous reviews reporting greater weight reductions after bariatric surgery for people who are moderately to severely obese as compared with non-surgical interventions (Colquitt, Picot, Loveman, & Clegg, 2009; Picot et al., 2009). Unsurprisingly, this promising effectiveness evidence has led to the significant increase in the number of publicly funded bariatric surgery procedures in the UK (Welbourn, Fiennes, Kinsman, & Walton, 2010) and the number of procedures conducted globally (Angrisani et al., 2015) over the past decade.

2.3.2.1. Issues with bariatric surgery

Despite marked weight loss following surgery and significant remission and improvement of obesity-related comorbidities (Brethauer et al., 2013), long-term weight regain (also referred to as weight recidivism) is a well-recognised issue of bariatric surgeries and may occur with all three of the most popular performed surgeries gastric bypass, gastric band, and gastrectomy (Gracia et al., 2009). Such weight regain is often referred to as surgical failure (Christou, Look, & MacLean, 2006; Magro et al., 2008), has been estimated to affect 10-20% of patients, with a weight regain of on average 7.3% of the initial weight in the long-term (i.e., during 2-10 years of follow-up Sjöström, Lissner, Wedel, & Sjöström, 1999), and is associated with the recurrence of obesity-related health problems such as Type 2 Diabetes (Brethauer et al., 2013).

A systematic review including 16 independent studies totalling 4,864 patients for analysis (seven case series, five surveys, and four non-randomised controlled trials) identified causative factors associated with post-bariatric weight regain. Findings suggested that weight regain in the included post-bariatric patients is multifactorial and factors can be categorised as patient-related or procedure-specific. Patient specific factors identified in the review were dietary non-compliance (n=5 studies), metabolic issues (n=3), psychological factors (n=5), and physical inactivity (n=1) (Karmali et al., 2013). In this review, post-bariatric dietary noncompliance was one of the most frequently referred to reason for weight regain.

Psychological factors or uncontrolled mental health disorders are also implicated as important precursors for weight regain. These factors include binge eating, depression and other psychological factors such as a lack of inhibition. In some obese patients, a lack of inhibition leads to greater susceptibility to impulsive eating, which has been shown to be a significant predictor of weight regain (Bond, Phelan, Leahey, Hill, & Wing, 2009; Colles, Dixon, & O'Brien, 2008; Odom et al., 2010). These factors affect weight regain through eating behaviours that lead to excessive energy intake. In contrast, physical inactivity was a patient-related factor identified only by one of the included studies. Overall, the evidence suggests that although bariatric surgeries may be effective in the short-term, they do not address prior reasons or behaviours that had been the cause of the initial weight gain. Therefore, the maintenance of lost weight post-surgery requires drastic lifestyle changes, including the adoption of healthy eating behaviour.

Weight loss surgeries are also expensive and invasive. Although surgery may be considered cost-effective for those who are severely obese (Picot et al., 2009), weight regain can result in recurrent costs associated with the management of obesity and related conditions (Karmali et al., 2013). In addition to the financial cost, like pharmacotherapy, bariatric surgery has serious adverse effects. Bariatric surgery has detrimental effects on bone density (Johnson et al., 2005), although the changes that occur are specific to procedure type (Stein & Silverberg, 2014). Moreover, the suicide risk following bariatric surgery is a major concern. One study that focused specifically on post-bariatric surgery suicides reported 30% of suicides occur within 2 year post-operative with 70% occurring within 3 years (Tindle et al., 2010). A systematic review of 28 prospective and retrospective studies including 40 947 patients estimated a 4.1 /10 000 person-years suicide rate (Peterhänsel, Petroff, Klinitzke, Kersting, & Wagner, 2013). However, very little is known about the possible causal factors involved in this relationship between bariatric surgery and suicide. A systematic review assessing the long-term effectiveness of bariatric surgery on psychosocial quality of life of adults who are clinically obese compared with non-surgical interventions reported initial post-operative increases in psychosocial and physical quality of life (up to 2-year follow-up). However, the improvements in psychosocial quality of life seems to disappear at longer-term (10 year) follow-up (Jumbe, Bartlett, Jumbe, & Meyrick, 2016).

2.3.3. Lifestyle interventions

Lifestyle weight management interventions for overweight or obese adults are programmes that aim to create an energy deficit by targeting changes in dietary and/or physical activity behaviours. As with pharmaceutical approaches, behavioural weight loss treatments can be seen as depending on “active ingredients” that facilitate the changes in behaviour required for weight loss. These active ingredients are referred to as behaviour change techniques (BCTs). Standardised definitions of BCTs such as in the well-cited Behaviour Change Technique Taxonomy (Michie et al., 2013) provide a useful framework for understanding how interventions work and have helped identify the specific BCTs used in a range of weight loss interventions. In particular, the CALO-RE taxonomy (Michie, Ashford, et al., 2011), is a standardised 40-item taxonomy that can be used for reliable identification and specification of BCTs targeting physical activity and dietary change. This taxonomy has been useful in the analysis and reporting of behavioural weight management interventions. Descriptions of effective interventions highlight that these include self-monitoring, feedback, and goal setting (Hartmann-Boyce, Johns, Jebb, Aveyard, & Behavioural Weight Management Review Group, 2014; Tang et al., 2014).

There are a variety of ways in which interventions and their behaviour change techniques can be delivered. Such delivery formats range from face-to-face individual or group support, distance delivery such as telephone, or text-messaging support, to self-delivered interventions via printed media or interactive software, or any combination of the various formats (e.g., eHealth or mHealth interventions delivered via mobile phones, internet or other digital devices; Hartmann-Boyce, Johns, Jebb, Aveyard, et al., 2014; Tang et al., 2014).

Systematic reviews have shown that behavioural weight loss interventions that facilitate changes in diet and physical activity to create a negative energy balance, can result in meaningful weight loss (2 to 3kg) (Franz et al., 2007; Shaw, O'Rourke, Del Mar, & Kenardy, 2005). However, there is huge variation in the effectiveness of such interventions (Greaves et al., 2011; Tang, Abraham, Greaves, & Nikolaou, 2016) which is possibly due to varying content, varying intensity /dose, and variations in delivery quality. Systematic reviews have attempted to identify the active ingredients in complex behavioural interventions for obese adults using direct and/or indirect comparison methods (Dombrowski et al., 2012; Hartmann-Boyce, Johns, Jebb, Aveyard, et al., 2014; Michie, Abraham, Whittington, McAteer, & Gupta, 2009). However, the evidence is not conclusive and the various reviews are not always in agreement. Meta-regression analyses (a technique that relates the presence of specific intervention components to effectiveness across multiple studies) have shown that incorporating self-monitoring is associated with increased effectiveness for behaviour change (pooled effect size 0.42 vs 0.26 for interventions without self-monitoring; (Michie et al., 2009). Another meta-regression (Dombrowski et al., 2012) shows that programmes using the specific change techniques "providing instructions", "relapse prevention" and "prompting practice", were associated with increased weight loss. However, yet another similar meta-regression (Hartmann-Boyce et al., 2014) was unable to detect the same associations. It is worth noting that these reviews utilised different taxonomies in their identification of change techniques in the included intervention reports, focused on different populations and followed different inclusion criteria in relation to the behavioural targets (i.e., dietary vs physical activity vs multi-component) which may explain the different findings.

2.3.3.1. Issues with current lifestyle interventions

Although potentially clinically meaningful, weight loss following behavioural interventions remains modest compared to surgical treatments (Gloy et al., 2013). In addition, behavioural interventions are only moderately effective in attenuating weight regain by about 1.6kg at 12 months (e.g., Dombrowski et al., 2014). People who successfully lose weight often return to their baseline weight within 3-5 years which is thought to be due to an inability to sustain the required behaviour changes (Katan, 2009).

Traditional weight loss interventions follow a face-to-face, individual or group-based support delivery format with regular on-site meetings. This requires resources for staffing (e.g., facilitators, their training, and admin), delivery space, and intervention materials (e.g., printed documents, measurement equipment, and training manuals). Such behavioural interventions are time and resource intensive and can be costly to implement. Hence, the NHS which is progressively resource-constrained, struggles to provide effective support to meet demand (Jolly et al., 2011). In addition, access to face-to-face interventions is hindered by practical restraints such availability and the participants' ability to travel in order to attend regular on-site meetings. This difficulty in accessing available support limits the reach of face-to-face behavioural interventions (Tate, Wing, & Winett, 2001). Moreover, accessibility restraints can also result in individuals who do enrol/sign up, to discontinue their programme (Wadden & Butryn, 2003). Finally, some people prefer an individual approach rather than a group setting in relation to the provision of health interventions which requires additional resources (Greaves & Campbell, 2007)

Due to variability in factors such as delivery context, settings, facilitator characteristics and group dynamics, consistent implementation of the face-to-face interventions is challenging (Alexander & Hearld, 2012). These factors therefore affect fidelity. Intervention fidelity refers to the extent to which a behaviour change intervention is designed, delivered, received, and used as intended, which is associated with the effectiveness of the intervention. For example, a pilot randomised controlled trial of a group-based lifestyle intervention for people with high risk of cardiovascular disease suggested that that attendance is related to outcomes, with those attending five sessions or more having lost 3.7Kg more at 4 months, and 4.1kg more at 12 months than those attending less (Greaves et al., 2015). The NIH Behaviour Change Consortium identified intervention fidelity as a key issue for the effectiveness of behaviour change interventions, with scope for improvements of fidelity in the key areas of design, training, delivery, receipt and enactment (Borrelli, 2011; Borrelli et al., 2005).

2.3.4. Digital behaviour change interventions

It is not only important to identify, or develop, effective obesity treatments but also to ensure they are scalable and cost-effectiveness. One way of maximising scalability is offering self-directed interventions (Tang et al., 2014) using the internet and digital devices. In addition, using digital technology as a platform has the potential of minimising variability in delivery fidelity (i.e., whether the intervention is delivered as intended). Such interventions using digital technology for health have been referred to as 'eHealth' interventions (e.g., (Hans Oh et al., 2005)However, recently and more specific to lifestyle interventions the term digital behaviour change interventions (DBCIs) has emerged, which typically refer to the use of websites and smartphones (Michie, Yardley, West, Patrick, & Greaves, 2017).

The promise of the use of technology for health has been championed over the past two decades (Atkinson & Gold, 2002) due to the potential for overcoming some of the limitations of face-to-face interventions mentioned above (Manzoni, Pagnini, Corti, Molinari, & Castelnuovo, 2011). In the UK alone 92.6% of the population has access to the internet via any digital device (Internet Live Stats, n.d.) and 81% of the UK adult population owns a smartphone (Deloitte, 2017). DBCIs therefore, have the potential of reaching a large scale population. Thus, if digital behaviour change interventions are found to be effective, even if only small changes are achieved, the potential reach of these programmes (scalability) can result in a significant public health impact (Glasgow, Nelson, Strycker, & King, 2006).

Systematic reviews suggest that self-directed DBCIs can achieve greater weight loss than when no treatment or minimal intervention is provided (such as information leaflets; Tang et al., 2014; Wieland et al., 2012). However, human support can increase the effects of DBCIs. For example, a recent randomised controlled trial (Little et al., 2016) investigated the effects of different levels of human support in addition to a web-based lifestyle intervention (POWeR). In this three-arm trial, a web-based weight management intervention including brief remote nurse support (three to five phone call or email contacts) was compared with the same web-based intervention supported by in-person nurse contact (either three to seven face-to-face appointments over six months) and a control group receiving two pages (web-based) of evidence-based dietetic advice. Both levels of facilitation were able to achieve greater weight loss compared to the control group averaged over 12 months (1.3kg greater weight loss for brief remote support and 1.5kg for face-to-face support). In addition, both groups maintained clinically meaningful reductions in weight up to one year significantly better than controls.

One of the most commonly cited justifications for developing and evaluating DBCIs is reducing health care and delivery costs (Griffiths, Lindenmeyer, Powell, Lowe, & Thorogood, 2006). Although DBCIs for weight management may have small to moderate effect sizes in changing dietary or physical activity behaviour, such interventions are likely to involve fewer costs to maintain compared to interventions that require regular contact with health care professionals. Thus, their relatively low delivery cost could result in them being highly cost-effective obesity treatments. However, the development of DBCIs require evidence and theory to maximise the possibility of their effectiveness. Moreover, it is important to ensure rigorous evaluation standards are put in place to be able to draw definitive conclusions about effectiveness and cost-effectiveness of both existing and novel digital behaviour change interventions (Michie et al., 2017).

2.4. The use of theory and evidence in intervention development.

Many health behaviour change interventions have not been optimally effective or fail to lead to expected changes in health-related behaviour in the target population. In order to effectively facilitate changes in behaviour a good understanding of the target behaviour, the context in which it occurs, and how the intervention brings about change, is required. This has led to intervention developers advocating the use of evidence-based practice and highlighting the utility of social psychological theory to inform intervention development (e.g., Bartholomew, Parcel, Kok, Gottlieb, & Fernandez, 2011; Michie, Johnston, Francis, Hardeman, & Eccles, 2008). The Medical Research Council (MRC) in the UK has published guidance for developing and evaluating complex interventions, which emphasizes that interventions should be described comprehensively and that mechanisms by which they work should be made explicit throughout the development. This guidance suggests starting by identifying the best available evidence and appropriate theory as an integral step to developing an effective intervention, before progressing to modelling of intended behaviour change processes and outcomes and then an experimental evaluation phase (Craig et al., 2013). Despite this, interventions are often developed without extensive use of theory (or reference to theory). One meta-analysis of 190 health behaviour change interventions focussed on diet and physical activity found that only 56% (107 interventions) explicitly reported that they were based on theory (Prestwich et al., 2014)

Theories of behaviour are plentiful, and it is important to identify the most appropriate theory for the target behaviour, as well as the delivery context and population of interest to enhance effectiveness. A systematic review of 85 internet-based health behaviour change interventions (including smoking, alcohol consumption, physical activity, and diet; Webb, Joseph, Yardley, & Michie, 2010) found that the most frequently used theories were social cognitive theory (SCT; Bandura, 1998), the transtheoretical model (TTM; Prochaska & DiClemente, 1983), and the theory of planned behaviour (TPB; Ajzen, 1991). This finding is in line with a recent systematic review of reviews on self-directed weight management interventions (Tang et al., 2014). Meta-regression analyses indicated that more extensive use of theory is significantly associated with larger effect sizes for behaviour change ($\beta = 0.22$). Interventions based on the TPB were associated with larger effects on health behaviour change (weighted average effect size $d_+ = 0.36$) than interventions based on the TTM ($d_+ = 0.20$) or the SCT ($d_+ = 0.15$; Webb et al., 2010). However, a separate meta-analysis including 107 interventions indicated that health behaviour interventions based on the SCT and TTM were no more effective than interventions that did not report a theory base (Prestwich et al., 2014).

According to the TPB, behaviour is determined by the individual's intention (e.g., the stronger the intention to eat healthily, the more likely it is that the individual will do this). These intentions, in turn, are proposed to be a function of the individual's attitudes toward the behaviour, social or subjective norms, and perceived behavioural control. Thus, the TPB proposes that an individual will intend to perform a behaviour (such as eating healthily) if they: (1) regard the outcome of the behaviour as favourable (*positive* attitude), (2) perceive social pressures to perform the behaviour (subjective norm), and finally, (3) believe they have control over the performance of the behaviour (perceived behavioural control). These antecedents are able to influence behaviour via their effects on a person's intention. Perceived behavioural control is also proposed to directly influence behaviour, in other words, the successful performance of a behaviour is likely to depend on actual control over the various factors that influence the performance of the behaviour in isolation from the motivational factors reflected by behavioural intentions (Fishbein & Ajzen, 2010).

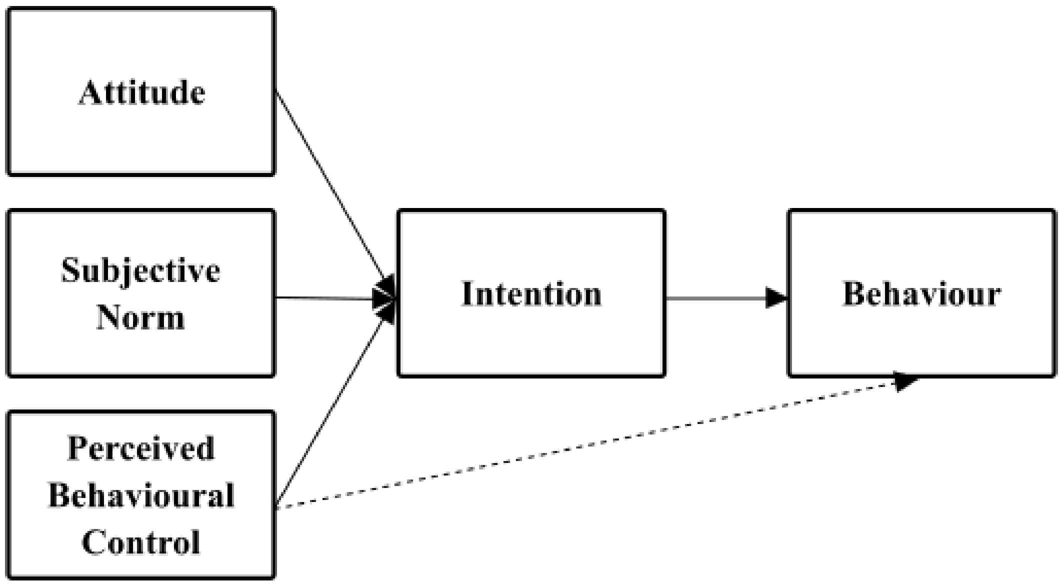

Figure 2.2 Theory of Planned Behaviour

However, an intention to change does not necessarily guarantee a change in behaviour. A meta-analysis investigating the predictive potential of the TPB including 237 independent prospective studies, found the TPB to explain 44% of the variance in intention, but only 19% of the variance in behaviour (although dietary behaviour was better predicted, 21.2%; McEachan, Conner, Taylor, & Lawton, 2011). In addition, Webb and Sheeran (2006) conducted a meta-analysis of 47 studies. This indicated that, although interventions are able to induce medium-to-large changes in intention (d = 0.66) this only translates into small-to-medium changes in target behaviour (d = 0.36).

This discrepancy between what people intend to do and their actual behaviour, is often referred to as the intention-behaviour gap (Orbell & Sheeran, 1998).

The intention-behaviour gap is thought to be, in part, due to the principle focus of TPB, and other dominant theories of health behaviour (e.g.,Bandura, 1998; Prochaska & DiClemente, 1983) on conscious (e.g., deliberative, reflective, reasoned, and slow) processes. This excludes a consideration of the influence of non-conscious (e.g., implicit, impulsive, automatic, and fast) processes on behaviour (Sheeran et al., 2013). A recent systematic review including 52 independent, cross-sectional and prospective studies, conducted with young adults, indicated that non-conscious processes were associated with physical activity behaviour (d = 0.67). The review also found that these effects are distinct from the impact of conscious processes as associations remained significant after accounting for these processes in 13 of 15 studies (Rebar et al., 2016)

As mentioned above, it is important to select a theoretical framework appropriate to the context, population of interest, and behavioural domain for intervention development. Weight management interventions typically target behavioural change through strategies such as goal setting, problem-solving, exploring motivations, changing explicit beliefs and expectations, and instructions on using self-regulation skills such as self-monitoring (Sniehotta, Scholz, & Schwarzer, 2005; Tang et al., 2014; Teixeira, Going, Sardinha, & Lohman, 2005; Teixeira et al., 2015). However, as eating behaviour is heavily influenced by habit, automatic or impulsive behaviour, or emotions, drawing on theories that focus on reflective thought processes alone may therefore not be the most effective approach.

2.4.1. Dual-process approaches to health behaviour

A more appropriate theoretical base for a weight management intervention focussed on eating behaviour may be found in the more recently proposed, dual-process approaches to explaining and predicting health behaviour (Friese, Hofmann, & Wiers, 2011; Gerrard, Gibbons, Houlihan, Stock, & Pomery, 2008; Hofmann, Friese, & Wiers, 2008). Dual-process models have contrasted conscious, slow, deliberative, controlled processes with automatic, fast, impulsive and non-conscious processes, which shape our everyday behaviour patterns. Such approaches (e.g., the Reflective-Impulsive Model; Strack & Deutsch, 2004) describe the interaction between these two qualitatively different systems. More specifically, they describe how behaviour, including eating, can be initiated automatically by situational cues with little conscious deliberation.

Impulsive processing transpires automatically through progressive activation of associative neuronal clusters which link perception, reward anticipation, and learned motor responses to generate established behaviour patterns. On encounter of situational cues, the associated behaviour patterns are triggered (Impulsive System). For example, the sight of a coffee buffet during a conference break leads delegates to pick up a cup and saucer, fill it with coffee or tea, and grab a biscuit to enjoy with their drink without any conscious thought about their health goals. Attitudes, behavioural norms, or self-efficacy. Perhaps a delegate has frequented multiple conferences where they have followed suit of the other delegates and has therefore had coffee with a biscuit in this situation on more than one occasion. Thus, at this point, the mere situational cue of a coffee break at a conference can trigger these consumption behaviours, even if the delegate doesn't consume biscuits with a hot drink in other situations (e.g., in the office, or at home). The reflective processes, in contrast, constitute effortful deliberative processing which requires cognitive resources to operate (i.e., making a conscious decision; Reflective System). For example, the delegate may be able to consciously decide not to have a biscuit, thus overriding (or inhibiting) the impulsively activated behaviour. Thus, the reflective and impulsive system can interact.

The way these processes operate are thought to have a great impact on successful self-regulation(Hofmann, Friese, & Strack, 2009; Hofmann et al., 2008; Marteau et al., 2012; Sheeran et al., 2013). In some situations, a conscious goal behaviour may differ from a behaviour that is impulsively triggered by a particular situation. This can result in a “tug-of-war” between the impulsive and reflective system over which behaviour to enact. Following the tug-of-war analogy, there are situational and dispositional boundary conditions that determine whether one system gains activation over and above the other system (Hofmann, Friese, & Strack, 2009). The reflective system is more likely to win in situations where the necessary cognitive capacity and motivation to exert control is available. However, the impulsive system is more likely to win when there is a strong deprivation of needs (e.g., hunger) or when strong affective reactions trigger the motivational drive to indulge in unhealthy foods. In this dual-process approach, impulsive control of behaviour, or a behavioural impulse, is a behaviour schema that has been activated in the associative network and is acted upon unless actively suppressed by the conscious activation of the higher-level goal-oriented reflective system.

As the impulsive system relies on associations that have been formed and strengthened through repeated simultaneous experiences of external stimuli, behavioural responses, and the resulting affective reactions, it is generally reward-driven. Thus, although someone may have a higher order goal of regulating their eating behaviour and reducing their calorific intake, their impulses might get in the way of that goal and direct their behaviour towards eating the unhealthy high palatable foods. Illustrative of this, restrained eaters (who are more likely to fail in attempts to manage their weight) have been shown to exhibit a dissociative pattern of negative explicit attitudes and positive implicit attitudes towards high calorie content when hungry (Hoefling & Strack, 2008). The conscious sensation of the internal struggle that arises when impulsive processes interfere with competing long-term goals, is what defines a temptation and is often considered to be a tug-of-war between impulses and self-control. In this “age of plenty” where an enormous variety of food is available and aggressively marketed 24/7, our impulsive and conscious control systems are in a constant tug-of-war, and as far as eating behaviour is concerned, the impulsive system seems to be winning (Kessler, 2009).

Thus, one way to explain the high prevalence of obesity, is that many people do not have sufficient conscious control over their eating behaviour (Moldovan & David, 2012). The mere presence of food is able to trigger overeating (Coelho, Jansen, Roefs, & Nederkoorn, 2009; Fedoroff, Polivy, & Herman, 2003; Nederkoorn, Smulders, & Jansen, 2000; Painter, Wansink, & Hieggelke, 2002; van Strien & Ouwens, 2003) and often people are not aware of how much they are eating (Diliberti, Bordi, Conklin, Roe, & Rolls, 2004; Rolls, Morris, & Roe, 2002). Moreover, impulsivity, the general tendency to act upon one’s impulses, has been associated with overeating, overweight and obesity (Guerrieri, Nederkoorn, & Jansen, 2007b; Nederkoorn, Braet, Van Eijs, Tanghe,

& Jansen, 2006; Nederkoorn, Guerrieri, Havermans, Roefs, & Jansen, 2009). It is important to note, that not every impulse is unhealthy (impulse to eat an orange), and not all goal-directed behaviours are healthy (eating-disorders). However, with regard to eating behaviour we can define an unhealthy impulse as one that results in overeating, or making unhealthy food choices (such as choosing the highly palatable high fat, high sugar, and high salt foods) which are associated with excessive energy intake. Thus, impulsive determinants of eating behaviour may be crucial factors in the prevalence of obesity.

The importance of accounting for the discrepancy between intended behaviour and impulsive behaviour has become a key focus of current health behaviour research, which suggests that modifying impulsive processes and reflective and reflective processes should both be considered (Hofmann, Friese, & Strack, 2009; Marteau et al., 2012; Sheeran et al., 2013). Thus, a weight loss intervention may be more effective if it takes into account the impulsive system as well as the reflective system, by incorporating techniques or strategies that keep unhealthy impulses from undermining long-term health goals.

2.5. Appropriate user involvement

As highlighted in the MRC framework, ‘appropriate’ users should be involved at all stages from development to outcome evaluation to increase the likelihood that more relevant science is conducted and implementable data are produced (Craig et al., 2008). User involvement is important in identifying and prioritising specific health and behavioural needs that are to be targeted by the intervention in the intended population. Moreover, such involvement can inform ways of minimising barriers and enhancing facilitators of engagement with the intervention itself. Engagement with a behavioural intervention is a precondition of effectiveness (Yardley et al., 2016), without engagement, a theory- and evidence-based intervention is either not delivered to, or implemented by, the user. Eliciting intended user perspectives on the intervention format, its content, and the use of the included behaviour change techniques using qualitative methods such as those used in “usability testing” of human computer interactions (Lin, Choong, & Salvendy, 1997) can help identify potential problems of low uptake and adherence (Kohl, Crutzen, & Vries, 2013) and ways to overcome them.

2.6. Conclusions

In the context of the global overweight and obesity epidemic and its' associated burden of chronic illnesses, effective and cost-effective treatment to support weight loss is vital. In particular, the role of excessive energy intake is a crucial concern. Behavioural weight management interventions including digital behaviour change interventions may be effective, but development should be guided by appropriate theory and evidence for the context, target population, and behaviour of interest. Given the impact of impulsive processes on eating behaviour and taking into account the accessibility and relatively low cost of digital behaviour change technology, a self-directed weight management intervention focussed on helping individuals to modify or manage disruptive impulses, could have a substantial public health impact.

Chapter 3. Modifying or managing impulsive processes to facilitate eating behaviour change for weight loss.

3.1. Introduction

The MRC guidance for developing and evaluating complex interventions provides advice for researchers on choosing appropriate methods and ensuring appropriate reporting at each stage in the development, evaluation and implementation of interventions (Craig et al., 2013). The first stage of the iterative process is the intervention development (See Figure 3.1).

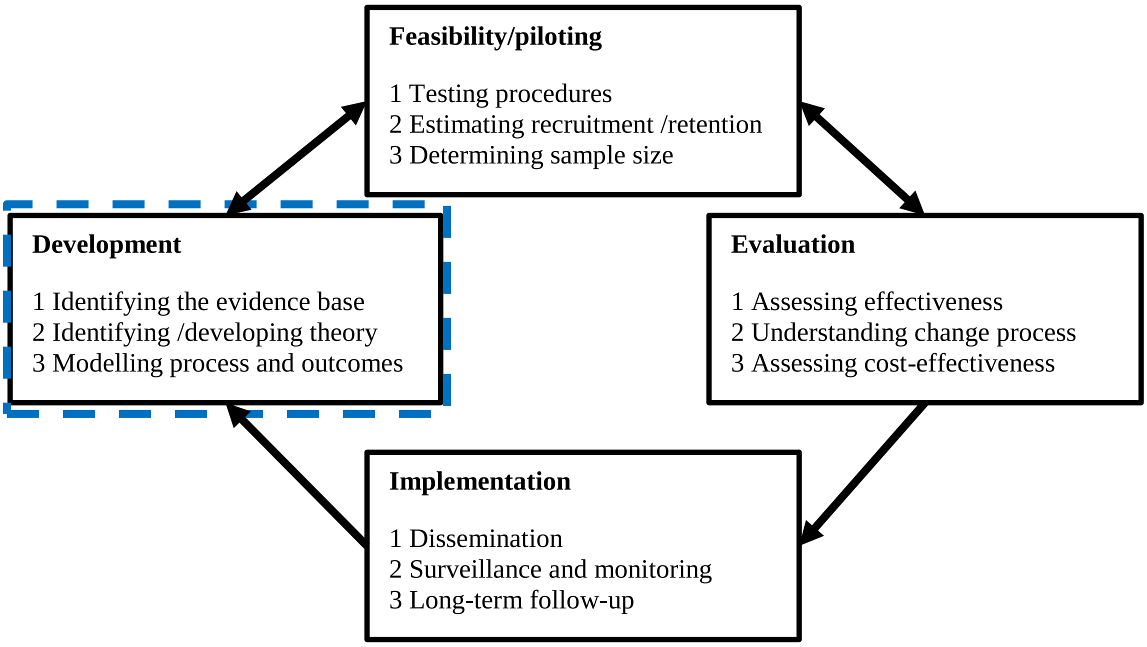

Figure 3.1 Corresponding phase in the key elements of the development and evaluation process, adapted from (Craig et al., 2013).

The guidance states that best practice is to employ a systematic approach, making use of the best available evidence and appropriate theory. The emergence of dual-process models and the increased recognition of the impact of impulsive processes in hindering successful behaviour change (which forms the theory base of the intervention developed during this doctoral programme and has been reviewed in Chapter 2) has led to growing research not only examining the mechanisms by which impulsive processes affect behaviour, but also developing and evaluating techniques to manage such processes to facilitate behaviour change (impulse management techniques). No comprehensive overview of the evidence on available techniques was available to draw from when development began. Initially, due to the relatively recent emergence of dual-process approaches to health behaviours it was thought that a complete overview of the literature might be necessary. Thus, literature was gathered on alcohol consumption, smoking, and drug use, in addition to eating behaviour to critically evaluate evidence on change techniques targeting impulsive processes, because of the potential transferability of such techniques. However, initial searches suggested that there was sufficient literature to warrant focussing specifically on eating behaviour.

This chapter therefore presents the first piece of empirical work in this thesis, which comprises a systematic review. This was conducted to answer the research question "*How could impulsive processes be modified or otherwise managed to support healthier eating and/or weight loss"* and to provide an overview of the available evidence, which can help to inform the development of a weight management intervention. The following text comprises mainly text published in *Health Psychology* (van Beurden, Greaves, Smith, & Abraham, 2016), but has been modified to minimise repetition.

3.2. Objectives

The key objectives for this systematic review were to; (i) identify and categorise the range of individual-level change techniques that have been used to modify or manage impulsive processes associated with unhealthy eating behaviour, (ii) describe the mechanisms targeted by such techniques, and (iii) summarise available evidence on the effectiveness of these techniques.

3.3. Methods

3.3.1. Inclusion and exclusion criteria

Included studies were: (a) Primary reports of experimental studies with or without a comparator group, evaluating the effectiveness of an intervention, technique or practical strategy that individuals could use to modify-impulsive processes regulating eating behaviour; (b) Conducted exclusively with adults (defined as aged 18 or older); (c) Published in peer-reviewed journals in English from 1993 onwards. Articles were excluded if they: (a) involved pharmacological, physical (e.g., acupuncture) or neurophysiological therapies (e.g., cortical stimulation); (b) contained a protocol only; (c) targeted multiple or other behavioural problems, including consumption of alcohol or drug abuse; (d) focused on eating disorders; or (e) only involved case reports.

3.3.2. Data sources and search strategy

We searched the electronic databases MEDLINE, PsycINFO, CINAHL, AMED, Web of Science in September 2014, using a comprehensive search strategy (See Appendix 1). Searches of titles, abstracts and keywords used key terms such as (impulse OR self-control OR temptation) AND (techniques OR intervention) AND (eating OR food). The terms were reviewed by several authors (SvB, JS, CG) and revised iteratively to ensure comprehensive coverage of the targeted literature. The reference lists of eligible studies were scanned for further records potentially meeting inclusion criteria.

3.3.3. Study selection

The titles and abstracts of identified papers were assessed independently by two researchers in relation to our inclusion and exclusion criteria. Full-texts were obtained for relevant articles, and all were assessed by at least two researchers (SvB, JS, CG). Inter-rater agreement on inclusion at both stages was assessed using prevalence and bias adjusted kappa (PABAK) statistics and any disagreements were resolved through discussion.

3.3.4. Data extraction

Data were systematically extracted on study level characteristics such as design, country of origin, recruitment method, and participant characteristics. Further extraction comprised: technique(s) under evaluation, mode of technique delivery, comparison group, follow-up period and retention, proposed underlying mechanism, and outcomes (see below), as well as the authors' interpretation of their findings.

3.3.5. Outcomes

Data were extracted on outcomes associated with impulsive processes (e.g., changes in attentional bias, cravings, approach/avoidance tendencies), as well as weight and behavioural outcomes such as food consumption and food choice.

3.3.6. Quality assessment

Due to the wide heterogeneity of study designs, no single quality assessment tool was deemed suitable. Therefore, study quality was assessed against potential sources of bias identified by the Cochrane Handbook for Systematic Reviews of Interventions (Higgins, Altman, & Sterne, 2011) for a wide range of study designs. These included whether there was potential for: (a) analytical bias (e.g., was the sample size adequate to detect the intended effects as evidenced by a credible a priori power calculation?); (b) sampling bias (e.g., was the sample representative of the general population or limited to particular sub-groups?); (c) selection bias (e.g., was randomisation used, were groups similar at baseline, and if not was this controlled for in analyses?); or (d) measurement bias (e.g., was evidence presented for the reliability and validity of measures? Were outcome measures objective or self-reported?). A small sample is defined here as less than 60 people per group, which is the number needed to have an 80% chance of detecting a SMD of 0.5 (i.e., a medium effect size) with $p<0.05$, and a very small sample as less than 30 per group. Overall study quality was not quantified due to the different methodological issues pertaining to different study designs. Instead, the quality assessment was used to (a) highlight potential sources of bias for each study and (b) identify areas of improvement for future research.

3.3.7. Analysis

Due to the heterogeneous nature of the study designs, intervention techniques, outcomes, and populations involved, a quantitative meta-analysis was not undertaken. Instead, a systematic narrative synthesis (Popay et al., 2006) was used to define and categorise the identified techniques according to the targeted mechanisms of action. Outcomes data and study design characteristics were systematically collated. Evidence for effectiveness within each technique category was narratively synthesised and categorised according to criteria relating to type, quantity and quality of available studies (Table 3.1).

Table 3.1 Criteria used to synthesise and categorise the evidence base

Evidence categorisation	**Criteria**
Promising findings (or ‘evidence against’ if evidence is negative).	At least one larger randomised study (>60 per group), OR 3 or more small (but not very small) randomised studies PLUS the majority (80%) of the studies showing significant differences in the same direction.
Mixed evidence	At least one larger randomised study (>60 per group), or 3 or more small (but not very small) randomised studies showing evidence in either direction.
Insufficient evidence	All small (less than 3) or very small studies OR no randomised studies

3.4. Results

The searches identified 4619 articles, with six further articles obtained from reference lists and experts. After title and abstract screening, 156 full-texts were reviewed and 66 articles (identified with an asterisk in the reference list) describing 92 unique studies that evaluated at least one technique for modifying or managing eating-related impulses were included (See Figure 3.2). The reviewers agreed on selection decisions for 98% of titles and abstracts (PABAK = 0.95), and 87% of the full-texts (PABAK =0.74).

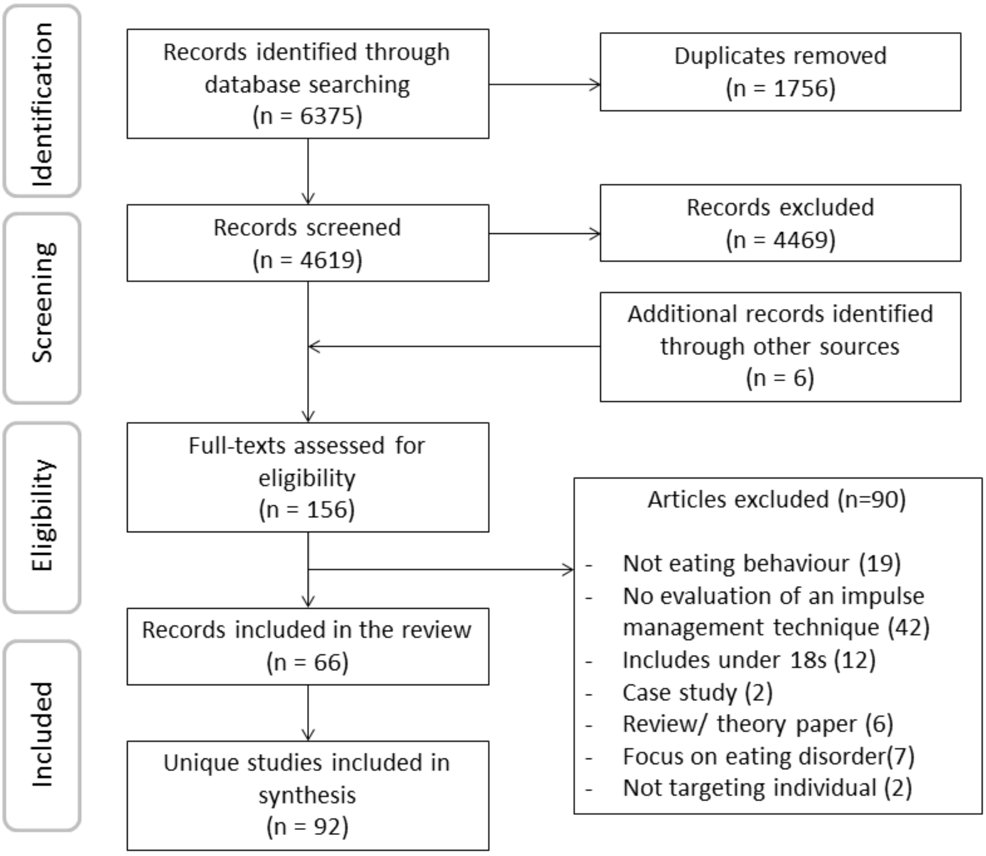

Figure 3.2 Study selection flowchart

3.4.1. Study and sample characteristics

The characteristics of the 92 included studies and justifications for the 90 excluded articles are summarised in Table 3.2 and Appendix 2References and justification code for excluded articles at full text screening. Most studies (85%) were conducted in the Netherlands (24), the US (21), Australia (17), and the UK (16). The studies covered a range of populations (e.g., general population, restrained eaters, overweight and obese people), however, most samples comprised University staff and/or students (70) with some targeting particular groups of students such as chocolate cravers, and regular snackers. In most studies, women comprised either all (34) or the majority of the sample (42), with only six having a majority of men (See Table 3.2).

3.4.1.1. Study type and quality

Study designs included randomised controlled trials (RCTs) (43), factorial experiments (18), non-randomised controlled trials (16) and an uncontrolled (pre-post) study (1) (See Table 3.3). The majority were conducted in a laboratory or classroom (71), with the remainder being community (18) or internet-based (3). The methodological quality of the 92 studies was generally weak with a high prevalence of potentially serious biases. The most common weaknesses were lack of randomisation (28), sampling bias (70 student-only, 34 female-only), and potentially inadequate statistical power /sample size (87) See Appendix 3 for detailed study information.

3.4.1.2. Outcomes and follow-up periods

A large variety of outcomes were measured (See Table 3.2 and Table 3.3) including weight (4), food consumption (23), craving (23), automatic evaluations (implicit associations about the pleasantness or unpleasantness of food items) (3), delay discounting (2), and attentional bias (3). For food consumption, 19 of 23 studies objectively observed consumption through use of taste tests, ad libitum snacking, or marked sweets that were taken home and returned the following day. The majority (72) of the studies only measured outcomes post-treatment, with other follow-up periods ranging from five minutes (3) to six months (3).

3.4.2. Identification and categorisation of techniques and mechanisms.

The review identified 17 distinct techniques, which were categorised into three groups according to their targeted mechanisms as articulated by authors (See Table 3.3). First, techniques that target the impulsive system directly by attempting to modify the generation or strength of impulses triggered by specific stimuli (n=6), hereafter referred to as impulse-focused techniques. Second, techniques which aim to engage the reflective system or cognitive resources in identifying and suppressing or otherwise managing urges or cravings before they are acted on (n=9), hereafter referred to as reflective techniques. Third, techniques where the mechanism was unstated or unclear (n=2).

Table 3.2 Study Characteristics of Included Studies

Study	Origin	Study Aim	Setting	Population	% Female	Age range/ Statistic	Key Outcomes
Achtziger et al. (2008) Study 1	UK	To investigate whether specifying the negative inner state of craving for high-fat food in the if-component of an implementation intention and linking it to an ignore response can protect striving toward the goal of eating healthily	Lab	University students	80.4	M=19.5 SD=3.8	Self-reported food consumption
Alberts et al. (2010)	NL	To test whether food cravings can be reduced by training in acceptance-based regulation	Community	Participants of a community-based weight loss program	89.5	M= 51.9 SD=12.8 28-74	Self-reported craving
Alberts et al. (2012)	NL	To explore the efficacy of a mindfulness-based intervention for problematic eating behaviour.	Community	Patients with problematic eating	100	M=48.5 18-65	BMI & Self-reported craving & Eating Behaviour
Alberts et al. (2013) Study 1	NL	To explore the short-term effect of acceptance-based coping on the intensity of food cravings	Lab	University students	80.0	M=21.4 SD=2.7 19-33	Self-reported craving
Andrade et al. (2012) Study 1A	UK	To investigate the effects of the clay-modelling task used by Stuart et al. (2006) to reduce trauma imagery, on craving and compare with other tasks that match the general resource loads of the clay-modelling task	Lab	University staff and students	69.8	M=30 18-70	Self-reported chocolate craving

Study	Origin	Study Aim	Setting	Population	% Female	Age range/ Statistic	Key Outcomes
Andrade et al. (2012) Study 2	UK	To investigate the effects of the clay-modelling task on craving and compare with other tasks that involve similar resource loads	Lab	University staff and students	85.1	M=22.7 18-49	Self-reported craving
Buckland et al. (2013)	UK	To examine the effect of a diet-congruent food cue on energy intake in restrained dieters who are also dieting to lose weight and unrestrained non-dieters, compared to exposure to a tempting food cue	Lab	University students with BMI between 18.5 and 40	100	Unrestrained non-dieters M= 27.7 SD=2.1 Restrained dieters M=24 SD= 2.5 18-55	Observed snack food consumption & Chocolate consumption
Coelho et al. (2009a)	Canada	To examine effects of exposure to a high-calorie food on eating behaviour in restrained and unrestrained eaters	Lab	University Students	100	Not reported	Observed cookie & chocolate cookie consumption
Daniel et al. (2013)	US	To assess whether episodic future thinking, compared with engagement in a control imagery task, reduces impulsivity and energy intake in overweight and obese individuals	Lab	Overweight and obese women	N/A	M=26.4 SD=5.7	Delay-discounting & Observed snack food consumption
Erskine et al. (2010)	UK	To examine whether the effects of thought suppression on subsequent eating behaviour would interact with participants' restrained eating status	Lab	University students	100	M=22.6 SD=6.4	Observed food consumption

Study	Origin	Study Aim	Setting	Population	% Female	Age range/ Statistic	Key Outcomes
Erskine et al. (2008)	UK	To investigate the effects of thought suppression, expression or verbalisation on subsequent chocolate eating behaviour	Lab	University students	50.0	M=22.6 SD=5.2	Observed chocolate consumption
Forman et al. (2007)	US	To compare an acceptance-based strategy to a distraction-based strategy for coping with food cravings	Community	University students with a liking for chocolate	48.0	M=19.6 SD=1.7 18-60	Self-reported craving & Observed chocolate consumption
Forman et al. (2009)	US	To test the preliminary feasibility, acceptability, effectiveness, and possible mechanisms of action of a behavioural treatment that was modified to incorporate components that (a) bolster participants' commitment to behaviour change, (b) build distress-tolerance skills, and (c) promote mindful awareness of eating behaviours and goals.	Community	University and Medical center staff with BMI +25 kg/m2	100	M=43.7 SD=9.8 23-58	Height and weight & Disinhibition, restraint, and emotional eating.
Forman et al. (2013a)	US	To evaluate the feasibility and acceptability of a full-scale trial of acceptance-based behavioural treatment (ABT) for obesity and its short- and moderate-term effectiveness relative to standard behavioural treatment	Community	Overweight and obese people	not reported	M=45.7 SD=12.8 21-65	Weight & Height
Forman et al. (2013b)	US	(1) To compare the efficacy of two cognitive-behavioural intervention strategies and (2) examine, in an overweight sample, the relationship between psychological traits, cravings and food consumption	Community	Overweight and obese women with a liking for sweets	100	M=32.5 SD=13.5 18-59	Self-reported Craving & Self-reported sweet consumption & Observed sweet consumption

Study	Origin	Study Aim	Setting	Population	% Female	Age range/ Statistic	Key Outcomes
Geyskens et al. (2008) Study 1	Belgium	To test whether prior exposure to non-actionable as well as actionable food temptations results in the activation of food restriction goals, as compared to the absence of prior temptations	Lab	University students	100	18-25	Diet-goal activation
Geyskens et al. (2008) Study 2	Belgium	To explore the role of 'actionability' in the activation of eating goals in tempting situations	Lab	University students	100	18-26	Eating-goal activation
Geyskens et al. (2008) Study 3B	Belgium	To test the effects of food temptations, differing in 'actionability', on' subsequent food intake	Lab	University students	100	18-26	Observed snack consumption
Geyskens et al. (2010)	Belgium	To investigate whether exposure to tempting food subsequently directs attention towards or away from food cues, comparing the effects of exposure to non-actionable versus actionable food temptations.	Lab	University students	100	M=20.10 SD=1.92	Attention processing
Giuliani et al. (2013)	US	To investigate whether cognitive reappraisal decreases self-reported desire, and is meaningfully related to validated measures of daily self-regulation of eating	Lab	Not reported	65.9	M=19.8 SD=3.5	Self-reported specific food craving
Guerrieri et al. (2012)	NL	To examine their effects of inducing impulsivity and inhibition on subsequent food intake	Lab	University students: normal weight females	100	M=21.4 SD=2.1	Observed snack food consumption

Study	Origin	Study Aim	Setting	Population	% Female	Age range/ Statistic	Key Outcomes
Hamilton et al. (2013)	UK	To examine whether body scanning and guided imagery are able to reduce food cravings	Lab	University students	76.5	M=20 18-45	Self-reported craving
Hardman et al. (2013)	UK	To examine the effect of experimentally manipulated food-related attentional bias on hunger and food intake	Lab	University students	58.3	M=23.2 SD=8.8	Self-reported appetite & Observed calorie intake
Hare et al. (2011)	US	Assess whether attention manipulations could be used to improve decision-making where self-control lapses are pervasive, in particular to whether direct attention to the healthiness of foods could improve dietary choices	Lab	Healthy non-dieting individuals	69.7	M=24.8 SD=5.1	Dietary choices
Harvey et al. (2005)	Australia	To explore the imaginal basis of food craving. Predicting that performing a visual imagery task would reduce elicited food craving	Lab	University students	100	M=21 SD=3.9 18-35	Self-reported craving
Hendrickson & Rasmussen (2013) Study 2	US	To test whether a mindful eating strategy changes impulsive discounting patterns for food	Lab	University students	71.6	M=25.5 SD=8.6	Delay-discounting
Hofmann et al. (2010) Study 1	Germany	To investigate the effects of cognitive transformation of a food object on its automatic evaluation	Lab	University students	79.0	M=23.8 SD=5.6	Implicit evaluations & Explicit attitudes

Study	Origin	Study Aim	Setting	Population	% Female	Age range/ Statistic	Key Outcomes
Hofmann et al. (2010) Study 2	Germany	(1) To investigate whether cognitive transformation works with the superordinate category of chocolate without any reference to specific brands (2) To investigate the effects of cognitive response control in the form of implementation intentions to refrain from consumption	Internet	People interested in their implicit attitudes	70.9	M=35.6 SD=11.5	Implicit evaluations & Explicit attitudes
Hong and Lee (2008) Study 2	US	To examine the effect of regulatory fit on willpower to resist temptation	Community	University students	70.3	not reported	Snack choice
Hong and Lee (2008) Study 3	US	To examine the effects of regulatory fit in a consumer-relevant context and examine how individuals choose goal pursuit strategies	Community	University students	32.4	not reported	Snack choice
Hooper et al. (2012)	Cyprus	To compare the effects of a short instruction in defusion versus suppression for food cravings on eating behaviour.	Community	University students	59.3	M=21.4 SD=4.3	Self-reported chocolate consumption & Observed chocolate consumption
Houben (2011)	NL	To examine whether increasing or decreasing inhibitory control respectively decreases or increases food intake relative to a control condition	Lab	University students with a liking for the study foods	100	M=21.5 SD=1.8	Observed snack food consumption
Houben & Jansen (2011)	NL	To examine whether practicing inhibition of food related responses reduces food intake relative to a control condition	Lab	University students: chocolate cravers	100	M=20.1 SD= 2.3	Observed chocolate consumption

Study	Origin	Study Aim	Setting	Population	% Female	Age range/ Statistic	Key Outcomes
Jenkins & Tapper (2014)	UK	To examine the effect of two mindfulness-based strategies, cognitive defusion and acceptance, on ability to resist chocolate over a 5 day period	Community	University students	71.5	M=20.5 SD=2.4	Observed chocolate consumption; self-reported chocolate consumption & behavioural rebound chocolate consumption
Johnston et al. (1999)	New Zealand	To investigate whether thought suppression results in a subsequent increase in the performance of behaviours related to those thoughts	Lab	Community sample	100	not reported	Task performance to receive chocolate
Jordan et al. (2014) Study 3	US	To examine the effect of induced state mindfulness on consumption behaviour and food choices	Lab	University students	50.0	M=19.8	Observed calorie consumption
Kemps & Tiggemann (2007) Study 2	Australia	To assess the effects of visual and olfactory imagery on cravings for chocolate	Lab	University students with a liking for chocolate	100	M=21.2 SD=2.9 18-35	Self-reported craving
Kemps & Tiggemann (2007) Study 3	Australia	To assess the effects of a craving induction procedure that does not rely on imagery on chocolate cravings	Lab	University students with a liking for chocolate	100	M=20.8 SD=3.8 18-35	Self-reported craving
Kemps & Tiggemann (2013a)	Australia	To investigate the effect of dynamic visual noise on everyday food craving and consumption following craving	Community	University students with frequent food cravings	100	M=21.3 SD=2.4 18-29	Self-reported craving & Self-reported consumption

Study	Origin	Study Aim	Setting	Population	% Female	Age range/ Statistic	Key Outcomes
Kemps & Tiggemann (2013b) Experiment 1	Australia	To investigate the effect of smelling an odour on food craving reductions	Lab	University students	100	M=22.2 SD=3.6 18-34	Self-reported craving
Kemps & Tiggeman (2013b) Experiment 2	Australia	To replicate craving reduction effect of odour smelling, on cravings for chocolate	Lab	University students with a liking for chocolate	100	M=21.0 SD=3.2 18-30	Self-reported chocolate craving
Kemps et al. (2004) Experiment 1	Australia	To test whether concurrent visuospatial tasks can reduce the vividness of food related images by competing for processing capacity in the visuospatial sketch pad, and in so doing, reduce the intensity of the associated craving	Lab	University students: dieting and non-dieting	100	M=21.5 SD=0.6 18-35	Self-reported craving
Kemps et al. (2004) Experiment 2	Australia	To test whether concurrent visuospatial tasks can reduce the vividness of self-generated images by competing for processing capacity in the visuospatial sketch pad, and in so doing, reduce the intensity of the associated craving	Lab	University students: dieting and non-dieting	100	M=22.0 SD=3.7 18-33	Self-reported craving
Kemps et al. (2005)	Australia	To investigate whether frequent and intense cravings for highly palatable and potentially addictive foods (chocolate) would be responsive to concurrent visuo-spatial processing	Lab	University students with and without cravings for chocolate	100	M=20.9 SD=4.1 18-35	Self-reported chocolate craving

Study	Origin	Study Aim	Setting	Population	% Female	Age range/ Statistic	Key Outcomes
Kemps et al. (2008)	Australia	To investigate the relative effectiveness of thought suppression and the working memory-based method of dynamic visual noise as craving reduction techniques in a community sample of overweight women following a prescribed weight-loss diet	Lab	Dieters and non-dieters	100	not reported 20-57	Self-reported craving
Kemps et al. (2012)	Australia	To compare the relative effectiveness of simple, commercially available food and non-food olfactory tasks on chocolate cravings	Lab	University students with a liking for chocolate	100	M=21.1 SD=4.1 18-35	Self-reported chocolate craving
Kemps et al. (2013) Experiment 2	Australia	To assess the effects of a modified implicit association task on approach /avoidance associations with regard to a craved food	Lab	University students with a liking for chocolate	100	M=20.5 SD=1.8 18-25	Self-reported chocolate craving
Kemps et al. (2014) Experiment 1	Australia	To examine whether attentional bias modification in relation to chocolate is possible and whether this has an effect on chocolate consumption and craving	lab	University students	100	M=20.4 SD=2.2 18-26	Attentional bias & Observed chocolate consumption & Self-reported chocolate craving
Knauper et al. (2011)	Canada	To test whether competing imagery can reduce the intensity of naturally occurring cravings	Community	University students with frequent food cravings	75.8	M=21.8 SD=3.1 18-38	Self-reported craving & Self-reported craving induced eating episodes & Self-reported consumption
Kroese et al. (2009) Study 1	NL	To test the effect of food temptations on importance of weight watching goals.	Lab	University students	100	M=24.4 SD=7.0	Goal-importance

Study	Origin	Study Aim	Setting	Population	% Female	Age range/ Statistic	Key Outcomes
Kroese et al. (2009) Study 2	NL	To test whether the effect of temptation exposure translates into goal intentions and healthy eating behaviour	Lab	University students	100	M=21.2 SD=2.6	Goal intention & Snack choice
Kroese et al. (2013) Study 1	NL	To test the indirect effect of temptation strength on consumption through perceived unhealthiness	Lab	University	100	M=22.6 SD=4.3	Observed food consumption
Laran (2010) Study 1	US	To investigate the influence of temporal distance on self-control decisions when primed with self-control of indulgence	lab	University students	48.1	not reported	Snack choice
Laran (2010) Study 2	US	To investigate the influence of temporal distance on self-control decisions when primed with self-control of indulgence	lab	University students	55.2	not reported	Snack choice & Information accessibility
Laurin et al. (2012) Study 3	Canada	To test whether reminding people of God increases temptation resistance	Lab	University students	74.0	M=20.3	Implicit evaluations
Laurin et al. (2012) Study 4	Canada	To test whether reminding people of God increases temptation resistance	Lab	University students	65.0	M=18.5	Observed cookie consumption
Magaraggia et al. (2013)	Australia	To determine the effects ofan autonomous choice learning condition on snacking on a glucose-rich food (jellybeans) compared with a controlled choice learning condition	Lab	University students	43.9	M=21.0 SD=2.9	Observed snack food consumption & Subsequent self-regulation task

Study	Origin	Study Aim	Setting	Population	% Female	Age range/ Statistic	Key Outcomes
May et al. (2010) Study 1	UK	To compare a mindfulness-based approach to unwanted food thoughts (Breath Focus) against two natural responses which either emphasise not having the thoughts at all (Thought Suppression) or diverting attention away from them when they do occur (Imagery Diversion)	Lab	University students	81.3	M=21.8	Self-reported craving
May et al. (2010) Study 2	UK	The test the effects of a Body Scan instruction against Guided Imagery and Control instructions, on intrusive thoughts.	Lab	University students	63.3	M=20.9	Self-reported craving
Moffitt et al. (2012)	Australia	To compare restructuring and defusion as cognitive strategies for resisting a craved food	Community	Chocolate cravers	85.5	M=46.2 SD=14.6 18-82	Self-reported craving & Observed chocolate consumption & Self-reported chocolate consumption
Oh & Taylor (2012)	UK	(1) To examine if a short bout of moderate intensity exercise could reduce ad libitum chocolate consumption during breaks in a computer-based cognitive task. (2)To explore if these effects would be different for a low vs. high demanding task. (3) To explore if these effects vary depending on participants' tendency to be emotional or restrained eaters. (4) to see if changes in affect from pre to post-exercise mediated the effects of exercise on chocolate consumption	Community	Chocolate cravers	57.7	M=24.9 SD=8.2	Observed chocolate consumption

Study	Origin	Study Aim	Setting	Population	% Female	Age range/ Statistic	Key Outcomes
Oh & Taylor (2013)	UK	(1) To assess whether a 15-min. brisk walk, compared with passive rest, decreased attentional bias towards chocolate images and craving for chocolate. (2) To examine if the effects of exercise were moderated by weight, duration of abstinence, emotional eating tendencies and trait chocolate cravings	Lab	Individuals with weight concerns and abstaining from chocolate for Lent	100	normal weight M=23.9 SD =6.9 overweight M=38.1 SD=11.6 lent abstainers M=25.9 SD= 9.7 18-45	Self-reported craving & Attentional Bias (dot probe task)
Oh and Taylor (2014)	UK	To assess if a 15-min bout of moderate or vigorous exercise, compared with rest, reduces attention bias to smoking and snack food video clips, and also cravings for cigarettes and snack food, among temporarily abstinent smokers	lab	Temporarily abstinent smokers	65.2	M=23.9 SD=4.8 18-45	Attentional bias & Self-reported craving
Papies et al. (2012) Study 1	NL	To assess a mindful attention procedure that aims to prevent participants' approach bias to attractive food	Lab	University students	N/A	not reported	Approach bias
Papies et al. (2012) Study 2a	NL	To assess whether a mindful attention procedure that aims to prevent participants' approach bias to attractive food only has a short-term effect, or one that persists over a distraction period	Lab	University students	N/A	not reported	Approach bias

Study	Origin	Study Aim	Setting	Population	% Female	Age range/ Statistic	Key Outcomes
Papies et al. (2012) Study 2b	NL	To assess whether a mindful attention procedure reduces existing impulses or prevents their development	Lab	University students	N/A	not reported	Approach bias
Papies et al. (2012) Study 3	NL	To examine whether mindful attention reduces reactions to novel food stimuli, on which participants had not directly applied mindful attention during the training phase	Lab	University students	N/A	not reported	Approach bias
Patrick and Hagtvedt (2012) Study 1	US	To investigate the influence of a linguistic element of self-talk, framing (I don't vs I can't) on resisting temptation and motivating goal-directed behaviour	Lab	University students	N/A	not reported	Snack choice
Raska and Nichols (2012) Experiment 1	US	To examine whether exposure to images of people who represent companionate love would lead to greater likelihood for making a healthy snack choice than exposure to images of people who represent sexual love	Internet	University students	47.0	M=23.7	Snack choice
Raska and Nichols (2012) Experiment 2	US	To examine whether exposure to companionate love symbols would lead to greater likelihood for making a healthy snack choice than exposure to sexual love symbols	Internet	University students	61.0	M=25.0	Snack choice
Raska and Nichols (2012) Experiment 3	US	To replicate the finding that exposure to companionate love results in greater likelihood of choosing a healthy snack as compared to sexual love, with a snack choice made in a realistic setting	University classroom	University students	51.0	M=21.0	Snack choice

Study	Origin	Study Aim	Setting	Population	% Female	Age range/ Statistic	Key Outcomes
Rodriguez-Martin et al. (2013)	Cuba	To evaluate the effectiveness of a Self-help Manual for reducing: (a) food cravings trait; (b) the emotional and behavioural impact of food-related thoughts and (c) the use of food thoughts suppression in a sample of overweight and obese individuals	Community	Overweight and obese people with frequent strong food cravings	72.5	M=39.3 SD=13.6 19-72	Food cravings trait & the emotional and behavioural impact of food-related thoughts
Stapleton et al. (2011)	Australia	To explore whether the Emotional Freedom Technique reduces food cravings in participants compared to a waitlist (WL) group	Community	Overweight and obese people with frequent strong food cravings	88.5	67.7% over 40 18-60	Self-reported craving & Perceived power of food & Food cravings
Steel et al. (2006)	Australia	To extend previous research by testing, in a more naturalistic craving experience, the efficacy of concurrent dynamic visual noise for reducing food cravings that were hunger driven as well as those that were not	Lab	University students	100	Hungry M=22.0 SD =4.3 Not hungry M=21.5 SD =4.2 18-3	Self-reported craving
Stillman et al. (2009) Study 3	US	To test the effects of psychological family presence (thoughts about one's family) on self-control in the eating of tempting treats	Lab	University students	71.2	not reported	Observed cookie consumption

Study	Origin	Study Aim	Setting	Population	% Female	Age range/ Statistic	Key Outcomes
Taylor & Oliver (2009)	UK	(1) To determine if physical activity reduces chocolate cravings and affect, and attenuates increases in cravings associated with stress and chocolate cue-elicited urges and (2) to explore whether chocolate cravings were associated with affect, and if any changes in affect and cravings were associated	Lab	Regular chocolate consumers	80.0	M=25.3 SD=9.7	Self-reported craving
Thayer et al. (1993) Experiment 2	UK	To study the effect of moderate exercise on self-rated mood and snacking, behaviour. To test whether different means of modulating mood are interchangeable	Community	Frequent sugar snackers	64.7	18-52	Self-reported urge to snack
Townsend & Liu (2012) Study 2	US	To examine how planning one's food intake for the day might affect a subsequent snack choice and provide insights into the mechanism underlying the negative effect of planning for those in poor goal standing	Lab	University staff and students	62.0	M=21.2	Unhealthy snack choice
Townsend & Liu (2012) Study 3	US	To investigate whether implementation concreteness combined with poor goal standing is associated with demotivation from self-regulation of eating	Lab	University staff and students	45.0	M=21.6	Taste test choice
Townsend & Liu (2012) Study 5	US	To examine the effect of temporarily manipulated self-perception of goal standing on the impact of planning	lab	University staff and students	64.0	M=21.1	Unhealthy snack choice

Study	Origin	Study Aim	Setting	Population	% Female	Age range/ Statistic	Key Outcomes
Van Dillen et al. (2013) Study 1	NL	(1) To show that participants allocate more attention to pictures of attractive compared to neutral food, but that this effect disappears when under cognitive load. (2) To examine whether cognitive load can disrupt the development of cravings when participants have been repeatedly exposed to potentially tempting stimuli	Lab	University staff and students	60.6	M=21.0	Self-reported craving & Attentional Bias
Van Dillen et al (2013) Study 2	NL	To demonstrate more directly that cognitive load prevents the activation of hedonic thoughts in response to attractive food items, by using a lexical decision task that assesses spontaneous thoughts about eating enjoyment when exposed to tempting food cues	Lab	University staff and students	55.1	M=21.0	Hedonic response to food stimuli
Van Dillen et al (2013) Study 3	NL	(1) To test the effects of cognitive load on healthy eating behaviour (food choice). (2) To examine whether cognitive load helps to reduce the hedonic effects of attractive food items for people who are particularly sensitive to the allure of food in their environment	Lab	University staff and students	73.5	M=21.0	Snack choice
van Gucht et al. (2008)	Belgium	To investigate the effects of repeated unreinforced exposure to chocolate cues in persons reporting chocolate craving	Lab	University students chocolate craving	100	M=20.7 SD=0.8 20-24	Self-reported craving & Saliva secretion

Study	Origin	Study Aim	Setting	Population	% Female	Age range/ Statistic	Key Outcomes
van Koningsbruggen et al. (2011) Study 1	NL	To test whether forming implementation intentions to ‘‘think of dieting’’ when tempted creates a strong association between temptation and dieting goals	Lab	Dieters and non-dieters	100	M=28.7 SD=14.0	Goal-activation
van Koningsbruggen (2011) Study 2	NL	To test whether think-of-dieting implementation intentions can reduce consumption of the targeted food items after 2 weeks	Community	Dieters and non-dieters	90.7	M=33.7 SD=14.7	Self-reported food consumption
van Koningsbruggen et al. (2014) Experiment1	NL	To test whether a) dieting implementation intentions or b) stop-signal training can influence portion size selection	lab	University students	53.9	M=21.8 SD=3.4 18-41	Ad libitum food-serving behaviour
van Koningsbruggen et al. (2014) Experiment 2	NL	To test whether two interventions to reduce impulsive eating behaviour (as above) can influence task performance that results in receiving sweets	Lab	University students	62.5	M=21.2 SD=2.2 18-30	Task performance to receive chocolate
Veling et al. (2011) Study 1	NL	To test whether presenting stop signals near palatable foods inhibits chronic dieters’ subsequent unintentional impulses toward these foods	Lab	University students	100	M=21.2 SD=3.4	Slowed responses on Go/no-go task

Study	Origin	Study Aim	Setting	Population	% Female	Age range/ Statistic	Key Outcomes
Veling et al. (2011) Study 2	NL	To assess whether training with stop signals extends outside of the laboratory and affects palatable food consumption over a one-day period.	Lab	University students	60.9	no-go M=21.3 SD=2.8 control M=21.0 SD=2.9	Observed sweets consumption
Veling et al. (2013) Study 1	NL	To examine the impact of stop signals on food choices among people with different levels of appetite (hunger)	Lab	Young adults	62.0	M=21.4 SD=2.9	Food choice
Veling et al. (2013) Study 2	NL	To test whether associating foods to stop signals, reduces choices for these foods among those with frequent past selections.	Lab	Young adults	61.4	M=21.5 SD=2.9	Food choice

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Table 3.3 Study designs, potential biases, and outcomes

	Total N Studies	Areas of potential bias	Outcomes	Study Designs				
				RCT	Non-randomised controlled trial	Factorial experiment	Crossover trial	Uncontrolled (pre-post) study
1. Impulse-focused technique	**35**			**13**	**5**	**10**	**7**	
1.1 Priming	**9**	5 No randomisation 8 Student Samples 9 No a priori power calculation 2 Self-report	Food consumption Hypothetical food choice Automatic evaluations	**4**	**1**	**3**	**1**	
1.2 Cue-exposure	**9**	6 No randomisation 9 Student Samples 9 No a priori power calculation 1 Self-report	Food consumption Craving Goal activation Goal importance and goal intentions Attention processing	**2**	**3**	**4**		
1.3 Inhibition Training	**9**	2 No randomisation 7 Student Samples 7 No a priori power calculation	Food consumption Hypothetical food choice Go/No-go response times	**5**		**2**	**2**	
1.4 Physical Activity	**5**	3 No a priori power calculation 3 Self-report	Food consumption Craving Attentional bias			**1**	**4**	
1.5 Attentional Bias training	**2**	2 Student Samples 2 No a priori power calculation	Food consumption Craving Attentional bias	**1**	**1**			

	Total N Studies	Areas of potential bias	Outcomes	Study Designs				
				RCT	**Non-randomised controlled trial**	**Factorial experiment**	**Crossover trial**	**Uncontrolled (pre-post) study**
1.6 Approach/Avoidance training	**1**	1 Student Samples 1 No a priori power calculation	Craving Approach bias	**1**				
2. Reflective technique	**55**			**28**	**10**	**8**	**9**	**1**
2.1 Mindfulness-based strategies	**19**	6 No randomisation 14 Student Samples 19 No a priori power calculation 2 Self-report	Weight Food consumption Craving Discounting patterns Approach bias	**10**	**4**	**4**		**1**
2.2 Visuospatial Load	**16**	11 No randomisation 17 Student Samples 16 No a priori power calculation 17 Self-report	Food consumption Craving	**6**	**1**	**1**	**8**	
2.3 Implementation Intentions	**9**	7 Student Samples 7 No a priori power calculation 2 Self-report	Food consumption Automatic evaluations Goal activation	**6**		**3**		
2.4 Cognitive loading	**3**	2 No randomisation 3 Student Samples 3 No a priori power calculation	Craving Snack choice Accessibility of hedonic information	**1**	**2**			
2.5 Thought suppression	**3**	2 No randomisation 2 Student Samples 3 No a priori power calculation	Food consumption Craving	**1**	**2**			

	Total N Studies	Areas of potential bias	Outcomes	Study Designs				
				RCT	Non-randomised controlled trial	Factorial experiment	Crossover trial	Uncontrolled (pre-post) study
2.6 Cognitive restructuring	**3 (+2)***	1 No randomisation 1 Student Samples 2 No a priori power calculation 1 Self-report	Weight * Craving Automatic evaluations	**2 (+2)***			**1**	
2.7 Emotional freedom technique	**1**	1 No a priori power calculation	Weight Craving Susceptibility to food	**1**				
2.8 "I don't" refusal framing	**1**	1 No randomisation 1 Student Samples 1 No a priori power calculation	Food consumption		**1**			
2.9 Autonomous learning conditions	**1**	1 Student Sample 1 No a priori power calculation	Food consumption Subsequent self-control	**1**				
3. Unclear mechanism	**3**			**3**				
3.1 Manipulating Regulatory Fit	**2**	2 Student Samples 2 No a priori power calculation	Food consumption	**2**				
3.2 Episodic future thinking	**1**	1 No a priori power calculation	Food consumption Delay discounting	**1**				

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3.4.3. Synthesis of evidence on effectiveness of techniques

Detailed evidence on the effectiveness of the 17 techniques is provided in Appendix 3. The table for each technique category organizes the studies by technique type, then by outcome (weight, food consumption, cravings and other measures), and then by study design, with mean differences (MD) and standardized mean differences (SMD) and significance levels reported where available. This standardized structure is reflected in the sections below. Each section begins with a brief literature-based definition, followed by a discussion of the postulated mechanism of action and an evidence synthesis. Finally, each section includes a brief summary of potential sources of bias. A synthesis of the overall quality and strength of the evidence (categorised as “promising”, “mixed” or “insufficient”; See Table 3.1) and further research needed for each of the techniques is provided at the end of the results section in Table 3.4.

3.4.4. (1) “Impulse-focused” techniques: targeting impulse generation or strength.

A total of 35 studies evaluated six impulse-focused techniques.

1.1 Priming **(N=9)** involves the use of cues to (re)direct behaviours. Primes automatically activate mental representations of personal concerns and goals and help to activate associated (healthy) behavioural schemas. The primes used in the 9 studies reviewed included reminders of God (2 studies), family presence (1), and love-related symbols (3).

Effects of priming on food consumption. One RCT, one non-randomised controlled trial and one factorial experiment investigated the effects of priming on food consumption. Based on a small sample (mean group size 23), the RCT (Raska & Nichols, 2012; Study 3) reported that people exposed to companionate love images (Abraham Lincoln) were significantly more likely (62% vs 29%) to choose a healthy snack post-treatment than those exposed to a sexual love image (Marilyn Monroe). One small non-randomised controlled trial (mean group size 12) also found significant reductions in observed food consumption post-treatment (SMD=1.24) for people primed with ideas about God compared with controls (Laurin, Kay, & Fitzsimons, 2012). The factorial experiment found no significant difference in healthy food consumption between groups post exposure to photos of loved ones (family). However, sub-group interaction effects suggested that diet primes significantly reduced post-treatment food consumption in restrained eaters (people who tend to set rigid rules about eating and normally consume more than unrestrained eaters) but not unrestrained eaters (Stillman, Tice, Fincham, & Lambert, 2009). Although the three studies used objective measures of food consumption, two did not randomise, none reported a priori power calculations, and all used student samples.

Effects of priming on hypothetical food choice. Two RCTs, one (non-randomised) crossover trial and two factorial experiments investigated the effects of priming on hypothetical food choice. The two RCTs reported positive effects of priming on hypothetical food choices after being exposed to companionate as compared to sexual love primes (SMD=0.4-0.7) or a control group (SMD=0.4) (Raska & Nichols, 2012; Studies 1 and 2). When cued to focus on the healthiness of a certain food in a non-randomised crossover trial, participants were significantly more likely to report to want to eat a food rated as healthy/untasty and significantly less likely to eat a food rated as unhealthy post-treatment, compared with controls (Hare, Malmaud, & Rangel, 2011). In contrast, interaction effects in two factorial experiments suggested that although priming self-control using scrambled sentence tasks improved present food choices compared with a neutral prime, it could have adverse effects on food choices for the future (self-reported post-treatment) (Laran, 2010). None of the five studies used a priori power calculations, all used students, and one did not randomise.

Effects of priming on automatic evaluations and information accessibility. One very small 3-arm RCT (N=37) showed that participants primed with the concept of God had significantly more negative automatic associations with unhealthy palatable foods than did those with either a neutral (SMD=1.03) or positive prime (SMD=1.03) (Laurin et al., 2012; Study 3). A larger factorial experiment (N=213, but with 8 groups), reported that when primed with self-control, participants were significantly faster to recognize words related to self-control than neutral words post-treatment in the present time frame, but not in the future time frame (Laurin et al., 2012 Study 2). Both studies used student samples and did not provide a priori power calculations.

***1.2 Cue-exposure* (N=9)** involves exposure to food cues to reduce future consumption. Although the use of cue-exposure may seem counterintuitive as the 'obesogenic environment' already automatically triggers eating behaviour, it is posited that temptations may automatically trigger goal-directed behaviour through the activation of long-term goals (Counteractive Control Theory; Trope & Fishbach, 2000).

Effects of cue-exposure on food consumption. One RCT, one (non-randomised) crossover trial, and three factorial experiments examined effects of unhealthy food cues (e.g., smell of cookies baking) on subsequent observed food consumption. The RCT found that exposure to strong temptations led to significantly higher self-reported calorie estimates post-treatment, compared to weak temptations (Kroese, Evers, & de Ridder, 2013). The crossover trial compared diet congruent and temptation cues and found no significant difference between groups post-treatment. One factorial experiment reported a significant difference in observed snack consumption between Non-Actionable Food Temptation cues, Actionable Food Temptation cues, and controls (Geyskens, Dewitte, Pandelaere, & Warlop, 2008). Subgroup analyses showed conflicting findings: Coelho et al.'s, (2009) results suggest that post-treatment food consumption was significantly reduced in restrained but not unrestrained eaters exposed to food (temptation) cues, compared with controls. Buckland, Finlayson, and Hetherington (2013) found the opposite (i.e. restrained dieters consumed fewer total calories following a pro-diet cue, compared to a temptation cue). Geyskens et al., (2008) found that Non-Actionable Food Temptation cues were associated with increased consumption post-treatment compared to controls for low convenience, but not high convenience, foods. This study also reported that for high, but not low convenience foods, Actionable Food Temptation cues were associated with increased food consumption compared to controls. All but one study involved small sample sizes, all used students, none provided a priori power calculations, only one used randomisation.

Effects of cue-exposure on craving. One non-randomised controlled trial reported that repeated cue-exposure without an eating response, significantly reduced craving scores at up to 3 days follow-up, compared to controls (Van

Gucht et al., 2008). A small student sample was used, no a priori power calculation was provided, and there was no randomisation.

Effects of cue-exposure on goal activation. A non-randomised controlled trial and a factorial experiment examined the effects of unhealthy food-cues on goal activation (Geyskens et al., 2008; Studies 1 and 2). Both actionable (bowl of chocolates) and non-actionable food cues (pictures) significantly increased the activation of goals to restrict food consumption post-treatment compared to controls (SMD=0.56 and 0.90 respectively). These studies had small student samples, no a priori power calculations or randomisation.

Effects of cue-exposure on goal importance and intentions. Two non-randomised trials (Kroese, Evers, & De Ridder, 2009) found that post exposure to temptation cues, both dieting goal-importance and goal intentions were self-reported to be significantly more important compared with controls. Both studies used small student samples without a priori power calculations and lacked randomisation.

Effects of cue-exposure on attention processing. One 3-arm RCT (Geyskens, Soetens, & Roets, 2010) found a significant difference in attention processing (attention being drawn away from food) favouring actionable food temptation and non-actionable temptation compared with a control group post-treatment. This RCT used a small student sample without a priori power calculations.

1.3 Inhibition training **(N=9)** involves repeatedly practicing an inhibitory response to presentations of images that are paired with stop cues. Inhibitory control represents higher-order processes that can inhibit pre-potent (pre-conscious) actions and facilitate deliberate executive control. Inhibition training aims to improve inhibitory control, by the automated response inhibition following repeated cue association training.

For example, Veling, Aarts, and Papies (2011) examined whether stop signals presented in a “go /no-go” task, can be used to control chronic dieters’ subsequent consumption of palatable foods. In such tasks, images of high palatable foods are consistently paired on a screen with stop-signals (No-go) in an attempt to train inhibition of the existing automated behavioural response. The participant is asked to either perform or withhold a certain action (e.g., pressing the spacebar), depending on the accompanying signal. We found nine studies that evaluated the effects of inhibition training.

Effects of inhibition training on food consumption. Two RCTs and two factorial experiments found that Inhibition Training significantly reduced subsequent observed food consumption post-treatment compared to impulsivity promotion training (Guerrieri, Nederkoorn, & Jansen, 2012) and control groups (Houben & Jansen, 2011; van Koningsbruggen, Veling, Stroebe, & Aarts, 2014). However, two RCTs and one non-randomised crossover trial found no significant effects of training on food consumption, compared with controls, post-treatment (Guerrieri et al., 2012; Houben, 2011) or at one-day follow-up (Veling et al., 2011). Sub-group effects within one RCT and one non-randomised crossover trial suggested that inhibition training may have positive effects on food consumption at one-day of follow-up only for people with relatively low inhibitory control (Houben, 2011), and may be particularly beneficial for chronic dieters and those with high appetite (Veling et al., 2011). Only two of the 6 studies provided a priori power calculations (van Koningsbruggen et al., 2014), and all six used small student samples.

Effects of inhibition training on hypothetical food choice. Two RCTs (Veling, Aarts, & Stroebe, 2013; Study 1&2) found that Inhibition Training significantly reduced unhealthy hypothetical food choices post-treatment compared to control groups. However, in sub-group analyses these positive effects were only apparent for people with high appetite and relatively high frequency of past behaviours towards the trained foods. These studies used small sample sizes but were not conducted with students.

Effects of inhibition training on response time tasks. One non-randomised crossover trial found reduced impulsive responding toward food stimuli immediately post-treatment (Veling et al., 2011). However, this study used a small student sample and did not randomise.

***1.4 Physical activity* (N=6)**. Undertaking active tasks such as exercise or walking. It has been proposed that physical activity stimulates pleasure-reward centres in the brain, interfering with the association between a range of unhealthy behaviours and stimulation of (the same) pleasure-reward centres (e.g. Janse Van Rensburg, Taylor, Hodgson, & Benattayallah, 2009)

Effects of physical activity on food consumption. One factorial experiment reported significant reductions in ad libitum snacking post-treatment, with 13.2g less chocolate consumed after exercise compared to controls (Oh & Taylor, 2013). One randomised crossover trial reported a significantly longer time (of almost 50%) before next snack consumption following exercise compared to a control task (Thayer, Peters, Takahashi, & Birkhead-Flight, 1993). Neither study used a priori power calculations and both had small sample sizes.

Effects of physical activity on craving. Four randomised crossover trials of physical activity reported reductions in cravings and desire to eat at up to 10-minutes of follow-up compared to a control task (d= 0.6-0.8) (Oh & Taylor, 2013, 2014; Taylor & Oliver, 2009; Thayer et al., 1993). However, in one study the maintenance of effects up to 10 minutes was only seen after vigorous, but not moderate, exercise (Oh & Taylor, 2014). Although sample sizes were small in these four studies, two did provide a priori power calculations to determine the number of participants needed for their study.

Effects of physical activity on attentional bias. Two of the above randomised crossover trials reported that a 15-minute brisk walk or cycling significantly reduced attentional bias, compared with passive controls post-treatment (d=0.42 to 1.42) (Oh & Taylor., 2013; 2014).

1.5 Attentional bias training **(N=2)** modifies impulses by changing existing attentional biases towards environmental stimuli such as highly palatable, energy-dense foods. Attentional bias is the selective attention to relevant information, in this case food cues, over neutral information. It is posited that cues that are associated with a reward (through conditioning) automatically capture attention and raise the salience of behaviour-reward schemas (Incentive Sensitization Theory; Robinson & Berridge, 1993). Attentional bias training involves retraining attention away from food cues using a computer-based modified dot probe procedure which directs attention away from the conditioned unhealthy stimulus by following a target that is presented near non-food pictures (Kemps, Tiggemann, Orr, & Grear, 2014).

Effects of attentional bias training on food consumption. Two studies using attentional bias training reported conflicting results. In one RCT attentional bias was significantly reduced from baseline to post-treatment after 'avoid' compared to 'attend' training (i.e. avoiding vs. attending to chocolate cues) with medium effect sizes. This translated into significant differences in observed consumption of chocolate muffins (d=0.67) but not blueberry muffins between the groups post-treatment (Kemps et al., 2014). In contrast, a smaller non-randomised controlled trial reported no significant differences in attentional bias or food consumption post-treatment between 'attend' training (i.e. towards cake), avoid training (i.e. away from cake), and controls (Hardman, Rogers, Etchells, Houstoun, & Munafò, 2013). These two studies both used small student samples and did not report a priori power calculations.

Effects of attentional bias training on craving. Although the RCT (Kemps et al., 2014) reported successful attentional bias modification, this did not translate into significant differences in cravings between the 'avoid' and 'attend' training groups post-treatment.

***1.6 Approach/avoidance training* (N=1).** Following the automatic capturing of attention (as above), reward stimuli trigger a motivational response that directs behaviour toward target acquisition and consumption (an 'approach' tendency). Approach/Avoidance training aims to modify the association to approach, thereby reducing craving and consumption. Like attentional bias training, this technique draws on Incentive-Sensitization Theory (Robinson & Berridge, 1993) and cognitive-motivational models of craving (e.g., (Franken, 2003; Kavanagh, Andrade, & May, 2005).

Effects of approach/avoidance training on approach bias and craving. In the only study on this technique, Kemps, Tiggemann, Martin, and Elliott (2013) conducted a two-arm RCT with 96 female students. They found that both approach bias and cravings associated with chocolate were significantly reduced post-treatment (d=0.5) for people receiving 'avoid' compared to 'approach' training. However, this study was conducted with a student sample, no a priori power calculation was used, and the sample sizes were small (48 per group).

3.4.5. (2) "Reflective" techniques: engaging the reflective system or cognitive resources.

A total of 55 studies investigated 9 distinct reflective techniques.

2.1 Mindfulness-based strategies **(N=19)** aim to raise awareness of the present moment by purposefully paying attention, without judgment, to the current experience that is unfolding, and observing its path without acting. Repeated exposure to eating cues without taking action is expected to result in reduction of the eating response, due to a disassociation between cue and reward. These strategies require the individual to bring the experience and decision-making process into conscious awareness. Mindfulness-based strategies include acceptance-based strategies in which the goal is to experience and observe eating urges or cravings whilst not taking action (e.g. (Forman et al., 2013a). Distraction-oriented mindfulness strategies are also possible, whereby participants are taught to fully experience any thoughts and feelings while focusing on other things, such as their breathing (Breath Focus) or parts of the body (Body Scan) (e.g. (May, Andrade, Batey, Berry, & Kavanagh, 2010).Nineteen studies, including 10 (53%) RCTs, four (21%) factorial experiments, four (21%) non-randomised trials, and one (5%) uncontrolled study examined mindfulness-based strategies (described as acceptance, defusion, mindful eating, body scan, and breath focus).

Effects of mindfulness-based strategies on weight. Three RCTs found no significant differences in weight loss post-treatment (after intervention periods ranging from 8-40 weeks) or at up to 6-month follow-up, compared to “standard behavioural treatment” involving control-oriented coping strategies such as cognitive restructuring or problem solving (Alberts, Mulkens, Smeets, & Thewissen, 2010; Alberts, Thewissen, & Raes, 2012; Forman, Butryn, et al., 2013). However, these RCTs found significant reductions in weight within both treatment groups. A subgroup analysis in one large RCT (N=128) showed that weight loss was significantly greater (6.1% more (SMD=0.74)) at 6-months in the mindfulness group when the treatment was delivered by experts, compared to those receiving standard behavioural treatment (Forman et al., 2013a). A further non-controlled study found a significant change in weight of 9.6% at 6-month follow-up (SMD= 0.58) (Forman, Butryn, Hoffman, & Herbert, 2009). Two of the RCTs had small samples and none reported a priori power calculations. The uncontrolled study examining weight had high drop-out (50%), leaving only 14 participants available for analysis.

Effects of mindfulness-based strategies on food consumption. One RCT and two non-randomised controlled trials reported significant decreases in self-reported or observed calorie consumption post-treatment (SMD= 0.45-0.99), compared with controls (Hooper, Sandoz, Ashton, Clarke, & McHugh, 2012; Jordan, Wang, Donatoni, & Meier, 2014) and generic relaxation training (Jenkins & Tapper, 2014). Intervention participants in one further RCT were significantly more likely to self-report abstinence from chocolate at seven-day follow-up compared with controls (Odds ratio 4.61) and with cognitive restructuring groups (Odds ratio 3.26) (Moffitt, Brinkworth, Noakes, & Mohr, 2012). Two further RCTs reported no significant difference in observed chocolate consumption post-treatment between mindfulness and cognitive control-based coping (Forman et al., 2007; Forman, Hoffman, Juarascio, Butryn, & Herbert, 2013b). None of these six studies reported a priori power calculations, three of the six used small samples, and only two did not use students (Forman et al., 2013b; Moffitt et al., 2012).

Effects of mindfulness-based strategies on food craving. The evidence here was also mixed. Three RCTs and three non-randomised trials found no significant post-treatment differences in craving between mindfulness and cognitive control-based coping groups (Forman et al., 2007; 2013b; Hooper et al., 2012; May et al., 2010 Study 1; Moffitt et al., 2012). Compared with non-active control groups, two RCTs (Moffitt et al., 2012; Forman et al., 2007) and two non-randomised trials (Hooper et al., 2012; May et al., 2010 Study 2) found no significant post-treatment differences in craving and two RCTs (Alberts, Thewissen, & Middelweerd, 2013; May, Andrade, Batey, et al., 2010) found significantly *increased* post-treatment craving scores in the mindfulness group compared with controls and at 20-minute follow-up. In contrast, three further RCTs found significant reductions in cravings compared with controls post-treatment (Alberts et al., 2010, 2012; Hamilton, Fawson, May, Andrade, & Kavanagh, 2013). Sub-group analyses in one RCT reported significantly reduced craving scores post-treatment compared with controls only for participants who were highly susceptible to food cues (Forman et al., 2007). None of the 10 studies reported a priori power calculations, nine used small samples, 6 of the 10 used students, and three were not randomised.

Effects of mindfulness-based strategies on discounting and approach bias. One RCT found a significant reduction in impulsive delay, and risk-averse probability discounting patterns (change in preferences for different sized rewards depending on the delay) for those who were trained to eat mindfully compared with controls post-treatment (Hendrickson & Rasmussen, 2013). In addition, four factorial experiments reported significant effects on approach biases post-treatment and at up to 5-minutes follow-up (Papies, Barsalou, & Custers, 2012 Studies 1, 2a, 2b, and 3). The five studies had small or very small samples, none reported a priori power calculations, one did not use randomisation, and all but one used students.

***2.2 Visuospatial Loadin*g (N=16)** refers to the use of tasks that occupy the sensory modalities associated with craving (i.e., sight or smell) to reduce the resources available for cognitive elaboration. It is proposed that craving episodes are triggered by both external and internal cues. External cues trigger automatic, associative processes resulting in spontaneous intrusive thoughts about the object of desire. These thoughts are then elaborated with visual and olfactory imagery of consumption, as well as eating-related cognitions. Mental imagery is held to be an important process affecting the maintenance and intensity of a craving (Elaborated Intrusion theory; Kavanagh et al., 2005). Thus, tasks that occupy the sensory modalities and so reduce the available cognitive resources have been hypothesized to reduce craving intensity by preventing development of mental imagery that would otherwise elaborate the craving. Sixteen studies examined visuospatial loading using delivery methods such as clay modelling, dynamic visual noise, visual imagery, and olfactory interference.

Effects of visuospatial loading on food consumption. One small RCT (group size 24, with no a priori power calculation) found that dynamic visual noise delivered on a hand-held device significantly reduced self-reported craving-related consumption (SMD=0.49) in female students post-treatment, compared with controls (Kemps & Tiggemann, 2013a)

Effects of visuospatial loading and olfactory interference on craving. Six RCTs (Andrade, Pears, May, & Kavanagh, 2012; Kemps & Tiggemann, 2007, 2013a; Knäuper, Pillay, Lacaille, McCollam, & Kelso, 2011; Rodríguez-Martín, Gómez-Quintana, Díaz-Martínez, & Molerio-Pérez, 2013) one factorial experiment (Harvey, Kemps, & Tiggemann, 2005), eight (non-randomised) crossover studies (Kemps & Tiggemann, 2013b; Kemps, Tiggemann, & Bettany, 2012; Kemps, Tiggemann, & Christianson, 2008; Kemps, Tiggemann, & Hart, 2005; Kemps, Tiggemann, Woods, & Soekov, 2004; Steel, Kemps, & Tiggemann, 2006), and one non-randomised controlled trial (Andrade et al., 2012) showed that visuospatial loading and olfactory interference tasks significantly reduced cravings post-treatment and at up to 3-months follow-up, compared with controls and comparison groups using tasks that did not engage craving-related sensory modalities. None of these 16 studies provided a priori power calculations, 13 used small samples, all used self-report measures, and the majority used student samples.

2.3 Implementation Intentions (if-then plans) **(N=9).** Forming an implementation intention involves identification of a cue that will be encountered in daily activities and consciously resolving to take a particular action when it is encountered. This technique can be used to manage impulsive processes. Although such plans initially require conscious deliberative planning, when the targeted temptation situation is encountered, the planned response may be initiated swiftly, automatically, and without need for conscious intent (Gollwitzer & Sheeran, 2006). Alternatively, the planned response may act as a trigger to bring decision making into conscious awareness, engaging the reflective system to override any undesirable impulses. The if-then planning components used in the six studies below involved either pre-specified responses such as ‘then I will think of dieting’, ‘then I will ignore that thought’ or self-formulated plans (e.g., Hofmann, Deutsch, Lancaster, & Banaji, 2010)

Effects of if-then planning on food consumption. One RCT reported that people forming impulse related implementation intentions had significantly reduced self-reported food consumption (SMD=0.41) compared with controls up to one-week follow-up (Achtziger, Gollwitzer, & Sheeran, 2008). Two factorial experiments (van Koningsbruggen et al., 2014 Studies 1 and 2) tested implementation intentions with or without inhibition training. These studies found a significant reduction in observed food consumption for both techniques compared with controls. However, these effects only occurred in the absence of the other technique (i.e., the intervention strategies both worked, but they did not have additive effects). One further RCT found no main effect for either implementation intentions or the “go /no-go” treatment although analysis of sub-group effects suggested that implementation intentions may have positive effects on food consumption at up to two-weeks follow-up only for unsuccessful dieters, as opposed to successful dieters or normal eaters (van Koningsbruggen, Stroebe, Papies, & Aarts, 2011). Only two of the above four studies reported a priori power calculations, all but two studies, used student samples, and two were based on self-report.

Effects of if-then planning on goal activation and automatic evaluations. One RCT reported significantly less positive automatic evaluations of, and explicit attitudes towards, food post-treatment for implementation intentions compared with controls (Hofmann et al., 2010). Sub-group analyses in a further RCT suggested that ‘think-of-dieting’ if-then plans may activate the diet goal for unsuccessful dieters but not successful dieters or normal-eaters post-treatment, compared with controls (van Koningsbruggen et al., 2011). Neither study reported a priori power calculations, but one used a relatively large sample (140 students).

Effects of other planning on food choice /consumption. Three studies evaluated planning (but not necessarily involving if-then plans) of daily food consumption, including defining sequences of action steps and personal behavioural guidelines. The setting of behavioural guidelines is hypothesized to prime and remind the individual of their higher order goals in temptation situations.

Townsend and Liu (2012) conducted two RCTs and a factorial experiment in which there were no significant effects of planning on healthy versus unhealthy food choices compared with controls. However, subgroup analyses in one RCT suggested that planning might only benefit those who consider themselves of average weight. For those who rated themselves as overweight, or very overweight planning was associated with a significantly increased likelihood of choosing an unhealthy snack post-treatment. Subgroup analyses in a second RCT suggested that concrete (as opposed to abstract) planning significantly increased the likelihood of those with a higher body fat percentage choosing an unhealthy snack option post-treatment, compared with controls. One factorial experiment found no effects of planning or weight perception on snack choice, nor any significant interaction effects post-treatment (Townsend & Liu, 2012). All three studies used student samples and they did not provide a priori power calculation. However, they did have larger than average sample sizes (50 or more per group). The subgroup analyses break randomisation and so these findings should be considered as associations, rather than causal evidence.

2.4 Cognitive Loading **(N=3)** involves use of tasks that occupy working memory using resources which are required for recognizing the hedonic value of foods. This in turn prevents the triggering of craving-related cognitive elaborations (i.e., craving imagery) (Van Dillen, Papies, & Hofmann, 2013). Three studies investigated cognitive loading, in the form of remembering a number with a large digit span.

Effects of cognitive loading on craving and other outcomes. One non-randomised controlled trial reported that compared to low cognitive loading tasks, high cognitive loading reduced craving post-treatment (SMD= 0.41, p=0.052) and significantly reduced attentional bias toward attractive food stimuli post-treatment (van Dillen et al., 2013 Study 1). High cognitive loading also significantly reduced hedonic responses to food stimuli compared with moderate loading and controls post-treatment (van Dillen et al., 2013 Study 2). Sub-group analysis in one non-randomised controlled trial suggests that cognitive loading significantly reduced the likelihood of choosing an unhealthy snack post-treatment compared with controls, but only for those who were highly susceptible to food cues (van Dillen et al., 2013 Study 3). None of these three studies reported a priori power calculations with small samples (group sizes ranging from 23 to 47), and all used paid volunteers in a University setting.

2.5 Thought Suppression **(N=3)** involves actively avoiding thinking about something with the intention to prevent engaging in associated undesirable behaviours. Thought suppression is often used as a strategy in the struggle against unwanted thoughts (Wenzlaff & Wegner, 2000) as a means of direct behavioural control (Baumeister, Heatherton, & Tice, 1994). However, suppression has also been hypothesized to lead to hyper-accessibility of the thoughts (Wegner, 1994) as well as behavioural rebound (Erskine, 2008).

Effects of thought suppression on food consumption and cravings. One RCT and two non-randomised controlled trials investigated the effects of thought suppression. Johnston, Bulik, and Anstiss (1999) found a significant increase in effortful behaviour to gain chocolates post-treatment for a group instructed to suppress thoughts of chocolate compared with controls (SMD=0.67). Two non-randomised controlled trials (Erskine, 2008; Erskine & Georgiou, 2010) reported a similar effect, with thought suppression significantly increasing chocolate consumption post-treatment, compared with controls and participants who were instructed to 'express' any thoughts about their intentions to eat chocolate. However, subgroup analyses suggested that this behavioural rebound effect was only present for 'restrained eaters'. None of the three studies provided a priori power calculations, and all used small samples.

An additional RCT and two non-randomised controlled trials included thought suppression as a comparison group but focused on assessing mindfulness-based strategies. One non-randomised trial reported that the thought suppression group ate significantly more post-treatment, compared with controls (SMD=0.38) and with a mindfulness treatment group (Hooper et al., 2012). The RCT reported that thought suppression significantly increased craving post-treatment and at up to 20-minutes follow-up (SMD=0.9 and 0.74, respectively) compared with controls (Alberts et al., 2013). In contrast, the other non-randomised controlled trial reported that craving levels remained constant up to post-treatment in a thought suppression group, whilst they increased in a mindfulness group (May et al., 2010).

2.6 Cognitive restructuring **(N=5)** is a form of cognitive stimulus control which involves altering the meaning of a situation or object so that the response to it is changed. This consists of considering a food item and either imagining it in a context that is not associated with consumption (e.g., marshmallows are pink fluffy clouds), or imagining negative aspects of the item (e.g., someone sneezed on it). With repetition, this may change positive automatic evaluations towards unhealthy food (Hofmann et al., 2010).

Effects of cognitive restructuring on weight. Two studies with weight outcomes used cognitive restructuring in their study comparisons (Alberts et al., 2010; Forman et al., 2013a), as control groups in studies assessing the effects of mindfulness and are reported in the above sections. These studies found significant reductions in weight for both groups, but no differences between the groups (See above text and Appendix 3).

Effects of cognitive restructuring on craving. In one non-randomised crossover trial cognitive restructuring significantly reduced self-reported desire to consume both craved foods and other foods post-treatment, compared with instructions to look at food and imagine consumption (SMD=1.81) (Giuliani, Calcott, & Berkman, 2013). However, this study provided no a priori power calculations (group size = 82).

Effects of cognitive restructuring on automatic evaluations. Two RCTs compared cognitive restructuring with a control group or implementation intentions and found that both implementation intentions and restructuring (SMD=0.52) resulted in significantly less positive automatic evaluations of chocolate post-treatment, compared with controls (Hofmann et al., 2010 Study 1 and 2). In one of these RCTs cognitive restructuring generated significantly more positive automatic evaluations than implementation intentions post-treatment (Hofmann et al., 2010, Study 1). Neither of the studies provided a priori power calculations but one RCT had group sizes of over 100.

2.7 Emotional freedom technique (EFT) **(N=1)** is a meridian-based intervention employing stimulation of acupressure points through a tapping motion whilst keeping the mind focused on the negative emotion. This technique is postulated to restore the energy balance of the body and eliminating the negative experience (such as cravings) which had initially caused the disturbances in the energy field (Craig, 2011). It is similar to some mindfulness-based techniques where “in-the-moment” attention is paid to one’s thoughts and feelings, in the absence of action, thereby deconditioning the previously automated response to an unhealthy eating cue. However, it is claimed that EFT actively counteracts the negativity by restoring the body’s energy balance.

Effects of emotional freedom technique on weight, craving, and susceptibility to food. One RCT (Stapleton, Sheldon, Porter, & Whitty, 2011) investigating the effects of four two-hour sessions of EFT involving eight acupressure points found no differences in weight loss between the EFT and control groups post-treatment or after six months. However, EFT significantly reduced cravings (SMD=0.90) and self-reported susceptibility to food post-treatment (SMD=0.68). No a priori power calculations were provided and there was a 52% loss to follow-up.

***2.8 "I don't" refusal framing* (N=1)** uses self-talk to increase the salience of temptation resistance schemas. It has been theorized that using self-talk phrased along the lines of "I don't eat X" versus "I can't eat X" each time you are exposed to the relevant temptation, invokes a degree of empowerment and control, resulting in a differential influence on the success of subsequent self-regulation processes (Self-Determination Theory; Deci & Ryan, 2000; Patrick & Hagtvedt, 2012).

Effects of "I don't" refusal framing on food consumption. One non-randomised controlled trial (Patrick & Hagtvedt, 2012) found that students using "I don't" refusal framing were significantly more likely to choose a healthy snack post-treatment compared to those instructed to use "I can't" refusal framing. However, subgroup analyses suggested this only benefitted those who felt healthy eating was a highly relevant goal. The study used a student sample, did not use randomisation, and provided no a priori power calculation.

***2.9 Autonomous learning conditions* (N=1)** involve facilitating the setting of goals reflecting one's own values (rather than external rewards, approval, or punishments). It is posited that autonomous learning is less depleting to the cognitive resources required for inhibition and control (Moller, Deci, & Ryan, 2006). Self-determination theory suggests that individuals who set goals in autonomous learning conditions should snack less than those who set goals in conditions with external controls such as close supervision and who use external (as opposed to internal) rewards or punishments to reinforce the target behaviour.

Effects of autonomous learning conditions on food consumption. One RCT showed that students in the autonomous learning condition consumed significantly fewer jelly beans post-treatment (SMD=0.7) compared with the controlled learning comparison group (Magaraggia, Dimmock, & Jackson, 2013).

Effects on subsequent self-control. In the same RCT, the autonomous learning group showed significantly better performance on a self-control task post-treatment compared with controls. This study did not provide an a priori power calculation and used a student sample.

3.4.6. (3) Unclear mechanism.

Three studies investigated the use of two techniques (episodic future thinking and manipulating regulatory fit) which targeted impulsive eating but did not describe or imply any proposed mechanism for how impulsive processes would be changed.

***3.1 Manipulation of regulatory fit* (N=2)** involves engaging in goal pursuit strategies that correspond (vs conflict) with the orientation of one's self-regulation focus. It is thought that eagerness strategies fit a promotion focus and that vigilance strategies fit a prevention focus (Hong & Lee, 2008). The mechanism by which this might impact on impulsive processes is not clear but may perhaps involve a reduction in self-regulatory resources required when regulatory fit is achieved.

Effects of manipulating regulatory fit on food consumption. In two RCTs Hong & Lee (2008) manipulated regulatory fit, through completion of regulatory fit questionnaires, following an ego-depletion task. In the regulatory fit conditions participants were asked to list current aspirations (to induce promotion focus) and "eagerness methods" (ways to ensure those aspirations are achieved), followed by a prevention questionnaire asking them to list any obligations (to induce prevention focus) and "vigilance methods" (ways of avoiding things that might prevent fulfilment of those obligations). In the regulatory non-fit induction condition participants were asked to list aspirations and vigilance means followed by obligations and eagerness means. They reported that increased regulatory fit significantly increased the likelihood of choosing the healthy snack over the unhealthy snack choice post-treatment, relative to the control group, who in turn, were significantly more likely to choose the healthy snack option than the regulatory non-fit group. However, these two studies used very small student samples, and provided no sample size calculations.

***3.2 Episodic future thinking* (N=1)** involves imagining future events. The mechanism of action of this technique is unclear.

Effects of episodic future thinking on food consumption and delay discounting. One RCT involving overweight and obese women examined the effects of future event imagery (Daniel, Stanton, & Epstein, 2013). The control group imagined recently experienced events. Episodic future thinking significantly reduced snack consumption post-treatment by 304.8 calories compared with controls (d=1.09), and reduced delay discounting (d=1.5). However, this study was small (group size 12-14), provided no sample size calculation, and reported differences between groups at baseline (which were controlled for in analyses).

Table 3.4 Evidence synthesis

Evidence	**Future research**
1. Impulse-focused Techniques (6 techniques)	
1.1 Priming. *Use of cues to (re)direct behaviours. Primes automatically activate mental representations of personal concerns and goals and help to activate associated (healthy) behavioural schemas*	
Insufficient evidence (One very small RCT and 1 very small non-randomised controlled trial for, one small factorial experiment against). Priming with love, family, or health focus cues may be able to reduce food consumption immediately post treatment for dieters and restrained eaters. There was no investigation of effects on cravings or weight.	More evidence from adequately powered RCTs in community-based samples is needed to generate definite conclusions and to assess the longer-term effectiveness of priming techniques on food consumption, weight loss, and craving.
1.2 Cue-exposure. *Exposure to food cues to reduce future consumption.*	
Insufficient evidence One very small RCT, one very small non-randomised crossover trial, two small randomised factorial experiments and one non-randomised factorial experiment suggested that exposure to unhealthy food cues does not reduce food consumption post exposure and may increase it.	There was insufficient evidence of effects on cravings to draw any conclusions and no evidence of effects on weight. Cue exposure does not seem a promising approach for further research.

Evidence	Future research
1.3 Inhibition Training. *Response inhibition following repeated cue association training.*	
Mixed evidence Inhibition training (e.g. go/no-go tasks) may be effective in reducing food consumption post treatment (one small RCT and two small randomised factorial experiments for; two very small RCTs and one very small non-randomised crossover trial against). All studies were limited to student samples, preventing any clear conclusions from being drawn. Sub-group analyses suggested that effects may be constrained to people with relatively low inhibitory control, chronic dieters and people with high appetite. There were no investigations of the effects on weight or cravings.	More evidence from adequately powered, community based RCTs on the short- and longer-term effectiveness on food consumption of inhibition training is needed, as well as evidence of the effects on weight and craving.
1.3 Physical Activity. *Undertaking active tasks such as exercise or walking.*	
Insufficient evidence One very small randomised crossover trial and one very small randomised factorial experiment that physical activity may reduce food consumption post activity. *Promising evidence* Two randomised crossover trials with a priori power calculations and two very small randomised crossover trials suggest that physical activity may reduce cravings for up to 10 minutes following the activity.	More evidence from adequately powered RCTs in community-based samples is needed to generate definite conclusions and to assess the longer-term effectiveness of physical activity targeting impulsive behaviours on food consumption and cravings.

Evidence	Future research
1.4 Attentional Bias Training. *Modifying impulses by changing existing attentional biases towards environmental stimuli such as highly palatable, energy dense foods.*	
Insufficient evidence One small RCT (for) and one very small (against) RCT provide insufficient evidence to suggest that attentional bias training may reduce food consumption immediately post training. There was no evidence of effects on cravings. There was no investigation of effects on weight.	More evidence from adequately powered RCTs in community-based samples is needed to generate definite conclusions and to assess the longer-term effectiveness of attentional bias training on food consumption, weight loss and cravings.
1.5 Approach/Avoidance training. *Following the automatic capturing of attention (as above), reward stimuli trigger a motivational response that directs behaviour toward target acquisition and consumption (an 'approach' tendency). Approach/Avoidance training aims to modify the implicit association to avoid (as opposed to approach), thereby reducing craving and consumption.*	
Insufficient evidence One small RCT suggests that cravings associated with chocolate may be reduced post treatment for people receiving 'avoid' training to modify approach-avoidance tendencies. There was no investigation of effects on food consumption or weight.	More evidence from adequately powered RCTs in community-based samples is needed to generate definite conclusions and to assess the longer-term effectiveness of Implicit Association Modification on food consumption and weight loss.

Evidence	Future research
2. Reflective Techniques (9 Techniques)	
2.1 Mindfulness-based strategies. *Aim to raise awareness of the present moment by purposefully paying attention, without judgment, to the current experience that is unfolding, and observing its path without acting.*	
Mixed evidence Sub-group analyses from one RCT and one uncontrolled study as well as within-group data from three RCTs suggested that acceptance-based mindfulness techniques, when delivered by expert practitioners might produce weight loss at up to 6-months follow-up. NB: In categorising this evidence we chose to ignore comparisons between mindfulness and other active treatments (as comparison with a non-active control group is needed to establish effectiveness). *Mixed evidence* Distraction-based mindfulness techniques might reduce food consumption at up to 7-days follow-up (two small and two very small RCTs <u>for</u>, one small and one very small RCT with active control groups <u>against</u>) and cravings post treatment (one small RCT and two very small RCTs <u>for</u>, 6 <u>against</u> (3 with active control groups) of which two small one very small RCTs and three very small non-randomised controlled trials).	More evidence from adequately powered RCTs with non-active control conditions on the short- and longer-term effectiveness of mindfulness strategies on weight, food consumption, and cravings, is needed, as well as evidence on the relative effectiveness of acceptance-based versus distraction-based mindfulness strategies.

Evidence	Future research
2.2 Visuospatial Loading. *Use of tasks that occupy the sensory modalities associated with craving (i.e., sight or smell) and reduce the resources available.*	
Insufficient evidence One very small RCT suggests that visuospatial load may reduce food consumption post treatment, but another very small RCT showed no differences in consumption between groups. There was no evidence of effects on weight. *Promising evidence* Six RCTs (four small and two very small), one factorial experiment, eight non-randomised crossover studies (seven small and one very small) and one very small non-randomised controlled trial all show that visuospatial loading or olfactory interference may reduce cravings for unhealthy foods immediately post treatment, and possibly for up to 3-months follow-up (one small RCT).	More evidence from larger, statistically powered RCTs is needed to draw any definitive conclusions about the effects on food consumption and to investigate longer-term effectiveness as well as evidence of the effects on weight.
2.3 Implementation Intentions *(if-then plans). Involves identification of a cue that will be encountered in daily activities and consciously resolving to take a particular action when it is encountered.*	
Promising evidence One small RCT and two small randomised factorial experiments and sub-group analyses in a larger RCT shows that forming impulse related implementation intentions (if-then planning) is effective in reducing food consumption post treatment and for up to one-week follow-up. There was no investigation of the effects on weight or cravings.	More evidence from adequately powered RCTs in community-based samples is needed to replicate these findings and assess the longer-term effectiveness of impulse related if-then planning on food consumption, as well as evidence of effects on weight and cravings.

Evidence	Future research
2.4 Cognitive Loading. *Use of tasks that occupy working memory.*	
Insufficient evidence One small non-randomised controlled trial suggests that cognitive loading may reduce cravings post treatment. Sub-group analyses in another small non-randomised controlled trial suggest that effects on food consumption may be limited to people who are more susceptible to food cues. There was no investigation of the effects on weight.	More evidence from larger, statistically powered RCTs is needed to draw any definitive conclusions and to investigate longer-term effectiveness on food consumption, craving and weight.
2.5 Thought Suppression. *Actively avoiding thinking about something to prevent engaging in associated undesirable behaviours*	
Insufficient evidence One very small RCT and two small non-randomised controlled trials (and an additional very small RCT using thought suppression as a comparison group in the evaluation of mindfulness-based strategies) suggest that thought suppression significantly increases food consumption and cravings post treatment. There was no investigation of the effects on weight.	Thought suppression does not seem a promising approach for further research.

Evidence	Future research
2.6 Cognitive Restructuring. *A form of cognitive stimulus control which involves altering the meaning of a situation or object so that the response to it is changed.*	
Insufficient evidence Due to a lack of studies comparing cognitive restructuring with control groups (the two, small and very small, RCTs in this field only used active treatments for comparison), no conclusions can be drawn regarding the role of these techniques in weight reduction. However, within-group data from three RCTs suggested that cognitive restructuring might produce weight loss at up to 6-months follow-up. *Insufficient evidence* One non-randomised crossover trial suggested that cognitive restructuring may reduce food cravings post treatment.	More evidence from RCTs with non-active control conditions on the short and longer-term effectiveness of cognitive restructuring on food consumption and cravings is needed, as well as evidence of the effects on weight.
2.7 Emotional Freedom Technique. *An acupuncture, meridian-based intervention employing stimulation of acupressure points through a tapping motion whilst keeping the mind focused on the negative emotion.*	
Insufficient evidence One small RCT found no effect of EFT on weight loss post treatment or at 6-months follow-up. However, EFT significantly reduced cravings post treatment. There was no investigation of the effects on food consumption.	More evidence from adequately powered adequately powered RCTs on the short and longer-term effectiveness of EFT on weight loss and cravings, as well as food consumption is needed, although it seems unlikely that this is a promising approach for further research.
2.8 "I don't" refusal framing. *Use of self-talk to increase the salience of temptation resistance schemas.*	
Insufficient evidence In one, small non-randomised controlled trial that using "I don't" refusal framing reduces unhealthy snack choice post treatment. There was no investigation on weight or cravings.	More evidence from adequately powered RCTs in community-based samples is needed to replicate these findings and assess the longer-term effectiveness of "I don't" refusal framing.

Evidence	Future research
2.9 Autonomous Learning Conditions. *Facilitating the setting of goals reflecting one's own values (rather than external rewards, approval, or punishments).*	
Insufficient evidence One very small student sample RCT suggests that autonomous learning conditions reduces food consumption and improves performance on a self-control task (e-hunt) compared with controlled learning at post treatment. There was no investigation of the effects on weight or cravings.	More evidence from adequately powered RCTs in community-based samples is needed to replicate these findings and assess the longer-term effectiveness of autonomous learning conditions on food consumption, as well as evidence of the effects on weight and craving.
Unclear Mechanisms (2 Techniques)	
3.1 Manipulating Regulatory Fit. *Engaging in goal pursuit strategies that correspond (vs conflict) with the orientation of one's self-regulation focus.*	
Insufficient evidence Two RCTs (one small and one very small) suggest that manipulation of regulatory fit may reduce unhealthy food consumption post treatment. There was no investigation of effects on cravings or weight.	More evidence from adequately powered RCTs in community-based samples is needed to generate definite conclusions and to assess the longer-term effectiveness of manipulation of regulatory fit on food consumption and weight loss.
3.2 Episodic Future Thinking. *Imagining future events.*	
Insufficient evidence One very small RCT suggests that episodic future thinking may reduce unhealthy food consumption post treatment. There was no investigation of effects on cravings or weight.	More evidence from adequately powered RCTs in community-based samples is needed to generate definite conclusions and to assess the longer-term effectiveness of episodic future thinking on food consumption and weight loss.

Promising findings (or 'evidence against' if evidence is negative) = at least one larger randomised study (>60 per group), OR 3 or more small (but not very small) randomised studies. Plus, the majority (80%) of the studies showing significant differences in the same direction. **Mixed evidence =** at least one larger randomised study (>60 per group), OR 3 or more small (but not very small) randomised studies showing evidence in either direction. However, no majority (80%) in one direction. **Insufficient evidence =** all small (less than 3) or very small studies OR no randomised studies. ^

3.5. Discussion

This review has systematically identified and categorised techniques used to modify and manage impulsive processes. For each technique we have also synthesised evidence of its effectiveness for regulating eating. Six impulse-focused and nine reflective techniques were identified, as well as two techniques with unclear mechanisms of action. Most of the research to date (55 studies on nine techniques) has been directed towards managing impulses once they become available to conscious awareness (e.g., using mindfulness techniques). Less research (35 studies on six techniques) has targeted processes that affect the initial generation or strength of eating impulses (priming, cue exposure, physical activity and interventions to modify attentional bias, approach /avoidance tendencies, and inhibitory control) in most cases through the use of associative training tasks. The review highlights a series of mechanisms and related change techniques that can usefully supplement available taxonomies of change techniques (e.g., (Abraham & Michie, 2008; Michie et al., 2013; R. Schulz, Czaja, McKay, Ory, & Belle, 2010). However, the quality of the evidence available limits the conclusions we can draw. Potentially important sources of bias were identified in most studies, such as the small sample sizes and lack of a priori power calculations. Thus, these studies could have been underpowered to detect hypothesised effects.

Despite these areas of potential bias, the patterns in the data suggest that some techniques may be able to help reduce cravings and food consumption, at least in the short term. Visuospatial loading, physical activity, and if-then planning showed promising evidence for effectiveness in reducing cravings and food consumption for up to one-week follow-up, at least in the context of the samples and settings studied. Mindfulness-based strategies showed mixed evidence in relation to weight loss and food intake, and inhibition training showed mixed evidence in relation to food intake. However, this may be due to the use of active control groups to which mindfulness-based strategies were compared. Within group comparisons did suggest such strategies might be able to produce weight loss at up to 6-months follow-up. In addition, for inhibition training the studies showing evidence for effectiveness are of better quality then those showing no evidence. Therefore, these techniques might still be considered promising in relation to weight loss and food intake. Although we found insufficient evidence on approach bias modification, it is worth noting that it has shown potential in changing alcohol consumption (e.g., Wiers, Eberl, Rinck, Becker, & Lindenmeyer, 2011; Wiers, Rinck, Kordts, Houben, & Strack, 2010). Conversely, evidence from smoking cessation (Erskine, Georgiou, & Kvavilashvili, 2010) and studies of smoking and alcohol use (Palfai, Colby, Monti, & Rohsenow, 1997), suggests that thought suppression is not effective.

Most of the techniques identified are still in the early stages of development, having been evaluated in primarily lab-based studies with predominantly female student samples. This limits the conclusions that can be drawn. For example, although visuospatial loading may be effective in reducing craving among female student chocolate cravers, it cannot be assumed that these effects would generalise to the wider, or a clinical, population. Similarly, a technique such as approach avoidance training may well be effective but due to the limited number and small size of the studies, this has not been fully established. Recommending techniques based on the current available evidence may result in using techniques that are not actually the most effective in facilitating behaviour change and weight loss. To extend, and improve the quality of, the evidence base, it is important to test the effects of these techniques among members of the general public or clinical samples wanting to lose weight. In addition, most of the evidence pertains to effects lasting only a few minutes post-treatment, and further research is needed on the longer-term effects of these techniques. Therefore, as outlined in Table 3.4, before definitive conclusions can be drawn concerning effectiveness which allow recommendations to be made about use of techniques on a larger scale, it is important to investigate their feasibility and acceptability to people who are trying to lose weight and their effectiveness (1) in the longer-term, (2) in general or clinical populations wanting to lose weight, (3) using “real-world” contexts, and (4) in sufficiently powered randomised studies. The feasibility of such a randomised controlled study is investigated in Chapter 5. There may also be scope for research on techniques that have not yet been applied to eating behaviour, drawing on the wider literature on techniques for compulsive disorders, managing alcohol, or other addictive behaviours.

3.5.1. Strengths and limitations

Rigorous systematic reviewing methods were used at each stage of the review, including a comprehensive search strategy, screening by multiple researchers (with high levels of agreement), structured data extraction, quality appraisal, and a systematic approach to narrative synthesis of the evidence. Nonetheless, several limitations need to be acknowledged. First, like other systematic reviews, the evidence presented in this review is potentially subject to publication bias. Second, the inconsistent use of terminology within the research literature may have limited the ability of the search strategy to identify all relevant studies. Third, our inclusion criteria excluded several studies with younger participants (e.g., Van Gucht, Baeyens, Vansteenwegen, Hermans, & Beckers, 2010; Veling, van Koningsbruggen, Aarts, & Stroebe, 2014). Although meta-analyses were not conducted, this might be possible for some of the techniques which have evidence from multiple trials, such as mindfulness, inhibition training, and visuospatial loading. Indeed, since conducting this systematic review a meta-analysis has suggested that inhibition training can positively influence health behaviour (alcohol consumption and eating behaviour) in the short-term (Allom, Mullan, & Hagger, 2015). It is worth noting that we combined general inhibition training (i.e., Guerrrieri et al., 2012) and food specific inhibition training (e.g., Veling et al.,2011). However, more recent studies found significantly greater reductions in self-reported snack intake and weight for the food specific training, compared with general inhibition training (Lawrence, O'Sullivan, et al., 2015; Lawrence, Verbruggen, Morrison, Adams, & Chambers, 2015). In addition, some overlap with our categorizations needs to be acknowledged. For example, physical activity has been classed with impulse-focused techniques, as the mechanism proposed by the authors involves non-conscious suppression of eating impulses as a result of physical activity stimulating reward centres in the brain. However, it could be argued that to engage in physical activity requires reflective control, and that the activity could potentially function as a distraction technique after conscious awareness of an impulse. Conversely, cognitive restructuring and if-then planning were both classified as reflective techniques but should eventually elicit automatic responses to suppress the future generation of impulses.

3.5.2. Conclusions

A range of techniques have been developed and tested for modifying and otherwise managing eating impulses. Visuospatial loading, physical activity, and if-then planning show potential promise for modifying cravings, and unhealthy food consumption, at least in the context of the samples and settings studied. Mindfulness-based strategies and inhibition training require further evaluation to clarify the currently mixed evidence base. High-quality, adequately-powered RCTs are now needed for definitive conclusions and to establish the longer-term effectiveness and cost-effectiveness of impulse management interventions to modify eating behaviour and weight in real world, community-based studies. The following chapter in this thesis will describe how the development of a novel weight management intervention draws on the findings of this systematic review.

Chapter 4. Development of a weight loss intervention supporting impulse management

4.1. Introduction

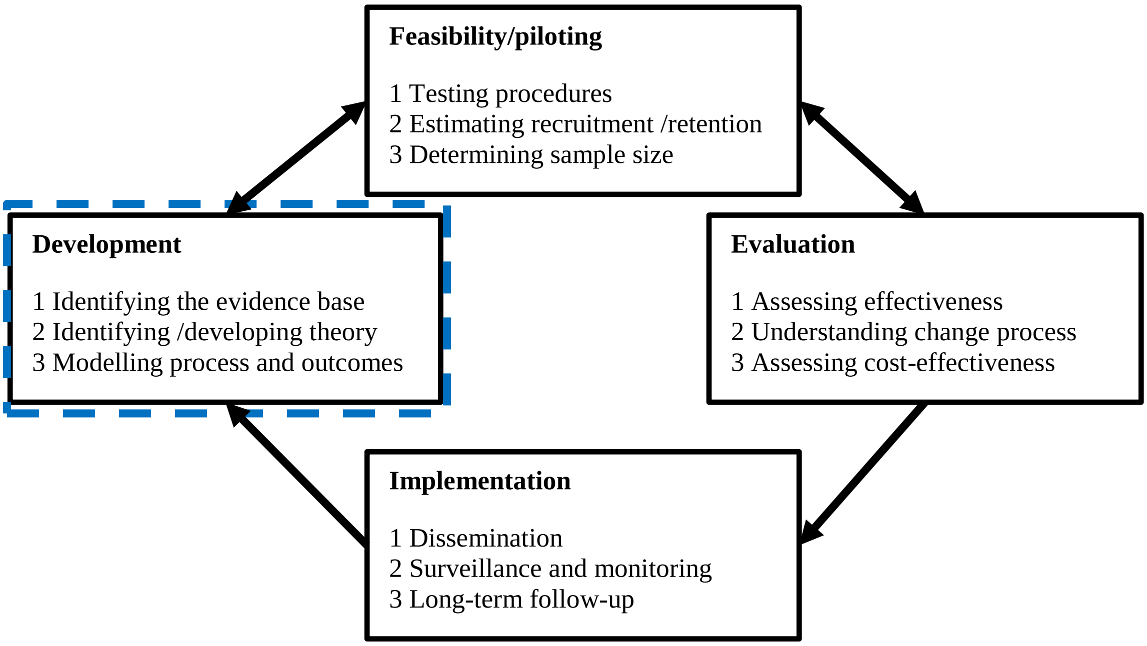


Figure 4.1 Corresponding phase in the key elements of the development and evaluation process, adapted from Craig et al., (2013)

The work described in this chapter was conducted prior to, in parallel to, and following the systematic review described in Chapter 3. The aim of Chapter 4 is to describe the systematic development of the self-delivered, smartphone app-based intervention called ImpulsePal and particularly addresses the question “*How can people be supported to manage impulsive processes to facilitate eating behaviour change and weight management, using a self-delivered intervention”.* There is a consensus that a current lack of adequate reporting of interventions is hindering the progress of the behaviour change research field in terms of replicability and our understanding of what works in what circumstances and why (Abraham & Michie, 2008; Dombrowski, Sniehotta, Avenell, & Coyne, 2007; Hoddinott, 2015; Michie & Abraham, 2008; Schaalma & Kok, 2009). Using established frameworks for developing and describing interventions may help to improve the transparency and clarity of reporting, quality of implementation, replication, and appropriate synthesis of evidence in systematic reviews. If an intervention is appropriately described, process evaluation of that intervention can subsequently provide detailed information regarding why an intervention has succeeded or failed, and allows identification of options for optimisation (Bartholomew et al., 2011).

Various frameworks are available for intervention developers to guide the development process such as the MRC Framework, the behaviour change wheel (Michie, van Stralen, & West, 2011), and Intervention Mapping (IM; (Bartholomew et al., 2011). Although, the MRC Framework recommends that interventions are described comprehensively and that the mechanisms by which they work are made explicit throughout their development (Craig et al., 2008), this framework does not offer detailed guidance on how to achieve this. The behaviour change wheel, is a well-established and often-cited method for intervention development which uses the COM-B model of behaviour (Capacity, Opportunity, Motivation, Behaviour) to guide the process. However, this framework is limited to a single unifying theory whereas Intervention Mapping allows developers to draw on a range of theoretical approaches depending on the behavioural targets and their modifiable determinants identified in the needs assessment, thus making this approach more specific to the behaviour, population, and context in which the intervention is to be implemented. More recent recommendations specific to the development of digital behaviour change interventions were published after the development process was started (Michie et al., 2017; Yardley, Morrison, Bradbury, & Muller, 2015). The general discussion presented in Chapter 7 will illustrate how the work described in this chapter and following chapters link to these recommendations and approaches.

The Intervention Mapping protocol provides a highly structured approach to development and encourages documentation of decision making throughout the process, thereby facilitating transparent reporting. The protocol encompasses MRC guidance recommendations in its approach as it (a) takes into account both theory and evidence in detailing how an intervention brings about changes, (b) takes an ecological perspective (i.e., with health behaviour viewed as a function of multiple levels of influence, including the individual’s biological and psychological characteristics, and his /her physical, social, and cultural environments), and (c) is grounded in user and provider participation allowing an appropriate range of stakeholders to contribute to the development process. At completion of the Intervention Mapping process the developer has a clear and detailed ‘blueprint’ of the intervention which comprehensively describes all elements of the intervention, justifies each decision made and provides a sound basis for evaluation (including process evaluation).

This chapter therefore describes the doctoral research that continued within the development stage of the MRC framework, with reference to the background and rationale presented in Chapter 2, and the systematic review of impulse management techniques presented in Chapter 3, where the development process draws on theory and evidence that has previously been described in this thesis. The remaining text in this chapter comprises mainly text in preparation for publication in the International Journal of Behavioural Nutrition and Physical Activity, with modifications to minimise repetition.

4.2. Objectives

The key aim of this development study was to develop a self-delivered intervention targeting impulsive processes to facilitate change in eating behaviour for weight management. Each step of Intervention Mapping has a separate set of objectives, as described below.

4.3. Methods and Results

An overview of the development process is provided in Figure 1. We used Intervention Mapping (Bartholomew et al., 2011), which is a well-established and widely used framework for developing and adapting health behaviour change interventions (Boekhout, Peels, Berendsen, Bolman, & Lechner, 2017; Dumas et al., 2017; Greaves et al., 2016; Lloyd, Logan, Greaves, & Wyatt, 2011). The Intervention Mapping protocol provides a structured approach to making intervention design decisions that are based on theory, evidence, and an appropriate range of stakeholder perspectives. The protocol comprises six iterative steps: 1) needs assessment; 2) identification of performance objectives and change objectives; 3) selection of theory-based methods and practical strategies; 4) development of intervention programme materials; 5) development of an adoption and implementation plan; and 6) development of an evaluation plan. The following sections describe the methods employed and the results of each step of the intervention development process (See Figure 4.2) following the structure.

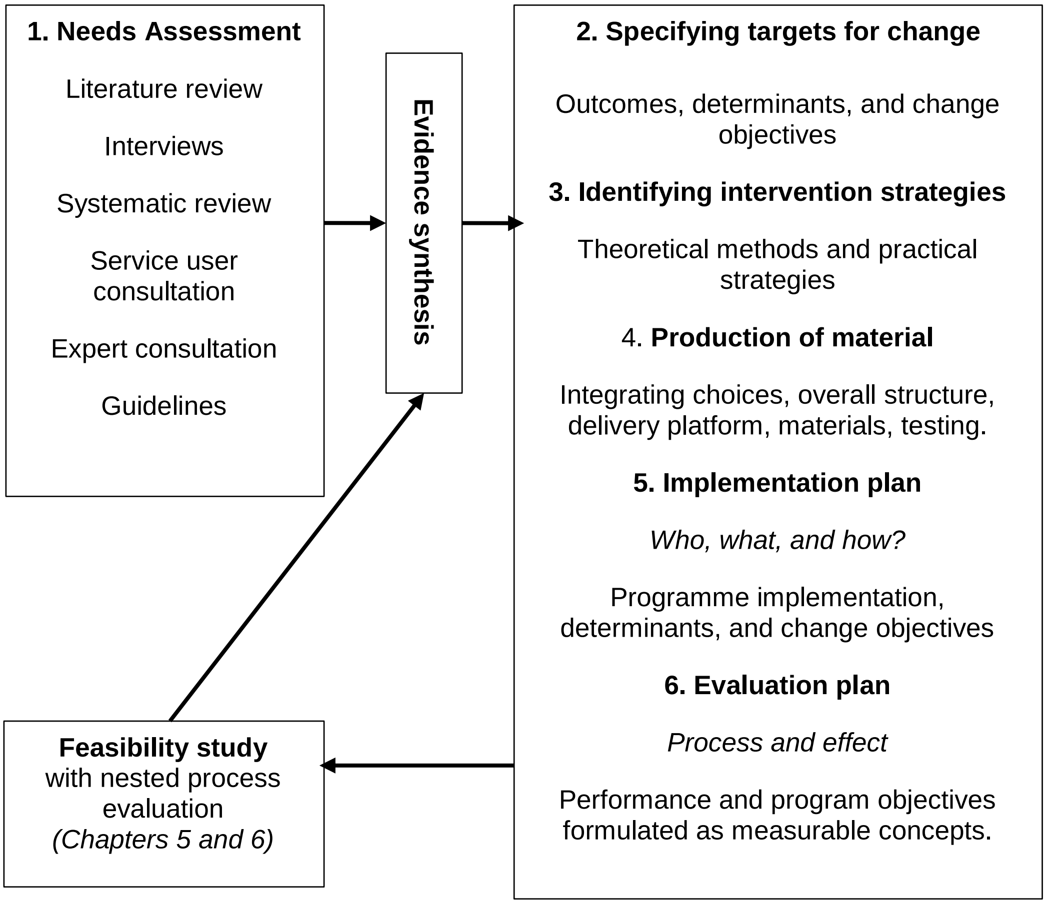


Figure 4.2 Intervention development process

4.1. Step 1: Needs Assessment

4.1.1. Needs assessment methods

Based on literature linking dietary behaviours to weight gain (as overviewed in Chapter 2), reduction in excess energy intake was adopted as the overall goal of the intervention. The main aims of the needs assessment were to (a) identify the specific targets for behaviour change and (b) their associated modifiable, impulsive determinants. Various activities were undertaken to achieve this which are described below.

4.1.1.1. Intervention development group

A multi-disciplinary intervention development group (n=7) was assembled to guide the process. This group included behaviour change experts (4), neuro-cognitive psychologists (2), and app programmers (2). The team was led by a behavioural scientist and discussed weight management, barriers and facilitators to weight management, findings from the systematic review, qualitative interviews, and expert and service user workshops (see below).

4.1.1.2. Qualitative study

Semi-structured interviews were conducted with 20 overweight and obese adults who were trying to lose weight using internet-based weight management programs within a primary care setting. The full topic guide and more detailed methods are reported elsewhere (van Beurden, Simmons, et al., 2018). These interviews aimed to identify (1) facilitators and barriers to digital behaviour change intervention uptake, engagement, and continued use, (2) behaviour changes made and strategies used, and (3) any additional unaddressed needs for making behaviour changes for weight loss.

4.1.1.3. Service user and expert consultations

In addition to the intervention development group, two other stakeholder consultation groups were convened. An existing local service user group involved in the development of a separate group-based intervention focused on weight loss maintenance were approached and invited to attend a workshop focussed on resisting impulses and temptations. This service user involvement group (n = 10; 90% female) consisted of people who had tried to lose weight or maintain their weight loss through various methods and were all educated professionals. An expert group was convened separately. An email was sent to University of Exeter staff inviting those with expertise and interest in behaviour change and/or weight management to take part in an intervention mapping workshop. This group of experts (n = 10; 60% female) consisted of people with expertise in behaviour change theory, techniques, eHealth, and the development of weight management and other behaviour change interventions. These consultation groups were led by the lead researcher (SvB) and discussed facilitators and barriers to the reduction of unhealthy eating behaviours, potential strategies to facilitate impulse management, and the potential targets for change. Session plans with topic guides were used to facilitate the workshops (See Appendix 4) and worksheets were provided to attendees to prompt idea generation (See Appendix 5 and Appendix 6). Two summary reports were created, one for each consultation (See Appendix 7 and Appendix 8), to collate the ideas from the different worksheets. The themes identified in this report were used to populate the needs assessment synthesis table (See Appendix 9).

4.1.1.4. Systematic review

A systematic review (van Beurden et al., 2016) was undertaken which aimed to: (a) identify a range of possible techniques to facilitate impulse management, (b) describe the mechanisms targeted by such techniques to identify modifiable “impulsive” determinants, and (c) synthesise available evidence on the effectiveness of these techniques to help inform intervention development. The full details of this review are reported in Chapter 3 (van Beurden et al., 2016).

4.1.1.5. Review of additional literature

An informal review of the literature was undertaken (SvB) on (a) factors affecting eating behaviour, (b) factors influencing engagement with digital interventions, and (c) current national guidance for weight management interventions.

4.1.1.6. Analysis and integration of needs assessment data

To synthesise the needs assessment data, summary reports and findings from the above sources were thematically coded (SvB) to identify common and contrasting themes. These were represented in a “needs assessment synthesis” table (Appendix 9) which was then discussed and agreed by the intervention development group. The focus of this synthesis was on identifying (a) targets for behaviour change (from here on referred to as performance objectives) and (b) their associated modifiable determinants. Using triangulation (O’Cathain, Murphy, & Nicholl, 2010) the performance objective themes were assessed for agreement, disagreement, or silence (Appendix 10). Areas of disagreement were further discussed with the intervention development group to identify the causes of disagreement and to seek resolution. The resulting themes were organised into a logic model of the problem (See Figure 4.3).

4.1.2. Results of the needs assessment

4.1.2.1. Intervention development group

Early discussions with the intervention development group, guided by the overview of the literature presented in Chapter 2, highlighted the importance of managing impulsive processes that influence unhealthy eating behaviour (excess energy intake) and lead to weight gain. The development group identified key ways in which impulses could result in unhealthy eating. In particular, impulses were agreed to affect the (a) initiation of unplanned eating, (b) type of food or drink consumed, and (c) amount consumed in one sitting. The modern obesogenic environment was expressed to be a crucial influence on the initiation of food-related impulses. An obvious intervention strategy highlighted in these discussions was to identify situations where implicit motives to engage in unhealthy eating behaviour are likely to be salient and develop strategies to help individuals anticipate and manage the cues that can trigger eating impulses, or to avoid the cues altogether. It was suggested that as impulsive processes drive behaviour on a moment-to-moment basis, any intervention targeting such processes related to eating behaviour would benefit from being accessible at any time.

Delivery methods of traditional weight management interventions (e.g., group-based, face-to-face) were not considered to be appropriate as they do not allow for the provision of in-the-moment intervention. Instead, the intervention development group highlighted smartphone technology as a promising delivery platform as people tend to have their phone with them most of the time and look at it frequently (Boschen & Casey, 2008; Miller, 2012; Morris & Aguilera, 2012). This pattern of smartphone use means that the intervention could be accessed whenever and wherever the user requires it most, allowing for the provision of the desired "in-the-moment support". Aside from being accessible, potentially cost-effective and scalable, mobile technologies such as smartphones have sensors which could identify when a person may be most vulnerable to influences that lead to unhealthy behaviours (e.g., Global Positioning System (GPS) and accelerometer). Moreover, digital interventions have been shown to be effective for modifying a range of health behaviours (Webb et al., 2010). Finally, programme engagement was considered crucial to effectiveness. Therefore, engagement with the intervention was highlighted as an important performance objective to consider throughout the development process.

4.1.2.2. Qualitative study

The qualitative study with overweight and obese patients identified a range of facilitators of, and barriers to, using web-based interventions to support weight management and recommendations for future development which are reported in detail in van Beurden, Simmons, et al., 2018). Although self-monitoring is considered an effective behaviour change technique in the literature and participants in this study found this intervention strategy motivating at first, over time they perceived the act of tracking calories to be effortful which resulted in reduced self-monitoring of behaviour. They felt knowledgeable about what was and was not considered healthy food, but felt current interventions were not focussed on strategies for dealing with portion sizes and temptation resistance for snacking between meals. In addition, participants recommended the use of smartphones as a delivery platform for weight management interventions to overcome some of the barriers to solely computer-based interventions (e.g., limited access). The interviews highlighted that programme engagement is susceptible to many barriers, including appeal of the interface, the effort required to engage with the intervention strategies, and ease of access to the intervention. Minimising these barriers may therefore be key to facilitating an individual's adherence to a programme and maximising the potential for programme success.

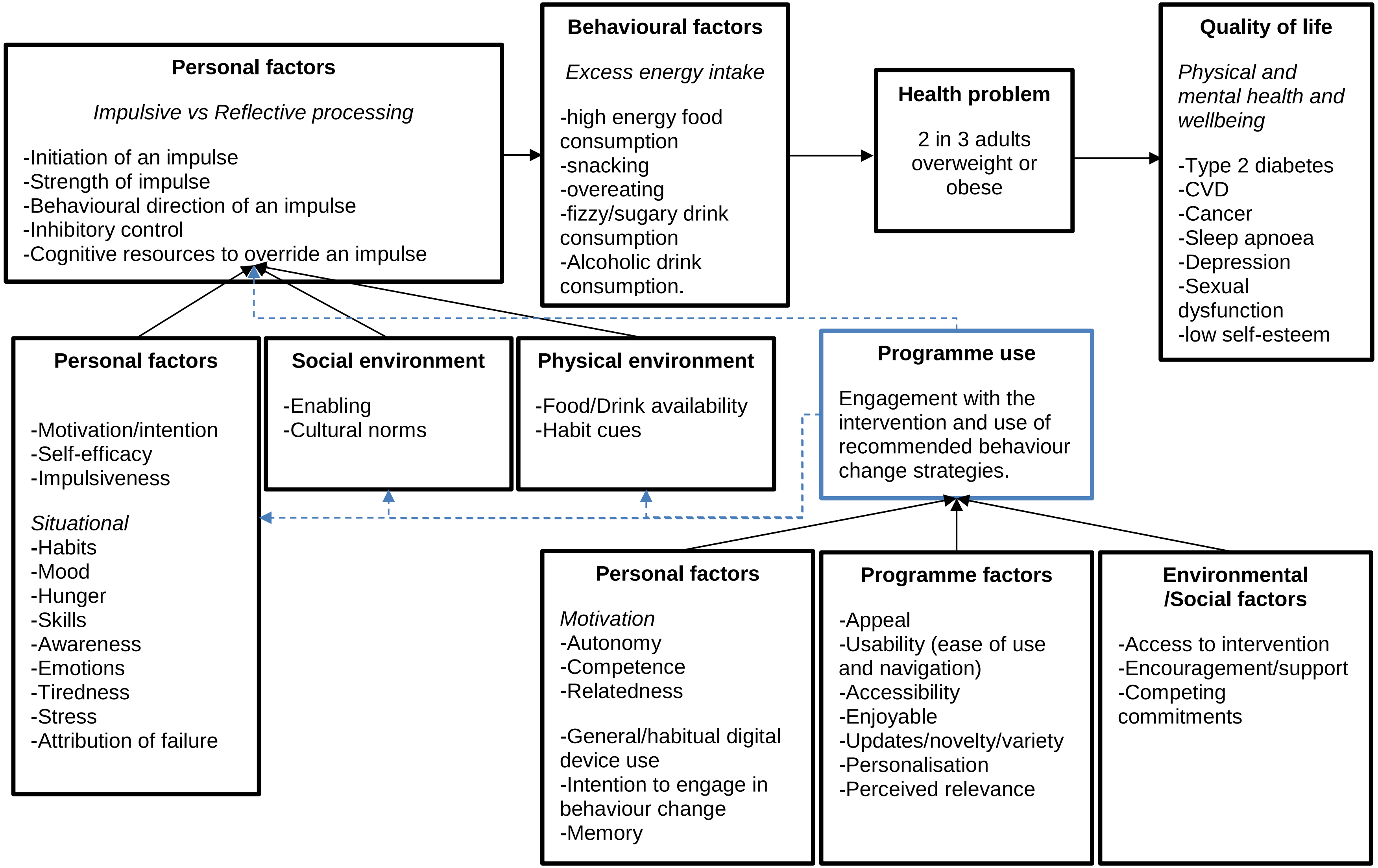


Figure 4.3 Logic Model of the problem and ImpulsePal

4.1.2.3. Service user and expert consultations

The service user and expert consultation groups discussed key targets for change, including reducing (a) unplanned eating, (b) unhealthy (high energy) food or drink choices, and (c) the amount eaten in one sitting, and facilitators and barriers to achieving these. Both service users and experts considered influences such as a lack of willpower or self-control, the abundance of cues in the environment, low self-efficacy, and bad habits as significant barriers to resisting unhealthy food choices. Strategies such as eliminating *internal needs (i.e., hunger*) and altering the *environmental cues* (e.g., buy food online, bring less money) were offered as potential ways of reducing unhealthy food choices. Habits, environmental cues, emotions, boredom, hunger, social influence, and accessibility were considered barriers to reducing unplanned unhealthy snacking, whereas availability of healthy options, removal of cues and access, and increasing confidence were regarded as potential strategies to overcome these barriers.

Another issue discussed at the workshops was overeating in one sitting, for which the barriers suggested were habits, social influence, self-control and environmental cues (e.g., food on the plate, portion sizes, multi-packs). Strategies for overcoming these barriers to stop overeating included using smaller plates, bringing the act of eating into conscious awareness, recognising risk and avoiding situations where overeating may occur (e.g., buffets). When asked about social pressures, particularly resisting social influences to eat unhealthily, service users expressed a lack of confidence to resist social influence and motivation to adhere to health behaviours as considerable barriers. Strategies suggested to overcome such barriers, or for dealing with social pressures, included goal reminders, mobilising social support, and planning. The expert consultation also highlighted that alcohol drinks are not only high in energy, but consumption of alcohol also acts as a potential facilitator of overeating and unplanned snacking.

4.1.2.4. Systematic review

The systematic review of the literature on techniques to modify impulsive processes related to unhealthy eating is reported in Chapter 3 (van Beurden et al., 2016). The review identified 17 distinct techniques that either (1) targeted the impulsive system directly by attempting to modify the generation or strength of impulses triggered by specific stimuli (impulse-focused techniques), or (2) aimed to engage the reflective system or cognitive resources in identifying and suppressing or otherwise managing urges or cravings before they are acted on (reflective techniques).

Of the 17 techniques identified, potentially promising evidence based on our pre-specified quality criteria; See Table 3.1 in Chapter 3) was found for one impulse-focused technique (physical activity) and two reflective techniques (implementation intentions and visuospatial loading). There was mixed evidence for mindfulness-based strategies and inhibition training. However, the better quality evidence included in the review was in favour of mindfulness-based strategies, and the evidence for inhibition training has since been strengthened following more recent research not included in the review (Allom et al., 2015; Lawrence, O'Sullivan, et al., 2015; Lawrence, Verbruggen, et al., 2015). Overall, the evidence for the techniques was limited by the use of lab-based settings with primarily female student samples, and short term follow-ups (e.g., post-training effects or up to one-week of follow-up). The MRC Framework states that "Best practice is to develop interventions systematically, using the best available evidence and appropriate theory," (Craig et al., 2008, p.8). The comprehensive systematic review identified the available evidence and the use of the quality criteria in categorising the evidence allowed the identification of "best available" evidence. Nevertheless, the evaluation of impulse management techniques is a novel and emerging research field, and the best available evidence has shortcomings, particularly in terms of its external validity. It is therefore important for any intervention incorporating such techniques, including the current intervention, to generate further evidence on their long-term effectiveness in wider settings and populations.

4.1.2.5. Review of additional literature

Further literature highlighted mechanisms by which impulsive processes might affect eating behaviour. Impulsive processes are proposed to guide behaviour based on hedonic reward-based motivations or habitual routines and are triggered by situational cues, such as tempting stimuli (Hofmann et al., 2008; Papies, Stroebe, & Aarts, 2007). These processes can result in mindless eating, including making unhealthy food choices and overeating, particularly if there are deficits in executive functioning, or if self-control resources are depleted (e.g., Allan, Johnston, & Campbell, 2010; Guerrieri et al., 2007b; Hagger et al., 2013; Nederkoorn et al., 2009).

Various factors may influence the “tug-of-war” between the impulsive and reflective systems. Initially, the reflective system needs to be engaged, or primed to override impulsive responding. However, there are several situations under which executive resources required for deliberative /reflective processing may become depleted (often referred to as ego depletion; Hagger, Wood, Stiff, & Chatzisarantis, 2010). These include *times of stress, tiredness, when engaged in multiple tasks (busy), and when trying to regulate behaviour or emotions* (e.g., quitting smoking or resisting food temptations or trying not to get angry; Baumeister, Vohs, & Tice, 2007; Hagger et al., 2010). When these resources are depleted people are more likely to give into food temptation and consume excess energy (Hagger et al., 2013; Hofmann, Rauch, & Gawronski, 2007a; Vohs & Heatherton, 2000).

The strength of the impulse to be controlled also influences the outcome. The stronger the impulse, the greater the likelihood of self-regulation failure (Baumeister & Heatherton, 1996). In addition, there are factors that affect whether an impulse is triggered in the first place such as food availability, portion size (Wansink, Painter, & North, 2005), habit cues (Verplanken & Aarts, 1999), and other situational cues (Papies, 2016). Alcohol consumption was identified in the literature as both a behavioural risk factor of obesity due to the extra "calories" that are consumed (Public Health England, n.d.), as well as a factor that predisposes unhealthy food intake and overeating. Acutely, alcohol impairs the ability to inhibit impulses directed towards food and increases food intake (Ferriter & Ray, 2011; Yeomans, 2004).

4.1.2.6. Synthesis of needs assessment data

Overall, the intervention development group agreed that the programme outcome should be weight loss and prevention of weight (re)gain in adults with a BMI of 25kg/m^2 or higher, and that the focus of the intervention would be dietary change to support weight loss. More specifically, the intervention needed to promote changes in (a) unplanned snacking, (b) unhealthy food or drink choices, (c) the amount eaten in one sitting, and (d) engagement with the programme. Thus, the overarching behavioural programme outcome is specified as "Reduction in dietary intake". The needs assessment synthesis table (Appendix 9) summarises the data from the above sources which was then used by the intervention development group to derive a set of potential performance objectives for the intervention.

4.2. Step 2: Specification of Outcomes, Performance Objectives and Change Objectives

4.2.1. Methods

The second step involved the detailed specification of who and what needed to change and how the programme outcome would be achieved. The potential objectives suggested by the needs assessment (above) were examined by the research team and the service user group to assess which objectives to prioritise. At the end of the service user group consultation, attendees were asked to prioritise targets for change based on their importance and achievability. They rated their top three most important (and achievable) objectives and identified possible facilitators of, and barriers to, the achievement of the objectives. The performance objectives were then further scrutinised by behavioural scientists (CG, JS, SvB) to identify the specific impulsive (and other) determinants of behaviour that would be useful in changing each performance objective. This task included reflecting on the facilitators and barriers identified in the qualitative study, consultations, and research literature.

The next stage in the mapping process required that change objectives of the interventions be stated to reflect actual changes that need to occur in the modifiable determinants for the performance objective to be achieved. This specification task involved creating a matrix of change objectives where performance objectives were cross-referenced with modifiable determinants and change objectives were formulated in the intersecting cells (See the first three columns of the table presented in Appendix 11. This table combines various tasks from the Intervention Mapping process into one overarching intervention map of ImpulsePal).

4.2.2. Results

The prioritisation task highlighted that, from a service user perspective, reductions in unhealthy food choices and overeating were the most important achievable objectives. Although social pressure came up as a barrier in the session a number of times, during prioritisation, the performance objective of resisting social pressures was rated the lowest. This low rating may reflect perceptions of achievability rather than importance. In addition, resisting unhealthy snacks was rated second to last. In consultation with the intervention development group and as a result of discussion with the service user group following the prioritisation task, this objective was later combined with reducing unhealthy food choices. The intervention development group refined the wording of the final selected performance objectives (Table 4.1). The intervention development group also agreed that alcohol and sugary fizzy drink consumption would be additional performance objectives as both are risk factors for excessive energy intake (See Step 1). Finally, to minimise barriers to uptake and use of the intervention and its strategies, programme engagement was specified from the outset as a key performance objective (See Table 4.1).

Table 4.1 Overall programme outcome and final agreed performance objectives

Programme outcome	Performance objectives
Reduction in dietary intake	• Individual reduces weekly frequency of unhealthy snack/food consumption. • Individual reduces frequency of overeating episodes (over a 28-day period). • Individual reduces weekly fizzy drink consumption. • Individual reduces weekly alcoholic drink consumption. • Individual effectively engages with the intervention.

The next task in step 2 was to specify how these performance objectives were to be achieved. Table 4.2 shows selected examples of change objectives for one of the performance objectives cross-referenced with a selection of the associated determinants. The full intervention map, including all other objectives, can be seen in Appendix 11.

Table 4.2 Example performance objective cross-referenced to determinants

	Determinants		
Performance objectives	***Initiation of impulse***	***Strength of impulse***	***Inhibitory control***
PO1. Individual reduces weekly frequency of unhealthy snack/food consumption	I.I. 1. Prevent initiation of impulse to eat unhealthy snack /food.	S.I. 1. Reduce strength of impulse to eat unhealthy snack /food.	I.C.1. Engage inhibitory control to inhibit behavioural responses towards unhealthy snack /food.
	I.I. 2. Initiate impulse to engage in alternative /healthier action.	S.I. 2. Engage strategies to cope with the strength of an impulse to eat unhealthy food /snack without eating.	
	I.I. 3. Identify personal cues /triggers that initiate impulses to eat unhealthy snacks and food.	S.I.3 Identify where strong impulses /cravings to eat unhealthy snack /food may occur.	

4.3. Step 3: Selection of Theory-Based Methods and Practical Strategies

4.3.1. Methods

The third step of Intervention Mapping involves choosing intervention techniques to influence the change objectives. For each change objective of each determinant, change techniques likely to alter the determinant were selected (Bartholomew et al., 2011). The selection of techniques drew on the systematic review conducted during the needs assessment to identify impulse management techniques (van Beurden et al., 2016) and the discussion during the service users workshop about possible ideas (strategies) to overcome barriers to change. A framework of theoretical behaviour change processes (the Theoretical Domains Framework; Michie et al., 2008), and a taxonomy of 93 behaviour change techniques (Michie et al., 2013) were also consulted. Techniques were selected based on the evidence for the techniques in their ability to modify specific determinants (as identified in the systematic review (van Beurden et al., 2016)) and the expert knowledge of the intervention development group. The intervention development group then discussed the resulting intervention map (See Appendix 11) which includes the performance objectives, modifiable determinants, change objectives, and the theoretical methods and practical strategies, to assess the appropriateness of the selected techniques and decide whether they were comprehensive in targeting the specified change objectives.

Results

Six key impulse management techniques were selected from the systematic review; (a) visuospatial loading, (b) inhibition training, (c) implementation intentions, (d) mindfulness-based strategy, (e) physical activity, and (f) situational priming. Additional techniques, such as behavioural practice and prompts/cues were included to facilitate engagement with the intervention and the strategies. How the selected intervention techniques relate to each specific change objectives and their determinants is illustrated in the full intervention map provided in Appendix 11.

4.4. Step 4: Creating the Programme

4.4.1. Methods

The next step in the Intervention Mapping process was to create an organised, structured programme. This step entailed defining the scope and the limitations of the intervention, translating the change techniques specified in step 3 into specific programme materials and identifying appropriate and feasible delivery methods.

The intervention development group discussed and guided the scope, selection of operational strategies, the feasibility of delivery via a smartphone app, and sequencing of the intervention components. Discussions with app developers focussed on the practicalities of each technique and their form within the intervention. Service-users (n=6) provided feedback on the textual content of a prototype app, the clarity of the written instructions, the flow of navigation, and any technical issues that arose (See Step 5). Usability and navigational issues were further assessed via individual “thinking aloud” testing sessions with two service users, during which the individuals were asked to continuously verbalise their thoughts as they moved through the prototype app. Any issues or misunderstandings were noted and addressed.

4.4.2. Results

The intervention was designed to be entirely self-delivered and interactive, allowing users to identify and specify personal barriers to unhealthy eating, identify strategies to overcome these barriers, and to track the usefulness of any impulse management techniques that they tried. Users register with a username and password. On successful registration, an additional thumbnail is added to users' smartphone home screen which functions as the "Emergency Button". Finally, users are presented with the app's welcome page, which provides information about what eating-related impulses are, when they might be triggered, and how they might be perceived (e.g., temptation, craving, desire). It also provides information about how users can identify their own triggers and a brief introduction to the app: "*This app will help you manage your impulses to avoid unhealthy eating. You will find a variety of tips and tricks from brain training to defence strategies such as if-then planning which you can apply in the heat of temptation."* The introduction is followed by a page asking users about their main motivation for losing weight and their key struggles in weight loss.

Once users have entered this information, they are directed to the main menu. The main menu (See Figure 4.4) acts as the home screen for the app and displays navigational buttons to return to the information about the app, the motivations page, and self-monitoring statistics on the user's progress with developing "temptation resistance". This main menu also displays navigational buttons to the five key components of the app: (1) Brain Training, (2) My Plan, (3) Urge Surfing, (4) Danger Zones, and (5) Emergency Button. These are described in turn below. Feedback from the service users on the prototypes is summarised in Table 4.3 which highlights the actions taken to address the issues raised (See Appendix 12 for additional screenshots and costs of development and ongoing maintenance).

Figure 4.4 The ImpulsePal app

Table 4.3 Key changes after prototype usability testing.

Screen	Issues identified in feedback	Action taken	Further issues raised in think-a-loud
Log in	Log in page is wordy.	Replaced: "Please enter the participant number and password that you were provided with." With "Log in"	
Welcome!	Too many boxes of text to open.	Provided a mix of textual content in drop-down boxes and as normal text.	Small typo.
		Incorporated a social dialogue tone: "Struggle with temptations? You are not alone" "That's why I am here."	
Motivations	Usually has some default text in the boxes to prompt writing.	Greyed out "Insert text" added in the user-entry boxes.	
Main Menu	Looks like a menu, but to be consistent with the other pages it is nice to know where this screen is within the app.	Main Menu (Header bar) added to menu page.	
	Like the two buttons that pop up when touching the ImpulsePal menu button.		

If-then plan instructions	Too many dropdown boxes with text again.	Provided a mix of textual content in drop-down boxes and as normal text. Only keeping the text following “if” and “then” in text-boxes.	Takes a while to read, but acknowledged necessary and text is not overwhelming.
	When all boxes are opened there is too much text on the screen.	Rule incorporated that only one text drop-down box is open at a time. (e.g., opening the next closes the previous)	
If-then plan	Unclear what to do next.	Removed the “then” drop down list to encourage choosing an “if” situation first. On selection of the “if” component, the then list appears.	
Urge-surfing instructions	Need more information about the technique and how to use it.	Incorporated more information about how the technique works in a drop-down text box.	Takes a while to read, but acknowledged necessary and text is clear and not overwhelming.
	Are there any examples?	Added links to general video on acceptance and commitment therapy, and mindful eating (initially in the STOP acronym).	
Urge-surfing	Too many open drop-boxes.	Removed lists and used sentences instead.	Video link doesn’t work.
	The lists under the drop-boxes make it difficult to read. Doesn’t flow.	Moved the links to the videos to the instructions page.	

	The practice and proceed drop-box has links out of the app. Doesn't look right here.		
Brain training instruction	Typo.	Changed text.	
	No need for the separate drop-down text boxes.	Merged the specific instructions into one drop-down box ("What do I have to do?"	
Brain training	Screen changes to landscape without warning.	Added a screen prior to the game session to say: "Place your phone in landscape mode", with an image to indicate change in direction.	
Danger Zones instructions	This prototype version doesn't do anything yet, like the idea.		Location reminder isn't going off.
Emergency button	It has added more than one emergency button to home screen.	Checked and fixed coding bug.	
Emergency button event question	N/A		
Overall	Not easy to navigate between the different components.	Added a bottom navigational bar to navigate back to home (main menu), emergency button, brain training, My plan, and motivations.	

Brain training operationalises the technique of inhibition training. In the instructions, users are informed that the brain training will help them inhibit motor impulses that are triggered when they see food. This training involves a Go/No-go task ((van Koningsbruggen et al., 2014)) and is presented as a game which provides feedback in the form of scores. During the game, users are presented with images of unhealthy food and neutral images. Only one image is presented on the screen at any given time and 100ms following presentation of an image a Go or No-go cue is presented. These cues are displayed as a green “Go” sign and red “Stop” sign, with neutral images consistently pared with a Go sign and unhealthy food images with the Stop sign. When a green Go sign appears on the screen, users need to touch the side of the screen where the image appeared. They are instructed to withhold touching the screen when a red Stop sign appears. Images are presented at random and before the next image is presented users are provided with performance feedback, with points given based on their correct response and reaction time. Two points are deducted for an incorrect response. All users are encouraged to play the 5-minute brain training game three times per week for four weeks and are prompted to engage with the feature via in-app reminders if the game has not been played on two consecutive days during the first four weeks.

My Plan operationalises implementation intentions in the form of if-then plans. This component presents users with a form where plans can be selected or created. Users are instructed to keep their overall goal in mind and to think of situations that could prevent them from achieving their goal. They are offered existing if-then plans which include common situations where people may struggle with eating-related impulses (“ifs”) and responses to deal with those situations (“thens”), which were derived from the two workshops and qualitative study. Alternatively, users can create their own if-then plans. Multiple if-then plans and amendments can be made and saved at any time.

Urge Surfing is a mindfulness-based strategy that helps users deal with in-the-moment temptations and cravings by reducing the intensity and frequency of cravings. This component provides users with information on how and when urge-surfing can be used and textual instructions which follow the steps: **S**top, **T**ake a breath, **O**bserve and imagine, and **P**ractice and proceed. The instructions encourage users to imagine cravings to be like waves which may build over time, but eventually subside and pass. Users are also encouraged to practice this technique in the absence of a craving.

Danger Zones makes use of smartphones' location function (GPS) to enable users to create location and time specific (situational) cues for themselves (thereby operationalising the priming technique). This requires users to identify their own "high-risk situations" for unhealthy eating that are location specific. Once a location has been selected on the map, users can link the particular location to their own specified goal for the location, which requires identifying the problem and problem-solving in advance. Whenever the smartphone location service (i.e., GPS) detects that the smartphone has entered the selected location, the app sends a notification which is presented in the notification bar. This notification reminds users of their specified goal for that particular location. The Danger Zones component also allows users to select "time boundaries" to more precisely define the high-risk situation. For example, if the location is only ever a personal trigger for unhealthy behaviour during lunch hours, then a notification outside these hours would not be helpful.

The Emergency button is a separate function of the app which enables users to access strategies to deal with the craving "in-the-moment", and (following such events) to record which strategy was chosen and how well the strategy worked. Users are encouraged to use the emergency button whenever they experience a strong craving or temptation. On pressing the emergency button, users are presented with a message congratulating them on putting their impulse on hold. The background of this screen consists of dynamic visual noise in the form of television static, which provides visuospatial loading (as described in Step 3). The next screen displays options for accessing if-then planning, brain training, or urge surfing to choose from (Figure 4.4), with their selection recorded.

Fifteen minutes after an emergency button event (when a user has indicated that a craving is particularly strong and that they required extra help), the app sends a notification that asks users about the strength of their craving at the time. Users are prompted to respond by rating their craving from 0 – 100 using a slider displayed on a visual analogue scale ranging from "very weak" to "extreme" craving. The craving scale is followed by a question about whether they were (a) successful, (b) partly or mostly successful or (c) not successful in resisting the urge to eat. The answer to this question is recorded and followed up with an associated message (e.g., congratulatory message or a message normalising a lapse and to encourage learning from the experience and continuing to practice). The statistics page found in the main menu displays the number of uses of the emergency button for the week and in total, and the success rate for resisting cravings using if-then plans, brain training, and urge surfing based on the users' answers to the prompt questions. Users are encouraged to try all techniques and use their statistics to review which techniques are most useful for them personally.

4.5. Step 5: Adoption and Implementation Plan

4.5.1. Methods

In this penultimate step, an adoption and implementation plan was created. As our study concerned a self-delivered eHealth intervention, the focus was on how the intervention could and should be distributed, informed by literature about factors influencing digital technology uptake and use. This step also involved including strategies within the intervention to facilitate sustained engagement (See step 2 and 3) informed by the qualitative study described in Step 1 and the informal scoping review. The intervention did not require a programme facilitator; therefore no training manuals were required. However, as the programme is not facilitated, the clarity of instructions and usability and navigation for users was very important. Clarity of instructions and further textual content in the app was addressed by giving a prototype to service users (n = 6) and asking them for feedback and suggestions for improvements. The service users were also asked to provide feedback on the navigation and flow of the prototype and to highlight any technical issues they may encountered. Usability and navigational issues were further addressed via individual thinking aloud testing sessions (See Step 4).

4.5.2. Results

Literature reviewed indicated that the UK user base for smartphones reached 81% of the population in 2016 (91% among 18-44 year-olds) and that smartphone use continues to permeate daily life (Deloitte, 2017). Thus, the potential reach of a smartphone-based behaviour change intervention is substantial. However, the qualitative study (Step 1; van Beurden, Simmons, et al., 2018) highlighted various facilitators and barriers to digital intervention uptake and use which informed development by ensuring determinants of programme engagement were addressed (Step 2 and 3).

Further facilitators and barriers were identified in a recent longitudinal qualitative evaluation of a national digital health innovation programme in the UK (Lennon et al., 2017). It highlighted that accreditation and clinical endorsement strongly influence the adoption and implementation of digital technologies. NHS Digital in the UK has recently launched two new digital platforms to make sure that leading healthcare apps are accessible and can be trusted by the public: (1) NHS Digital Apps Library (NHS Digital, n.d.-a) and (2) a Mobile Health space for developers (NHS Digital, n.d.-b). The library will use the labels “being tested in the NHS” or “NHS approved” and each hosted healthcare app will have to go through an assessment to ensure it is safe to use. To facilitate uptake in the longer term, we therefore plan to get our app-based intervention assessed, validated, and hosted on the NHS Digital Health Apps Library. To further address the issue of being trustworthy concerning data protection and confidentiality, we also make clear within the app that data collected are encrypted and stored anonymously at the University of Exeter owned servers, and no data are shared with third parties.

In addition, the intervention will be downloadable from commonly used app stores and download websites. Depending on its effectiveness we may issue press releases to raise awareness. In addition, local organisations with whom we are already working will be encouraged to refer people to the intervention through their ongoing health promotion programmes and official websites.

4.6. Step 6: Evaluation Plan

The final step of the Intervention Mapping process involved creating an evaluation plan. Briefly, this consisted of a protocol for an initial feasibility randomised controlled trial (RCT) with nested process evaluation, incorporating two cycles of action-research to refine the intervention in close collaboration with its intended users (See Chapter 5 and Chapter 6). If the study shows that the intervention is feasible, the next step of the evaluation would be to progress to a fully powered RCT to investigate the effectiveness of the intervention and further process evaluation to explore and optimise the mechanisms of action.

4.7. Discussion

This chapter describes the systematic development of a smartphone app-based weight management intervention. To our knowledge, ImpulsePal is the first app comprehensively designed to explicitly target impulse management processes for dietary behaviour change to facilitate weight loss. The app was iteratively developed using the Intervention Mapping protocol (Bartholomew et al., 2011). This protocol enabled us to consider behaviour change theory, incorporate evidence-based change techniques, and co-create the app-based intervention with potential end-users and experts in a systematic way. Thus, following the MRC framework which recognises the importance of, and encourages the use of methodological rigour at the development stage (Craig et al., 2008).

Clear and transparent systematic descriptions of behaviour change interventions are lacking which has led to calls for increased reporting of intervention development studies and clearer reporting of intervention content in evaluation studies (e.g., Abraham et al., 2015; Hoddinott, 2015). Although the process is time-consuming and can be resource- intensive, its systematic approach ensured that all ImpulsePal components were practical translations of change techniques that targeted our specific change objectives and thus the associated determinants of the behavioural targets. Using this approach enhanced transparency, provided a clear framework for evaluation and process evaluation, and facilitates replicability. It also maximises the potential of the intervention to accomplish the desired outcome of weight loss.

Unlike most other digital weight loss interventions (Tang et al., 2014), ImpulsePal is designed to address both impulsive and reflective processes. As well as action-planning and self-regulation tools (which are widely used in other weight management apps; Bardus, van Beurden, Smith, & Abraham, 2016), ImpulsePal provides in-the-moment support where temptations cause difficulty for successful self-regulation (Baumeister & Heatherton, 1996) and offers strategies to manage impulsive and automatic behaviour (Hofmann et al., 2008; Marteau et al., 2012; Strack & Deutsch, 2004). This approach acknowledges that good intentions are not always enough to prevent lapses and therefore that additional support may be required at crucial times. A smartphone-app delivery platform allows the provision of 24hr easy access to the intervention and the inclusion of an “Emergency Button” feature emphasises this element of the programme.

4.8. Strengths and Limitations

This is one of the few studies to describe in detail the systematic development of a smartphone app-based weight management intervention. It used rigorous methods to move from a sound theory and evidence base to practical intervention techniques and strategies, whilst incorporating strong service user involvement (Craig et al., 2008; Yardley, Ainsworth, Arden-Close, & Muller, 2015). Although the intervention has been developed in a UK context, it may be suitable (with proper translation and adaptation) for use in a wide range of countries and cultures. There is no evidence that impulsive processes are culturally patterned (although triggers may be culturally specific, the process itself is not), and the app does not include any country-specific information content. One element that would require cultural adaptation is the Brain Training component consisting of the Go/No-go task, which includes pictures of common foods eaten in the UK. Adaptation of the images based on culturally appropriate food preferences would, therefore, be advisable.

Several limitations need to be acknowledged regarding the use of IM. Firstly, due to its iterative and comprehensive nature, as has been reported in other development studies using Intervention Mapping (Gillison et al., 2012; Lloyd et al., 2011), it is a time-consuming and resource-intensive process. Secondly, definitions of what constitutes a performance objective, a determinant or behaviour change technique can become blurred. Using a behaviour change technique can be considered a behaviour in itself and could, therefore, be mapped with its own *determinants*. For example, to use our mindfulness-based Urge-Surfing strategy an individual requires *knowledge* about when, where, and how to use urge-surfing, they may need to increase their *skill* and *self-efficacy* to effectively make continued use of the technique. This can make it difficult to distinguish where mapping of the “active ingredients” in the intervention ends, and considerations regarding receipt and enactment of the intervention (i.e., appropriate implementation of the techniques by individuals) begin.

Furthermore, determinants can be considered at different levels of specificity. For example, impulsive processes can be broken down into the initiation of an impulse, strength of impulse, behavioural target/direction of an impulse, and initiation of an impulse can be broken down into attentional bias, presence of cues, and activation of associated neuronal clusters. As such, the complexity of this process affects replicability whereby different techniques may be considered depending on at what level of specificity the change objective is formulated. Despite the systematic steps and transparency enabled by the Intervention Mapping protocol, it is probable that a different intervention development group using the same methods would produce a different intervention. Throughout the process, decisions were based on available evidence, appropriate expertise (behaviour change experts, app developers, neuroscientists), experience (service users), and practical considerations. Thus, intervention development is a function of these variables and the interaction between those involved in collective decision-making at a particular point in time. Some limitations in relation to the methods used during the Intervention Mapping process also need to be acknowledged. The service user group included educated professionals only. Due to limited resources for the PhD study the service user involvement group were recruited through convenience sampling methods. A more representative service user group may have been recruited via General Practice or weight management groups. Moreover, only two think-a-loud interviews were conducted limiting the potential variety of experiences of using the ImpulsePal app that were elicited. However, the think-a-loud interviews were conducted after initial feedback on the prototype from 6 other service users, therefore most issues had already been resolved. The two think-a-loud sessions were used to identify any remaining technical or navigational issues.

It is also important to acknowledge the limitations with our intervention. Firstly, although some of the techniques do not require motivation to be effective (e.g., Go/No-go task; van Koningsbruggen et al., 2014) the use of the strategies may still be influenced by a motivation to lose weight and willingness to change (Tang, Abraham, Stamp, & Greaves, 2015). Engagement with the intervention was considered as a key performance objective throughout development and to try to increase the likelihood of users maintaining motivation to engage with the intervention, strategies were used to enhance autonomy, competence, and relatedness while drawing on game design elements to increase enjoyability (e.g., Cugelman, 2013). However, the assumption was made that people who decide to download a weight management app are interested and motivated to make changes to lose weight. Therefore, this app may not be appropriate for those who are at risk of weight-related health issues, but do not wish to or are not motivated to lose weight. Secondly, the technological landscape is ever-changing. The research field investigating impulse management techniques is evolving. As described in Chapter 3, although the evidence base is currently limited by the lack of appropriately powered randomised controlled trials using community or clinical samples with long term follow up, new research is rapidly emerging. Adding better quality research to the evidence base may alter conclusions that have been drawn about the effectiveness of the techniques (e.g., research on inhibition training) on the basis of current best available evidence. Therefore, although the intervention may currently be appropriate and fully functional, it is important that it evolves with both technological and scientific advances when required. Thirdly, smartphone apps generally have short life spans. Of 26,176 apps which had peak monthly users in 2011, 2012, and 2013, half lost 50% of their peak number of users within 3-months after reaching that peak usage, although apps used for news and health lose users at a slower rate (Gorden, 2014).

4.9. Future Directions

Further research is now needed to assess the effectiveness and cost-effectiveness of the ImpulsePal intervention. A feasibility RCT (See Chapter 5) with nested process evaluation (See Chapter 6) have been conducted to assess the feasibility of an effectiveness evaluation and the intervention, and to identify areas for refinement. Should the intervention be shown to be feasible and acceptable, the evaluation will progress to a fully-powered RCT. Beyond this, further research might include: (a) assessing effectiveness of the intervention on weight loss maintenance, (b) optimisation of the intervention using factorial designs to evaluate individual intervention components and interactions in terms of effectiveness or increasing the lifespan of app use, (c) implementation research about how the intervention (if effective) could be best integrated with existing health service infrastructure, (d) assessment of the impact of facilitation on intervention effectiveness.

4.10. Conclusions

ImpulsePal is a novel, theory and evidence informed, person-centred app to improve impulse management and promote healthier eating behaviour for weight management. Intervention Mapping was a useful framework for helping to develop this intervention and the resulting intervention map provides clear guidance for evaluation and process evaluation which are reported in the following chapters.

Chapter 5. The feasibility randomised controlled trial of ImpulsePal

5.1. Introduction

As covered in the previous chapters, weight management interventions may benefit from targeting impulsive processes. The growing recognition of the influence of such processes on health behaviours led to the development of a multitude of techniques. These impulse management techniques aim to help people to modify or otherwise manage impulsive processes to facilitate behaviour change (here changes in eating behaviour to support weight loss attempts). The systematic review of evaluations of such techniques (Chapter 3) indicated that some are supported by promising evidence in terms of changing eating related outcomes such as snack intake, craving strength, and body weight. However, studies examining the effects of impulse management techniques had been primarily conducted in lab-based settings, with majority female, student samples (See Chapter 3). Therefore, there was a need to investigate whether such techniques can be adapted into usable and scalable interventions for use in more diverse samples and in real-life settings.

The ImpulsePal intervention was developed using Intervention Mapping methods (Bartholomew et al., 2011) to address needs that are highlighted in Chapter 2 and specified Chapter 4 and builds on the systematic review of the literature concerning impulse management techniques (van Beurden et al., 2016; described in detail in Chapter 3). As described in Chapter 4, the intervention was designed specifically to a) support the reduction in unplanned, unhealthy snacking, and overeating for weight management in people who are overweight, b) include components for which there was promising evidence that they could modify or otherwise assist in managing impulsive processes related to unhealthy eating, and c) have the potential for delivery on a large scale. Therefore, both Chapter 3 and Chapter 4 (as well as the background and rationale built in and Chapter 2) address the development stage of the MRC framework (Craig et al., 2013).

This chapter moves this doctoral research programme to the next stage in the framework, namely, the feasibility/piloting stage (See Figure 5.1) and aims to address the following question: "*Is an effectiveness evaluation of*

ImpulsePal using a randomised controlled trial design with objective measurement of weight, completion of questionnaires, and semi-structured interviews feasible?"

Before a full evaluation assessing the clinical effectiveness of the ImpulsePal intervention can take place, it is imperative to assess the feasibility of (a) conducting an effectiveness evaluation with the planned trial procedures, and (b) delivering a weight management intervention that focusses on impulsive processes to reduce unhealthy eating behaviours via a smartphone app. Assessing the feasibility of trial procedures and the intervention provides the opportunity to identify potential problems concerning trial procedures including recruitment, retention, and appropriateness of measures (described in the current chapter) but also concerning the acceptability to users (described here and in more detail in Chapter 6), compliance, and delivery of the intervention (described in Chapter 6). Feasibility studies can also produce data to help estimate the likely range of potential effect sizes and to estimate the standard deviation in outcome measures proposed for use in a subsequent trial. Therefore, a feasibility study enables the opportunity for refinements to be made to trial procedures the intervention prior to a full evaluation, which would enhance the likelihood of the evaluation being appropriate and successful, and the intervention being effective

This chapter describes the protocol for, and findings of, the feasibility randomised controlled trial (RCT) of the ImpulsePal intervention. The study was designed to a) inform the planning of a fully-powered trial to determine the clinical effectiveness of the intervention in overweight adults and b) inform the refinement of the intervention in close collaboration with its intended users. Data pertaining to the nested mixed-methods process evaluation are reported in Chapter 6. The following text comprises mainly text under review for publication in JMIR uHealth and mHealth, with modifications to minimise repetition.

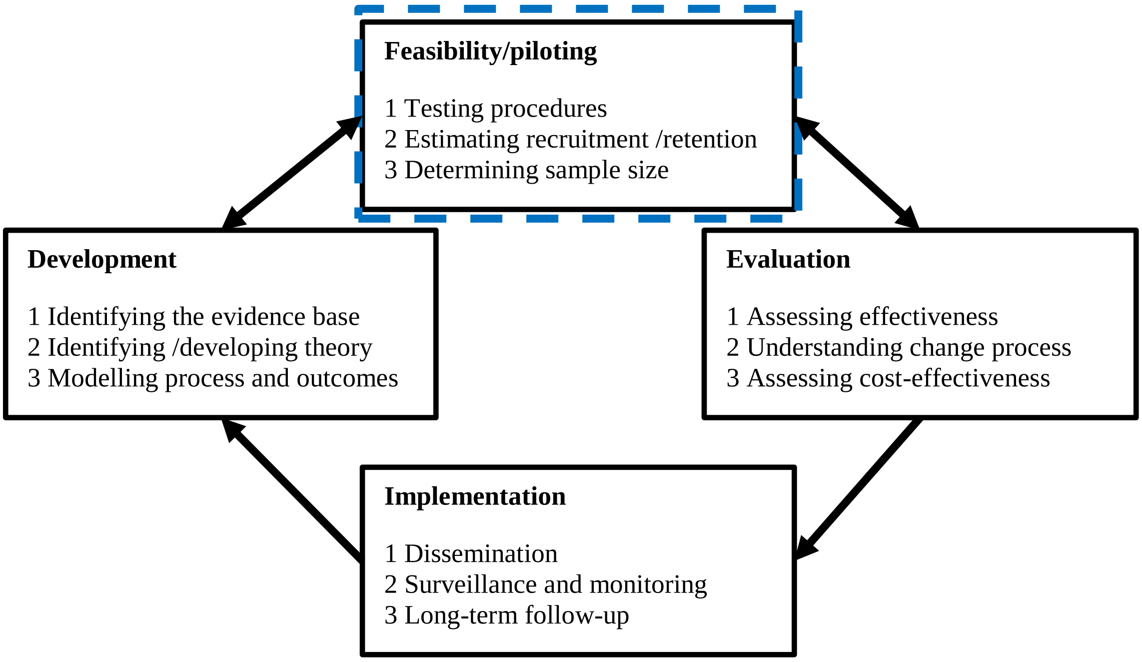


Figure 5.1 Corresponding phase in the key elements of the development and evaluation process, adapted from from Craig et al. (2013)

5.1.1. Objectives

The key objectives for this feasibility trial were to:

- Assess feasibility of the trial procedures, including rates of recruitment, data collection methods and loss to follow up.
- Obtain estimates of the standard deviations of continuous outcome measures to inform sample size calculations for a full-scale trial.
- Assess the usability of, and satisfaction with, the ImpulsePal intervention and trial methods and procedures.

5.2. Methods

This study is reported in accordance with Consolidated Standards for Reporting Trials (CONSORT) recommendations for reporting of pilot randomised controlled trials (Eldridge et al., 2016) and the Template for Intervention Description and Replication (TIDieR) recommendations on reporting of behaviour change interventions (Hoffmann et al., 2014).

5.2.1. Study design and setting

This was a parallel feasibility RCT with a nested quantitative and qualitative process evaluation (See Chapter 6 for the process evaluation).

Participants were randomised in a 2:1 ratio to the intervention or waiting list control arm respectively to maximise data on engagement with the intervention. The study incorporated two cycles of intervention delivery and user feedback. Data collection primarily took place at the University of Exeter Medical School. However, home visits were offered to those who were not able to attend study visits at the university. Refinements were made to intervention content at the end of each cycle, informed by qualitative feedback from participants reported in Chapter 6. Figure 5.2 illustrates the two cycles of intervention delivery and evaluation in this study design. Data from the two cycles are reported together. The study was approved by the UK National Health Service (NHS) National Research Ethics Services Committee South West – Exeter (Ref: 15/SW/0181).

5.2.2. Participants

Participants were recruited between September 2015 and March 2016 for Cycle 1 and October 2016 and April 2017 for Cycle 2 in the county of Devon in the United Kingdom.

5.2.2.1. Eligibility criteria

People were eligible to take part if they: a) were at least 16 years old, b) had a BMI of 25kg/m^2 or more, c) owned an Android-based smartphone, and d) lived within travelling distance of Exeter, UK. Exclusion criteria included: a) pregnancy within the last 6 months, or planned pregnancy during the study period, b) not speaking or understanding written English, c) participation in concurrent weight-related interventional research (though participants could be accessing weight loss services outside of research), d) currently receiving treatment for an eating disorder. Our original protocol required a minimum BMI of 30 kg/m^2 (and 27.5 for specific ethnicities), but we reduced this to 25 kg/m^2 to facilitate recruitment and to capture a broader range of people's experiences with the intervention.

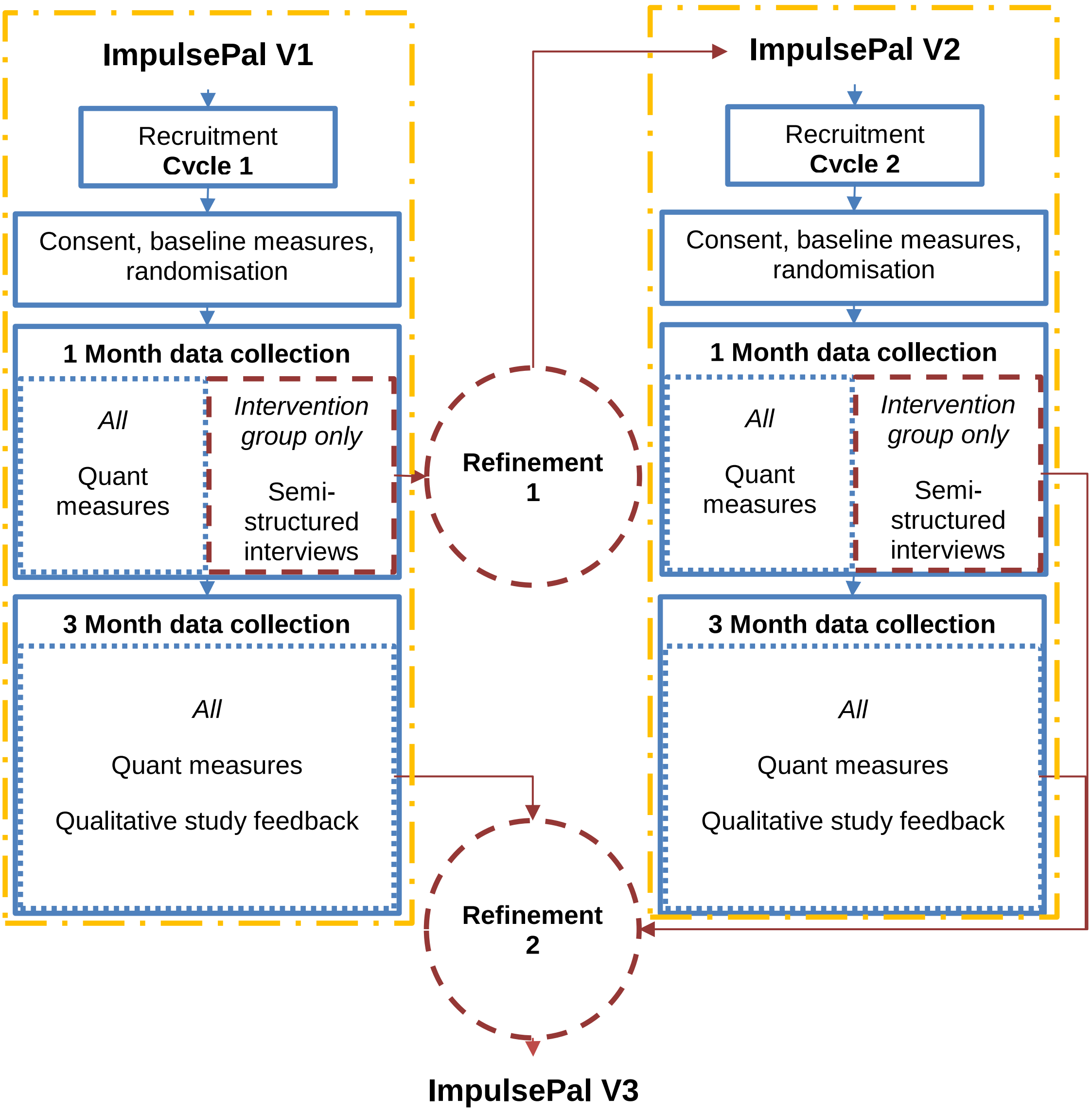


Figure 5.2 Cyclical process of intervention delivery and evaluation using ImpulsePal V1 and ImpulsePalV2

5.2.2.2. Identification and recruitment routes

At the time the study commenced, Tier 2 weight management services operating in Devon were recruiting through referrals from GPs or other NHS health professional. Such referrals were directed to Health Promotion Devon (HPD), a lifestyle hub that helped individuals to select a weight management programme from a range of group and one-to-one options. Once a week, a staff member of the HPD referral hub ran a database search to generate a list of people who met the study inclusion criteria and checked for any recorded exclusion criteria (i.e., pregnancy and referral to concurrent interventional research). Where appropriate, a study invitation on HPD letterhead was sent out with the Participant Information Sheet, a reply slip and a freepost envelope addressed to the PhD student. To allow estimation of the representativeness of the sample recruited in relation to the eligible population, anonymised data including age, gender, (pre-service) BMI, and postcode for all individuals who were invited to take part by HPD were requested.

In the original protocol it was stated that the study would recruit solely through the local Tier 2 (referral to face-to-face lifestyle intervention) weight management service. However, to increase recruitment rate and because the HPD service was withdrawn after commencement of the study, additional recruitment routes were added. These included: (a) displaying study posters in three local GP surgeries, three local gym facilities, and two online local community noticeboards, (b) offering study flyers to individuals referred to local Tier 3 (hospital-based) weight management services in Devon, (c) inserting a study advert in the University's newsletter, (d) and placing two separate adverts in the Exeter 10 000 project's (ExTend: www.exeter10000.org) yearly newsletter. All adverts, posters, and flyers informed potential participants that the study involved a smartphone app for weight management and included the PhD student's contact details for seeking further information about the study.

5.2.3. Procedures

5.2.3.1. Telephone screening

People who expressed interest in the study by directly contacting the researcher (SvB) or returning a reply slip, were contacted by the researcher by telephone. The researcher provided further information, addressed any questions about the study and screened verbally for eligibility. Where not already provided (additional recruitment routes), potential participants were asked for contact details and sent the participant information sheet. Full eligibility screening then took place during a subsequent telephone contact initiated by the researcher. Those who were eligible but declined to participate, were invited to give reasons but were not obliged to do so.

5.2.3.2. Consent and assessment visits

Potential participants who were eligible and provided oral consent to take part were invited to attend a "baseline assessment visit" at the University of Exeter or in their home (if preferred). A baseline invitation pack was sent with information about the visit and a baseline questionnaire for completion in advance. At the baseline visit, after obtaining written consent, the PhD student a) asked for the questionnaire and checked for completeness and understanding, b) took other baseline measurements, and c) randomised the participant to either the intervention or control group. Participants randomised to the intervention group (see below for randomisation procedures) were provided with instructions for downloading and installing the ImpulsePal app and an anonymised username and password. Follow-up assessments were carried out in the same way at one month and three months post baseline. Semi-structured interviews (findings reported in Chapter 6) were conducted at the one month follow up assessment with a subsample of the intervention group (based on willingness and availability to be interviewed). Further feedback was requested at the three-month follow about their trial participation experience.

5.2.3.3. Randomisation

Participants were allocated in a 2:1 ratio (2 intervention: 1 waiting list control) using a centralised web-based randomisation service (www.sealedenvelope.com). The allocation sequence was stratified in an attempt to achieve balance across the groups in terms of gender, age group (16-24, 25-35, 36-54, 55+ years) and BMI categories (<35, 35-40, >40 kg/m^2). Block randomisation was used, with a block size of six, to ensure minimal variation from the desired 2:1 ratio between groups. Following entry of a unique participant number and the participant’s gender, age, and BMI, the participant’s allocation code was generated. The researcher was able to request randomisation either via the web-based interface or via a text messaging service, facilitating a timely randomisation process particularly in cases where the baseline assessment did not take place at the research site. Neither the participant nor the researcher, were aware of group allocation until this point. The same researcher (the PhD student) enrolled participants and assigned participants to the study arms.

5.2.4. Intervention

The development and content of the ImpulsePal intervention are described in detail in Chapter 4. Briefly, ImpulsePal is a self-delivered smartphone app-based weight management intervention that was developed to

a) support the reduction of unplanned, unhealthy snacking, drinking, overeating for weight loss in people who are overweight, b) include components for which there was promising evidence that they could modify or otherwise assist in managing impulsive processes related to unhealthy eating, and c) have the potential for delivery on a large scale. As well as building on the systematic review of impulse management techniques (van Beurden et al., 2016); reported in Chapter 3) the development process involved extensive consultation with service users and behaviour change experts (See Chapter 4). Table 5.1 presents the key components of ImpulsePal comprising techniques informed by the systematic review, b) their respective mechanisms of action, c) recommended timing of use, and d) the operationalisation of the technique into a workable app component. In Cycle 1 participants were provided with ImpulsePal v1 and in Cycle 2 participants were provided with ImpulsePal v2 which resulted from data driven recommendations for refinement (Chapter 6).

As described in Chapter 4 additional components which were identified from service user and expert consultations, and additional literature review were also incorporated. These included an emergency button to provide easy access to the impulse management techniques "in-the-moment". As well as providing quick access to the other techniques (See Table 5.1), the emergency button text screen is displayed against a background of dynamic visual noise to induce visuospatial loading. Fifteen minutes after pressing this button, the app sends a question about temptation strength and whether or not the temptation was successfully resisted. The user is able to monitor their "Stats" (in version 1) or "My resistance" (in version 2) in the form of a table containing information about the number of times a strategy (e.g., if-then planning, brain-training, urge surfing) was selected during an emergency button event and the success rate for each strategy in the previous week and overall. Further strategies were included to enhance engagement with the intervention and behaviour change techniques such as a reminder system and gamification (whereby users are provided with scores which take into account both the speed and accuracy of responding) and personalisation (in version 2 whereby the individual was able to select the food categories to train) in the inhibition training technique. In version 2, audio-guided urge-surfing was incorporated in addition to the written instructions. Following randomisation to the intervention group, participants were verbally encouraged to use the app for the first four weeks and as much as they wanted throughout the study period.

Table 5.1 Key components, mechanisms, timing of use, and Operationalisation in the ImpulsePal app

Technique	Mechanism of action	Timing	Operationalisation
Visuospatial Loading	Inhibit elaboration of craving imagery by loading the visuo-spatial cortex with a competing task.	In-the-moment	Present dynamic visual noise a visual interference pattern (such as television "snow") in the background to text window that follows pressing of the "Emergency Button". (See in accompanying text).
Implementation Intentions	Pre-empting problem situations and making specific plans to overcome problems.	In advance /pre-emptive	Provide option to create "if-then" plans. Prompt identification of "high risk situations" and pre-emptive problem-solving., using pre-specified "if" situations, and "then" responses to select and save to "my plan", or to create own if-then plans.
Inhibition Training	Improve inhibitory control, devaluing of stimuli.	In advance	Presented as a "Brain Training game" consisting of a stimulus-response task (Go /no-go)
Mindfulness strategies	Raise awareness of the present moment by	In-the-moment	Text-based steps guide the user through principles of "Urge-Surfing". Cravings are

	purposefully paying attention, without judgment, to the current experience that is unfolding, and observing its path without acting.		conceptualised as being like a wave which may build in intensity, but will eventually subside.
Location specific goal primes	Bringing long-term goals to mind and engaging reflective processes to override the impulse.	In-the-moment	Use of geo-caching and location services to highlight high risk locations on a map along with specific goals for the location. Notifications are sent in the app when the user enters the location. The user is able to specify time boundaries for the notifications.

5.2.5. Control group (waiting list)

Participants in the control group received no intervention and were provided with access to the ImpulsePal app intervention after their three-month follow-up.

5.2.6. Sample size

The sample size was calculated to obtain realistic estimates (and confidence intervals; CI) for the uptake and retention rates, as well as standard deviations of the primary outcome using the formulas presented in Figure 5.3 (Ukoumunne, Warren, Taylor, & Ewings, 2015).

Uptake rate[a]

$$p \pm (1.96 \times \sqrt{(p \times (100 - p)) / n})$$

Retention rate[b]

$$n = (15.37 \times p(100 - p)) / w^2$$

Standard Deviation estimation[c]

$$\sqrt{(n - 1)s^2 / \chi^2_{0.025,n-1}} \quad \text{to} \quad \sqrt{(n - 1)s^2 / \chi^2_{0.975,n-1}}$$

Figure 5.3 Parameter estimation formulas
In each formula, n is the to be recruited sample size. [a] where p is the expected percentage that will be recruited. [b] where w is the acceptable width (margin of error) of the 95% CI. [c] $\chi^2_{0.025,n-1}$ and $\chi^2_{0.975,n-1}$ are the 2.5th and 97.5th quantiles of the χ^2 distribution with n-1 degrees of freedom.

From recent UK-based trials of interventions to support dietary change, it was estimated that 25-30% of those contacted would take part and of those 70-75% would be retained at 3 months (Jebb et al., 2011; Spring, Duncan, Janke, & et al, 2013). Using the formulas above, estimating an uptake rate of at least 25% with a margin of error based on the 95% CI of +/- 9%, requires 90 participants to be recruited. A sample size of 90 would allow estimation of a retention rate of 70-75% with a margin of error of +/- 9%. This sample size (with a 2:1 allocation ratio) also provides an ample pool of intervention participants from whom to collect qualitative feedback. A retention rate of between 70 and

75% would be large enough to allow estimation of the standard deviation for weight loss to allow sample size calculation for a future, full-scale trial. Sample sizes between 24 and 50 participants have generally been recommended for feasibility studies to allow such estimation of the standard deviation for a full-scale trial sample sizes (Julious, 2005; Sim & Lewis, 2012). Moreover, using the final formula in Figure 5.3 suggests that a retention rate of 70 and 75% would be large enough to estimate the standard deviation to within 18 and 21%, respectively, of its true value (Ukoumunne et al., 2015).

5.2.7. Blinding

Post-randomisation, blinding of the participant was not possible as participants were by necessity aware of whether they were receiving an app or not. In addition, the PhD student was not blinded to group allocation at follow-up as interviews (reported in Chapter 6) with the intervention group participants were conducted during the assessment visit where possible. Blinding to group allocation during analyses was not possible either due to the uneven group sizes (2:1 allocation to intervention or control group).

5.2.8. Outcomes and measures

For this feasibility RCT, the main outcomes of interest were a) uptake rate, b) retention rate (the proportion providing data at three months), and c) the standard deviation of weight loss at three months of follow up. Other feasibility outcomes of interest were measures-completion rates (the proportion of participants who completed each measure at each time point) and acceptability of the intervention and the study procedures (percent satisfied with the ImpulsePal app and study procedures).

Questionnaires and study records were used to record demographic data at baseline in terms of age, gender, completed level of education, ethnicity, and area deprivation (Index of Multiple Deprivation deciles derived from postcode and national census data; Jordan, Roderick, & Martin, 2004). In addition, participants reported their smoking status (currently smoking, never smoked, or quit date if ever having smoked), any medications or diagnoses that might affect weight (such as thyroid problems) or diet (such as food allergies) and concurrent participation in other lifestyle-related weight management programmes at baseline and any changes in these at one-month and three-month follow-ups. Participants tendency and intent to consciously restrict their food intake in order to control body weight or promote weight loss was measured at baseline using the (dietary) cognitive restraint subscale of the Three Factor Eating Questionnaire – R18 (Karlsson, Persson, Sjöström, & Sullivan, 2000), a short form of the of the Three-Factor Eating Questionnaire (Stunkard & Messick, 1985). This validated subscale comprises 6 items of which 5 are rated on a 4-point Likert scale and one question asking to rate restraint on a scale of 1 to 8. All responses are given a score between 1 and 4, including the restraint rating where ratings of 1 and 2 are scored as 1, ratings of 3 and 4 are scored as 2, and so forth. The six item scores are summated into a total raw score. This raw score is then converted to a scale of 0 – 100 [((Raw score – possible raw score) / possible raw score range) x 100] with higher scores indicating greater cognitive restraint.

All measures intended for use in the full-scale trial were also taken, as follows below. The full measurement schedule can be seen in Table 5.2 and questionnaires can be found in Appendix 13.

5.2.8.1. Body measurements

Body weight in kilograms (primary outcome) was measured using a calibrated Seca 899 weighing scale. Height was measured using the Seca 213 portable stadiometer at baseline only to calculate BMI.

5.2.8.2. Secondary outcomes

We measured unhealthy snack food /drink consumption using a 7-day recall 11-item food frequency questionnaire (FFQ) adapted from a questionnaire used by Churchill and Jessop (Churchill & Jessop, 2011). This FFQ asked participants to rate how often they had eaten food from specific categories over the course of the last week, focussing on the number of times it had been consumed rather than the number of packets or items. The items in the FFQ included: crisps, chocolate, ice-cream, chips, sweets, cakes, biscuits, pastries/sweetpies, soft drinks, low sugar/ diet soft drinks, and alcoholic drinks. A seven-point response scale was presented for each item (ranging from *1 = never*, to *7 = three or more times per day*). A total FFQ index was calculated as the average of the 11 item scores (thus ranging from 1 to 7). In this index, a higher score indicates more unhealthy eating as previously used by Lawrence and colleagues (Lawrence, O'Sullivan, et al., 2015). Two sub-scales were created in the same way for the eight snack items (FFQ Snack) and for the three drink items (FFQ Drink) with higher scores indicating more unhealthy snacking and unhealthy drinking. To gather frequency data on episodes of overeating, we used three items from the Eating Disorder Examination Questionnaire (EDE-Q; Fairburn & Beglin, 1994) referring to the frequency of overeating episodes and loss of control during overeating (over a period of 28 days) and the number of days uncontrolled overeating occurred.

Table 5.2 Measurement schedule

Measure	Baseline	One-month	Three-month
Weight (kg)	x	x	x
Height (cm)	x		
Snack consumption (FFQ)	x	x	x
Overeating episodes (EDE-Q)	x	x	x
Demographics	x	-	-
Co-intervention & Co-morbiditiy	x	x	x
Intervention Satisfaction	-	x (intervention)	-
Trial satisfaction	-	-	x
Trial feedback			x
Process questionnaires	x	x	x
Semi-structured interview		X (intervention)	
Restraint	x	-	-
BIS-15	x	x	x
PFS	X	x	x
FCQ-T-r	x	x	x
Self-efficacy	x	X	x

5.2.8.3. Intervention usage

Intervention usage was measured via the app which recorded time and date stamps for each screen visited alongside the time spent on the respective screen. For the purposes of this feasibility chapter intervention usage is measured as the total time spent using the ImpulsePal app and the number of days the app had been accessed. However, engagement (rather than usage) with the intervention and its key components is explored in more depth in the process evaluation reported in Chapter 6.

5.2.8.4. Feasibility of use and satisfaction

At the one-month assessment visit, intervention group participants were asked to complete a satisfaction questionnaire which asked about the usability of (e.g., "*How easy is ImpulsePal to understand and use?*") and satisfaction with the ImpulsePal app (i.e., "*Please indicate how satisfied you are /were with ImpulsePal*."). The questionnaires used 5-point Likert response scales (1 = disagree to 5 = agree and 1 = very dissatisfied to 5 = very satisfied). In addition, an open-ended question (i.e., *"Is there anything we could do to improve ImpulsePal?")* was used to prompt ideas for intervention improvement.

Similar questions, with the same rating scales described above, were asked of all participants at the three-month visit pertaining to satisfaction with the study procedures ("*The study procedures were easy to understand*"; "*The questionnaires were easy to complete*"; "*Is there anything we could do to improve the study?";* "*Please indicate how satisfied you are with your research study experience.").*

In addition to these satisfaction questionnaires, at the three-month follow-up (during the visit or over the phone) participants were also asked for quantitative and qualitative feedback on their trial participation experience. Questions included, "*In deciding to take part in the study you were given a Participant Information Sheet. Was this helpful*?" with a yes/no response. "*How would you rate the amount of information that the researchers collected from you*?" (rating from 1 – Far too much, to 5 – Far too little), and did you have problems with your information being sent via the ImpulsePal app (intervention group only) or your weight being measured? with a yes or no response and further comments noted where offered.

5.2.8.5. Process evaluation

A mixed-methods (qualitative and quantitative) process evaluation was conducted to further assess the feasibility and acceptability of the intervention more in depth, the usefulness of different intervention components, to explore mechanisms of action and to identify ways to refine the intervention and the process measures for full scale trial. The process evaluation methods, materials and findings are described in detail in Chapter 6. In brief this incorporated (a) semi-structured interviews, (b) questionnaires at baseline and follow up to assess changes in process variables targeted by the intervention (i.e., Barratt Impulsiveness Scale-15, Spinella, 2007; Food Cravings Questionnaire-Trait, Meule, Hermann, & Kübler, 2014; Cognitive Restraint subscale of the Three Factor Eating Questionnaire – R18, Karlsson et al., 2000; Power of Food Scale, Lowe et al., 2009; a self-efficacy questionnaire constructed for this study), and (c) fidelity checks in terms of the delivery /receipt of intervention components.

5.2.9. Analysis

To assess recruitment and retention, participant flow through the study was summarised using the CONSORT diagram (adapted for complex interventions). Uptake and retention rates using descriptive statistics with 95% confidence intervals (CIs). Completion rates are reported using frequency (N) and group percentages (%). Sample characteristics were analysed using descriptive statistics reporting mean and standard deviations (SDs) for continuous data and N(%) for categorical data.

Although the study was not statistically powered for between-group comparisons, we conducted exploratory analyses based on the intention-to-treat (ITT) principle where participant data were analysed in the groups to which they were allocated following randomisation. Moreover, we used a complete case principle to deal with missing outcome data (i.e., including only participants who provide data at both time points). In this study, ITT and missing outcome data are considered separate issues, for a detailed discussion on the use of ITT analyses and guidance for reporting see Alshurafa et al. (2012). We used analysis of covariance (ANCOVA) to compare differences in weight loss (reported as mean difference of the change with 95% CIs) between intervention and control groups at one and three months controlling for baseline BMI. Where descriptive information of baseline characteristics suggested potential differences between groups, analyses including and excluding the potential covariates were conducted to explore sensitivity of the data to baseline differences. We also calculated the mean changes in secondary outcome measures between baseline and follow up time points for each group. Where questionnaire data were incomplete, scores were imputed using the participant’s average for the respective scale if at least 80% of the items were completed.

App usage data were analysed using descriptive statistics reporting median and interquartile ranges (IQRs) and satisfaction questionnaires, were analysed using descriptive statistics reporting means and SDs.

5.3. Results

5.3.1. Recruitment and retention

A total of 194 people responded to HPD invites, local advertising, or snowballing /word-of-mouth invitations of which 93% (95% CI: 88.5% to 96.0%) of those expressing an interest were screened for eligibility and 45% (95% CI: 38.4% to 52.4%) were eligible for inclusion and randomised into the trial between September 2015 and April 2017 (See Figure 5.4 and Figure 5.5). Recruitment efforts stopped in April 2017 after the target number of participants had been scheduled for enrolment into the study. Of the 585 invitations sent to HPD referrals 10% expressed an interest in taking part (95% CI: 8% to 12%) but only 3% of those invited took part (95% CI: 1.6% to 3.8%). The majority (82%) of the recruited sample came in to the study via the ExTend newsletter (N = 24, 27%), local advertising (34, 39%) or word of mouth (14, 16%). Of those randomised, 74 (84%) provided weight data at one month (95% CI: 76.4% to 91.7%) and 67 (76%) at three months (95%CI: 67.2% to 85.0%).

The primary reason for exclusion was not being able to run the Android-based app (n = 66, 37% of individuals assessed for eligibility). Of the excluded individuals, 57 (32% of total screened) owned an iOS operated device and the remainder either had a Windows device (n = 2), had a version of Android that was too old to run the app (n = 1), or had no smartphone (n = 6).

The average recruitment rate was 7.3 participants per month and was achieved with one researcher working on average 1.5 days per week during recruitment periods (See Figure 5.5).

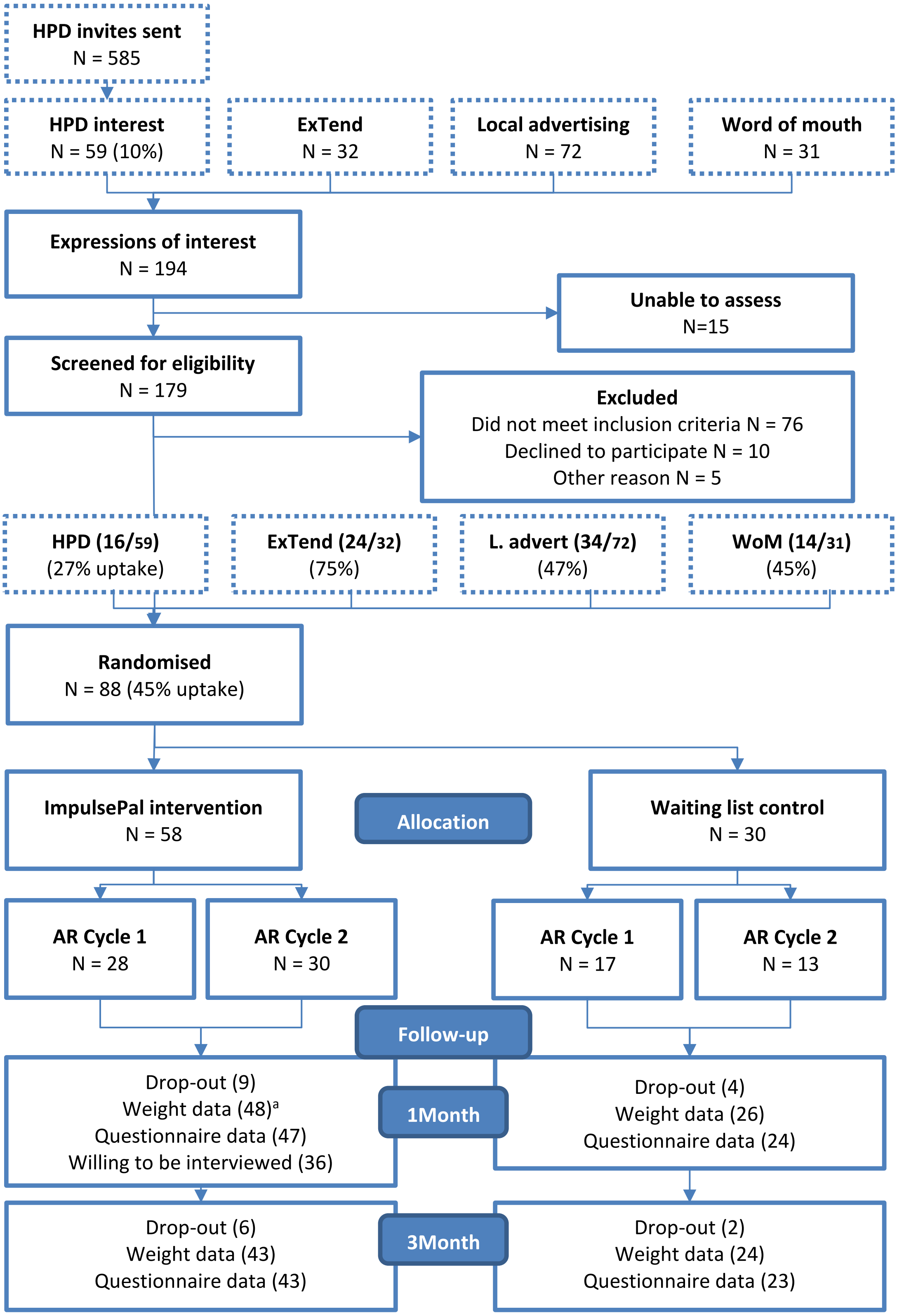


Figure 5.4 Participant flow chart
[a] One participant in the intervention group was unable to attend an assessment visit and was unable to provide weight data.

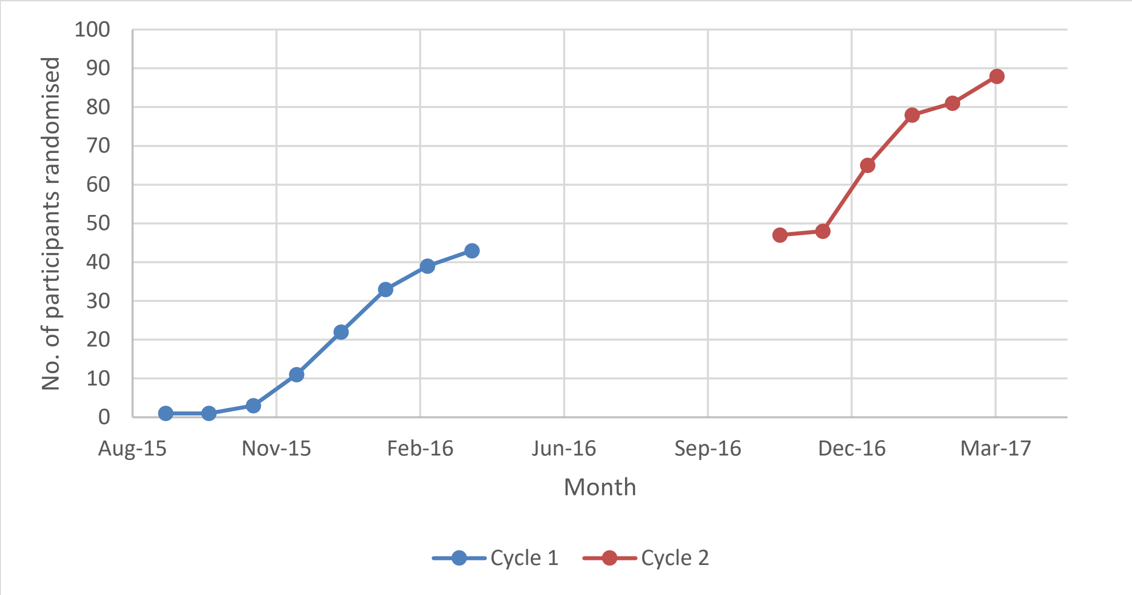


Figure 5.5 Cumulative recruitment

Of those who declined to take part (n=10), five were invited to take part via HPD who were unable to commit to the three study assessments over three months in addition to their weight management programme (n=4) or said that they did not need help with cravings (n=1). The remaining five eligible participants who declined to take part came in through local advertising (n=4) and ExTend (n=1) and were unable to commit to the study requirements.

5.3.2. Measures completion, internal consistency, and missing data

The proportion of participants completing specific measures ranged from 94% for overeating episodes to 100% for weight at baseline, from 78% for loss of control during overeating to 84% for weight (and BMI) at one month, and from 73% for loss of control during overeating to 76% for weight at three months. Cronbach's alphas for multi-item scales ranged from 0.64 to 0.96 at baseline, 0.62 and 0.96 at one month, and 0.48 to 0.96 at three months (See Table 5.3). Among the completed questionnaires, most frequently missing were an item on the Barratt Impulsiveness Scale "I plan for job security" (n=7 (8%) missing), and an item assessing the participant's confidence to successfully stick to their healthy eating goals "in the work place" (n=11 (13%) missing).

Table 5.3 Measures completion and internal consistencies

	Baseline		One month		Three months	
	N	**Cronbach's alpha**	**N**	**Cronbach's alpha**	**N**	**Cronbach's alpha**
Weight	88 (100%)	-	74	-	67	-
BMI	88 (100%)	-	74	-	67	-
Age	87 (99%)	-	-	-	-	-
Ethnicity	85 (97%)	-	-	-	-	-
Co-intervention /or changes in	84 (95%)	-	71	-	66	-
Co-morbidity /or changes in	84 (95%)	-	71	-	66	-
Medication /or changes in	84 (95%)	-	71	-	66	-
Education level	85 (97%)	-	-	-	-	-
Smoking Status /or changes in	84 (95%)	-	71	-	66	-
Food Frequency Questionnaire	85 (97%)	0.64	71	0.62	66	0.48
Overeating Frequency	83 (94%)	-	70	--	65	-
Loss of control frequency			*69*		*64*	
No. of days			*70*		*66*	
Cognitive Restraint	85 (97%)	0.78	-	-	-	-
BIS-15	85 (97%)	0.83	71	0.83	65	0.83
PFS	85 (97%)	0.92	71	0.92	66	0.94
FCQ-T-r	85 (97%)	0.96	70	0.96	66	0.96
Self-efficacy	84 (95%)	0.85	71	0.84	66	0.90
Satisfaction App	N/A	-	43	-	-	-
Satisfaction Trial	N/A	-	-	-	66	-
Brief interview trial procedures	N/A	-	-	-	66	-

5.3.3. Sample characteristics (Table 5.4 and Table 5.5)

The sample was 65% female and 95% White with a mean age of 46.8 years. The mean BMI was 33 kg/m^2, 67% had a BMI of 30 or higher (obese), and 26% started the study alongside another existing weight management programme. Most of the participants had completed professional training, undergraduate training or a postgraduate course (71%), were non-smoking

(91%) and 17% disclosed a comorbidity that might affect their weight or diet such as thyroid problems and diabetes.

There were no substantial differences between the recruited sample and the wider Health Promotion Devon (HPD) population in terms of age and gender (See Table 5.4). However, the recruited sample had a substantially lower BMI (Mean difference -5.71 kg/m2, 95% CI: -6.94 to -4.48). Although the BMI of the HPD participants did not differ from that of the wider HPD population, the participants who came into the study through the other recruitment routes had a substantially lower BMI than the HPD participants (Mean difference = -6.7kg/m^2), which has likely driven the difference between the recruited sample and the wider HPD population (See Table 5.4). There were no substantial differences between the participants who completed the study and those who dropped out in terms of age, gender, or BMI. Within the recruited sample (See Table 5.5), there were no substantial differences between the intervention and control groups in terms of age, gender, or other demographic variables. However, the control group were on average 5.2kg heavier and had BMI scores that were 1.6kg/m^2 higher than the intervention group. Snacking scores from the FFQ were also higher in the control group.

Table 5.4 Characteristics of participants and wider HPD population

	Participants						HPD Invitees[a]	
	Non-HPD	**N**	**HPD**	**N**	**All**	**N**		**N**
Mean (SD) Age	45.6 (14.2)	71	51.8 (12.0)	16	**46.8 (13.9)**	**87**	**48.0 (14.2)**	**585**
N(%) Female	46 (64%)	72	12 (75%)	16	**57 (65%)**	**88**	**420.0 (72%)**	**585**
Mean (SD) BMI	32.1 (5.4)	72	38.8 (6.1)	16	**33.3 (6.1)**	**88**	**39.0 (5.4)**	**585**
Mean (SD) IMD Score	18.5 (10.7)	65	16.8 (9.3)	13	**18.2 (10.4)**	**78**	**19.9 (10.0)**	**564**
N(%) IMD quintile		65		13		**78**		**564**
1 (least deprived)	8 (12%)		-		**8 (10%)**		**58 (10%)**	
2	18 (28%)		7 (54%)		**25 (32%)**		**181 (32%)**	
3	17 (26%)		2 (15%)		**19 (24%)**		**172 (31%)**	
4	17 (26%)		3 (23%)		**20 (26%)**		**91 (16%)**	
5 (most deprived)	5 (8%)		1 (8%)		**6 (8%)**		**62 (11%)**	

[a] The HPD invitees include those who participated in the feasibility trial as we were unable to identify them from the anonymised data provided.

Table 5.5 Sample characteristics at baseline

Variable	Intervention	N	Control	N	Whole sample[a]	N
Mean (SD) weight (kg)	93.1 (17.8)	58	98.3 (20.9)	30	**94.9 (19.0)**	**88**
Mean (SD) BMI (kg/m^2)	32.8 (5.6)	58	34.4 (6.9)	30	**33.3 (6.1)**	**88**
N (%) Female	37 (63.8%)	58	20 (66.7%)	30	**57 (64.8%)**	**88**
Mean (SD) Age	46.7 (13.6)	58	46.9 (14.8)	30	**46.8 (13.9)**	**87**
Ethnicity:		56		29		**85**
N (%) White	52 (92.9%)		29 (100%)		**81 (95.3%)**	
N (%) Other	4 (7.1%)		-		**4 (4.7%)**	
Area deprivation:						
Mean (SD) IMD score	17.7 (10.9)	51	19.2 (9.5)	27	**18.2 (10.4)**	**78**
N (%) IMD quintile:		51				**78**
1 (least deprived)	6 (12%)		2 (7%)		**8 (10%)**	
2	20 (39%)		5 (19%)		**25 (32%)**	
3	10 (20%)		9 (33%)		**19 (24%)**	
4	11 (22%)		9 (33%)		**20 (26%)**	
5 (most deprived)	4 (8%)		2 (7%)		**6 (8%)**	
N (%) Co-intervention (Including Orlistat)	16 (28.6%)	56	6 (21.4%)	28	**22 (26.2%)**	**84**
N (%) Co-morbidity	8 (14.3%)	56	6 (21.4%)	28	**14 (16.7%)**	**84**
N (%) Medication (not for weight loss but that can affect weight)	17 (30.4%)	56	5 (17.9%)	28	**22 (26.2%)**	**84**
N (%) Education:		56		29		**85**
N (%) Secondary up to 16y	7 (12.5%)		3 (10.3%)		**10 (11.7%)**	
N (%) Secondary up to 18y	5 (8.9%)		3 (10.3%)		**8 (9.4%)**	
N (%) Professional training or University	39 (69.6 %)		21 (72.4%)		**60 (70.6%)**	
N (%) Other	5 (8.9%)		2 (6.9%)		**7 (8.2%)**	
Smoking status:		56		28		**84**
N (%) Never smoked	29 (51.8%)		15 (53.6%)		**44 (52.4%)**	
N (%) Currently smoking	5 (8.9%)		3 (10.7%)		**8 (9.5%)**	

Variable	Intervention	N	Control	N	Whole sample[a]	N
N (%) Given up smoking[a]	22 (39.3%)		10 (35.7%)		**32 (38.1%)**	
Mean (SD) Cognitive Restraint[b]	37.8 (19.6)	56	35.6 (18.1)	29	**37.2 (19.0)**	**85**
Food frequency [c]		56		29		**85**
Mean (SD) Total Index	2.1 (0.4)	56	2.4 (0.8)	29	**2.2 (0.6)**	**85**
Mean (SD) Snack Index	2.1 (0.5)	56	2.3 (0.8)	29	**2.2 (0.6)**	**85**
Mean (SD) Drink Index	2.1 (0.8)	56	2.6 (1.3)	29	**2.2 (1.0)**	**85**
Overeating:		55		28		**83**
Mean (SD) Overeating Frequency *(No. times during 28 days)*	7.6 (8.0)	55	6.6 (6.9)	28	**7.2 (7.6)**	**83**
Mean (SD) Loss of control *(No. times during 28 days)*	5.4 (7.6)	55	3.0 (4.6)	28	**4.6 (6.8)**	**83**
Mean (SD) Uncontrolled overeating *(No. days)*	5.4 (7.2)	55	4.7 (6.7)	29	**5.19 (7.0)**	**84**
Process Questionnaires						
Barratt Impulsiveness Scale [d]		56		29		**85**
Mean (SD) BIS – NP score	11.5 (3.6)	56	11.4 (3.2)	29	**11.5 (3.4)**	**85**
Mean (SD) BIS – M score	11.0 (2.8)	56	11.6 (3.8)	29	**11.2 (3.2)**	**85**
Mean (SD) BIS – A score	10.1 (3.1)	56	10.2 (2.5)	29	**10.2 (2.9)**	**85**
Mean (SD) BIS Total	32.6 (7.0)	56	33.2 (7.3)	29	**32.8 (7.1)**	**85**
Power of Food Scale [e]		56		29		**85**
Mean (SD) PFS Aggregate Domains	3.0 (0.8)	56	3.1 (1.0)	29	**3.0 (0.8)**	**85**
Mean (SD) Food Cravings Questionnaire-Trait-reduced[f]	59.4 (14.3)	56	60.3 (18.9)	29	**59.7 (15.9)**	**85**
Mean (SD) Self-efficacy [g]	50.1 (14.0)	55	51.0 (21.7)	29	**50.4 (16.9)**	**84**

[a]Average 9.6 years since quit date. [b] Cognitive Restraint scores from 0 – 100 with higher scores indicating greater restraint. [c] FFQ scores out of a maximum 7 with higher scores representing more frequent unhealthy consumption. [d] BIS-15 scores of 15 – 60 with higher scores representing higher impulsivity. [e] PFS score ranging from 1-5 with higher scores indicating greater susceptibility to the food environment. [f] FCQ-T-r, scores ranging from 15 to 90 with higher scores indicating more thinking about food, intentions to eat, loss of control, and emotional impact on eating behaviour. [g] Self-efficacy scores ranging from 0 – 100 with higher scores representing greater confidence in ability to regulate eating habits.

5.3.4. Exploratory analyses of weight loss

The ITT completers analysis (See Table 5.6) showed that the intervention group lost 0.88 kg at one-month and continued to lose weight, with an average weight loss of 1.63kg at three months. The control group initially gained 0.12 kg at one month but then lost 0.95kg by three months. Adjusting for baseline differences in BMI, this resulted in mean differences in weight loss between groups (favouring the intervention group) of 1.03kg at one month (95%, CI: 0.33 to 1.74), $d = 0.7$, and 1.01kg at three months (95% CI: -0.45 to 2.47), $d = 0.2$. Our sample showed a pooled standard deviation of weight loss of 1.48 kg at one month and 3.11 kg at three months.

5.3.5. Sensitivity analyses

Sensitivity to missing data was explored using an ITT analysis this time dealing with missing outcome data through imputation, using the method of last observation carried forward (LOCF). Adjusting for differences in baseline BMI, the pattern of weight loss remained the same, with the intervention group losing 0.91kg more weight than the control group at one month, (95% CI: 0.30 to 1.52), and 0.84kg more at three-month, (95% CI: -0.35 to 2.02). In addition, sensitivity of the data to potential baseline differences in snacking behaviour, co-interventions, weight-affecting medications, and ethnicity distribution were examined and none of these factors substantially altered the pattern of the findings. Finally, one participant showed a weight loss of more than three SDs from the mean at three months. Removing this participant from the ITT completers analysis, to explore sensitivity to outliers, did not alter the pattern of findings.

To explore the potential utility of ImpulsePal as a standalone intervention, a subgroup analysis (using an ITT with complete case analysis, see above) was conducted exploring variations in weight change alongside co-interventions. Among the control participants, those who took part in other weight management programmes (N = 6, 21.4%) lost 2.12kg more than those who did not (22, 78.6%) (95% CI: 0.55 to 3.70) and 3.42kg more at three months (5, 21% vs 19, 79%) (95% CI: -0.96 to 7.81). In the intervention group those who engaged in co-interventions (15, 31%) only lost 0.49kg more than those who used ImpulsePal as a standalone intervention (33, 69%) (95% CI: -0.35 to 1.33) and 0.96kg at 3 months (13, 30% vs 33, 69%) (95% CI: -0.45 to 2.38).

Table 5.6 Changes in the primary and secondary outcomes proposed for a full-scale trial.

Variable	Group	Change 0-1 month M(SD)	N	Adj. between group mean difference[a] (95% CI)	Change 0-3 month M(SD)	N	Adj. between group mean difference[a] (95% CI)
Weight (kg)	Intervention	-0.88 (1.34)	48	-1.03 (-1.74 to -0.33)	-1.63 (2.1)	43	- 1.01 (-2.47 to 0.45)
	Control	0.12 (1.73)	26		-0.95 (4.4)	24	
BMI	Intervention	-0.32 (0.49)	48	-0.36 (-0.62 to 0.11)	-0.58 (0.76)	43	-0.36 (-0.88 to 0.16)
	Control	0.02 (0.63)	26		-0.35 (1.55)	24	
FFQ Total	Intervention	-0.36 (0.50)	47	-0.16 (-0.41 to 0.8)	-0.34 (0.46)	43	0.07 (-0.20 to 0.33)
	Control	-0.20 (0.45)	24		-0.40 (0.58)	23	
FFQ Snack	Intervention	-0.42 (0.51)	47	-0.19 (-0.46 to 0.08)	-0.43 (0.46)	43	-0.86 (-0.34 to 0.17)
	Control	-0.23 (0.60)	24		-0.34 (0.53)	23	
FFQ Drink	Intervention	-0.20 (0.79)	47	-0.09 (-0.47 to 0.29)	-0.09 (0.75)	43	0.47 (0.02 to 0.91)
	Control	-0.11 (0.68)	24		-0.55 (1.01)	23	
Overeating	Intervention	-4.99 (7.75)	45	-3.33 (-6.69 to 0.02)	-4.87 (7.47)	43	-2.33 (-5.79 to 1.12)
Frequency	Control	-1.67 (4.27)	24		-2.89 (4.52)	22	
Loss of control	Intervention	-4.60 (7.19)	44	-4.81 (-7.81 to -1.82)	-3.76 (7.41)	43	-3.31 (-6.65 to 0.03)
	Control	0.21 (2.89)	24		-0.66 (3.27)	22	
Uncontrolled	Intervention	-4.14 (6.85)	45	-3.82 (-6.73 to -0.90)	-3.85 (7.31)	23	-3.02 (-6.40 to 0.35)
overeating (no days)	Control	-0.33 (2.76)	24		-1.07 (4.56)	43	

[a]ANCOVA analyses of change scores with baseline BMI value entered into the model to adjust for baseline differences.

5.3.5.1. Individual weight change pattern

The pattern of weight loss for individuals in the intervention group and the control group at one month can be seen in Figure 5.6 and Figure 5.7, and the pattern for change at three months can be seen in Figure 5.8 and Figure 5.9. These show that the majority of the 48 participants in the ImpulsePal intervention group lost weight at one month (77%) and a greater majority having lost weight at three months (84%). In contrast, in the control group less than a third lost weight at one month (27%) and nearly half lost weight by three months (45%).

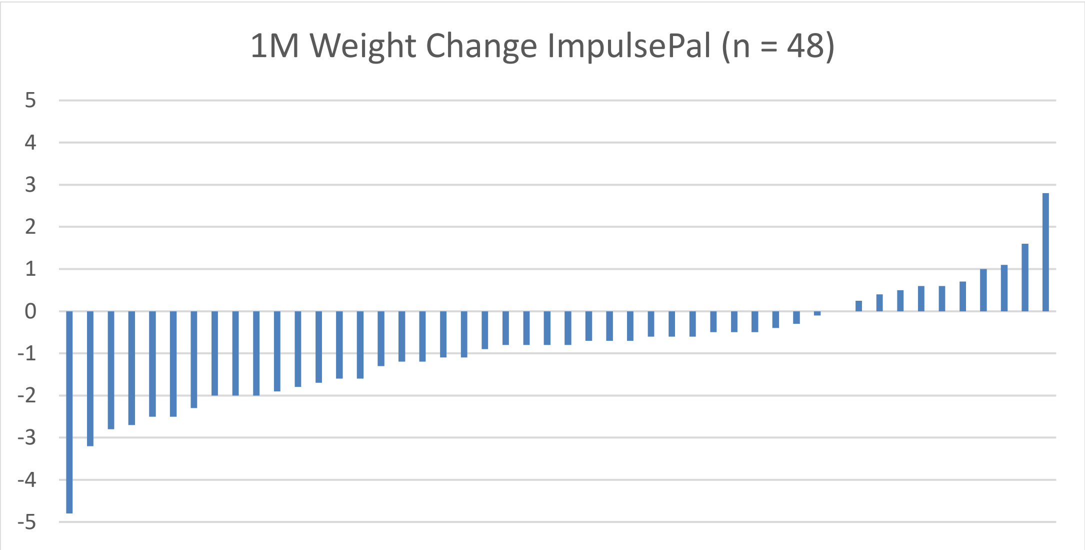


Figure 5.6 Pattern of individual change scores at one month in the intervention group.

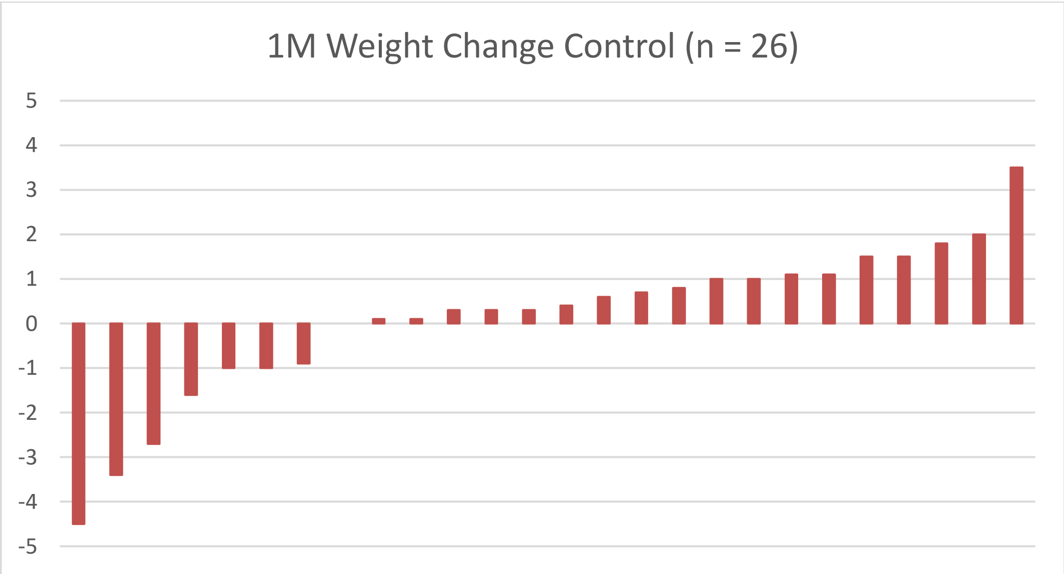


Figure 5.7 Pattern of individual change scores at one month in the control group.

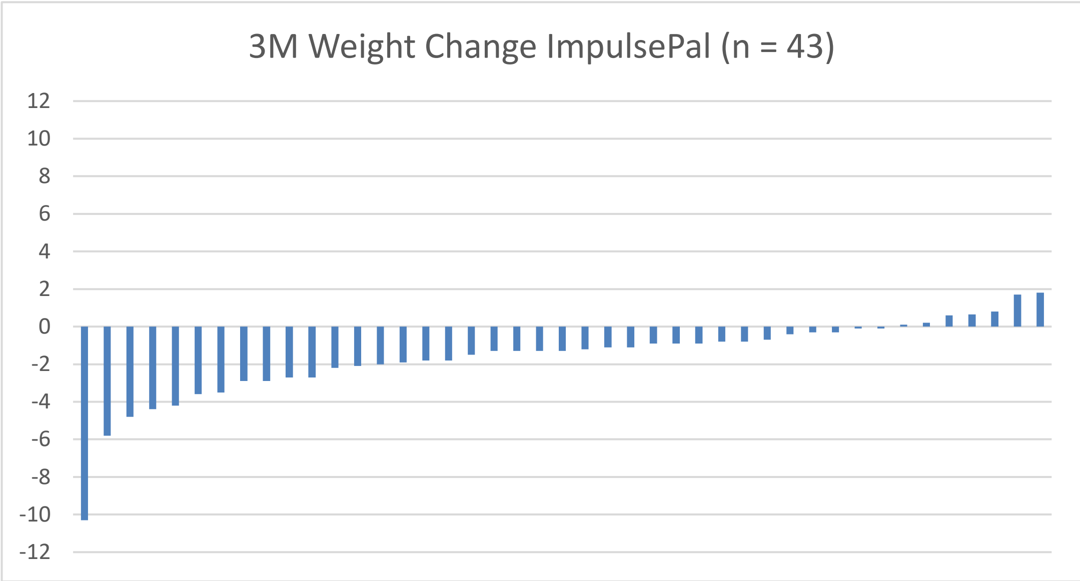


Figure 5.8 Pattern of individual change scores at three months in the intervention group.

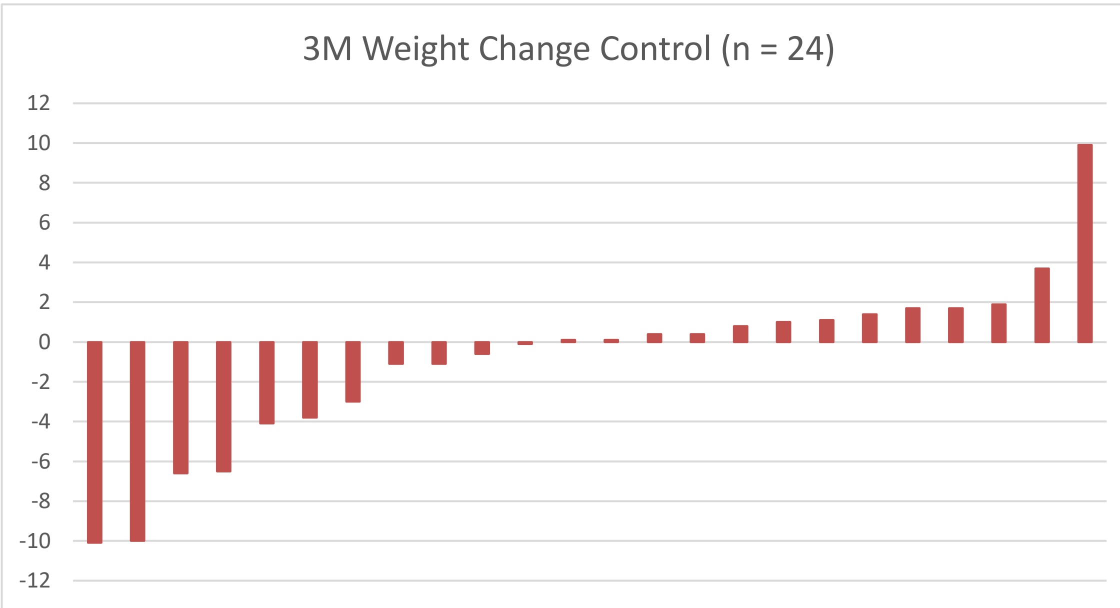


Figure 5.9 Pattern of individual change scores at three months in the control group.

5.3.6. Eating behaviour

There were positive changes in nearly all measures reflecting reductions in snacking behaviour and overeating, reductions in loss of control and uncontrolled eating episodes from baseline to one-month and three-months in both the intervention and control group, with greater reductions in the intervention group (except for drink consumption) and significantly greater reductions in frequency of loss of control during overeating and number of days of uncontrolled overeating when adjusting for baseline differences in BMI (See Table 5.6).

5.3.7. App use

Usable app usage statistics were available for 56 (out of 58) participants in the intervention group. Total minutes spent on the app during the first month (from first log in) ranged from 3.5 minutes to 446.8 minutes with a median usage of 38.1 minutes (See Table 5.7). Of these 56 participants 70% continued use after one month (based on app usage statistics). Fidelity checks of intervention delivery showed good overall fidelity of delivery but highlighted some further areas for improvement which are reported and discussed in detail in Chapter 6. Furthermore, qualitative data from the semi-structured interviews described in Chapter 6 suggest that although participants may no longer be using the app, some still used strategies which do not require the app itself once learned (e.g., urge-surfing; See Chapter 6). Of those who did not access the app after the first month (n = 17), 38% had dropped out of the study. In contrast, of those who were still accessing the app after the first month (n = 39), three were lost to follow up for questionnaire and weight data at one month, and an additional five were lost to follow up by the three-month visit. Finally, intervention usage in terms of contact time (total minutes and number of days) was not significantly correlated with weight loss within the intervention group either at one month, $r = -0.16$ and $r = -0.01$ respectively, nor at three months, $r = 0.04$ and $r = -0.02$ respectively.

Table 5.7 ImpulsePal app usage in total minutes spent using the app, and number of separate days on which the app was accessed.

	Total minutes **Range** **Median (IQR)**	**N**	**Separate days.** ***Range*** ***Median (IQR)***	**N**
During first month	3.5 to 446.8 38.1 (53.7)	56	1 to 23 7.0 (5.0)	56
Excluding lost to follow up	3.48 to 446.8 39.2 (54.9)	47	1 to 23 7.0 (5.0)	47
During first three months	3.5 to 1444.6 46.4 (70.3)	56	1 to 51 10.0 (11.0)	56
Excluding lost to follow up	3.48 to 1444.6 52.6 (96.5)	41	1 to 51 11.0 (10.5)	

	Total minutes Range Median (IQR)	N	Separate days. *Range* *Median (IQR)*	N
Since first month up to three months for those accessing after the first month	0.02 to 1376.10 17.7 (38.7)	39	1 to 29 10 (10.3)	39
Excluding lost to follow up.	0.98 to 1376.10 19.1 (3.5)	31	1 to 29 5.0 (7.0)	31

5.3.8. Feasibility of use and satisfaction with the ImpulsePal app.

Forty-three (74%) usable app satisfaction questionnaires were returned by intervention group participants at one month. Data from these suggested a high level of satisfaction with the intervention. Ninety-eight percent agreed or strongly agreed that ImpulsePal was easy to understand (M = 4.6 (out of 5), SD = 0.6), 98% agreed or strongly agreed that ImpulsePal was easy to use (M = 4.7, SD = 0.5), and 93% was satisfied or very satisfied with ImpulsePal (M = 4.3, SD = 0.7). In the available app satisfaction questionnaires of Cycle 1 (n=19), the open-ended question elicited qualitative data which suggested that (a) the Brain Training (go/no-go task) component was too lengthy (5 minutes) and became boring over time. Suggestions for improvement included shortening the time to complete the task and including a greater variety of images; (b) the app and strategy instructions are not always read, and (c) the Danger Zones (GPS enabled reminders) were not accurate enough and required a better reminder system. After Cycle 2 (n = 24 questionnaires), answers to the open-ended question still suggested further improvements to the Brain Training component were required and elements of gamification were mentioned (e.g., adding difficulty levels, rewards).

5.3.9. Feasibility of use and satisfaction with the trial procedures.

The study satisfaction questionnaires (returned by 66 (75%) participants in both groups at the three-month visit) also indicated high usability of, and satisfaction with the trial materials and procedures. Ninety-seven percent agreed or strongly agreed that the trial procedures were easy to understand (M = 4.8, SD = 0.7), 99% agreed or strongly agreed that the questionnaires were easy to complete (M = 4.7, SD = 0.5). Finally, 96% were satisfied or very satisfied with their research study experience (M = 4.7, SD = 0.5). The qualitative feedback in the open-ended questions suggested improvements could be made to (a) the questionnaires (e.g., shorter or fewer questions and the use of an online form instead of pen and paper), and (b) the study visit reminder. Although this question asked participants about the study procedures, some intervention group participants were referring to the ImpulsePal app in their answer, suggesting to make ImpulsePal available on iOS or include variety in the "Brain Training" component. In addition, the brief structured interviews indicated that (a) the amount of data collected was "*about right*" (100%), (b) the PIS was helpful in their decision making about the study (85%) and some could not remember reading it (15%), (c) they did not have any issues with data being sent via the app (100%; intervention group only) and (d) did not mind being weighed by the researcher (100%). In terms of suggested improvements, some mentioned online or shorter questionnaires, better parking arrangements at the research site, and a text reminder on the day of the study visit in addition to the phone call reminder prior to the day.

5.4. Discussion

The present study examined the feasibility of conducting a full-scale trial of the ImpulsePal intervention. We successfully recruited a sample of overweight adults seeking weight management support in the South West of England, showing that people are willing to use smartphone applications to support their weight management. This study showed acceptable uptake and retention rates and high participant satisfaction with, and use of, an intervention targeting impulsive processes to support changes in eating behaviour for weight management. Moreover, this feasibility study showed high participant satisfaction with, and completion of, the trial procedures. The exploratory analysis of differences in weight loss between groups suggests that approximately 1 kg of weight loss might be achievable at the one and three-month follow-up, with a medium and small effect size respectively. Based on our findings, a fully-powered RCT would need to recruit a total of 457 participants, assuming a pooled standard deviation of 3.1 kg and the lower bound CI of retention (67%), to have 80% power to detect a 1.0 kg difference between groups at three months of follow up at the 5% significance level. Longer term follow-up may require larger sample sizes as our data suggest that the standard deviation for weight loss increases over time.

With regards to trial procedures, firstly, our uptake improved following the addition of a variety of recruitment routes (e.g., local advertising and the Exeter 10 000 project newsletter). However, another way in which study recruitment for a full-scale trial could be further improved, would be to accommodate a third of the screened potential participants who were not eligible to take part in this study. Offering ImpulsePal on devices using other operating systems in addition to Android, could therefore substantially extend the reach and uptake of the study. Secondly, retaining participants in trials of digital behaviour change interventions is challenging (Kozak et al., 2017; Ware, 2003) but our retention rates compare well with other digital weight management studies which typically range from 70% to 85% at up to three months of follow-up (Kodama et al., 2012; Levine, Savarimuthu, Squires, Nicholson, & Jay, 2015; Manzoni et al., 2011), therefore our follow-up procedures are acceptable for use in a full-scale trial.

The pattern of weight change in the current study is similar to that found in other app-based weight management interventions. One meta-analysis found that adding app-based weight management interventions significantly reduced body weight by 1.04 kg, and reduced BMI by 0.43 kg/m^2 compared to various control groups (ranging from waiting-list control groups to intensive counselling (Mateo, Granado-Font, Ferré-Grau, & Montaña-Carreras, 2015). However, these apps primarily focussed on weight change through dietary self-monitoring, physical activity trackers, and nutritional information. To our knowledge, this is the first study to examine the potential impact of a theory and evidence-based app-based weight loss intervention that explicitly targets both impulsive and reflective processes that underpin eating behaviour.

Even if digital behaviour change interventions (including ImpulsePal) only produce 1kg of weight loss, this is likely to be at a cost far lower than conventional interventions that deliver higher weight loss. This may result in a cost per kilogram weight loss well below that found in popular effective weight loss programmes ranging from commercial weight loss programmes to weight loss medications (Finkelstein & Kruger, 2014). Furthermore, digital behaviour change interventions are likely to have a greater reach than face-to-face programmes due to their accessibility. Nonetheless, considering 26% of our sample took part in concurrent weight management programmes, it may also be interesting to investigate whether the use of ImpulsePal alongside other weight management support would result in additive effects which may improve the cost-effectiveness of existing programmes. In light of ongoing major cuts to public health infrastructure and services in the UK (Local Government Association, 2017), including face-to-face weight management services as occurred during this study, there is a need for low-cost solutions to maximise the efficiency of public health spending and digital behaviour change interventions are increasingly being used as alternatives to or supplements to existing weight management services.

Furthermore, although not all significant, the findings relating to the secondary outcomes also show promise in favour of the intervention. The greater reductions in snacking behaviour and significantly greater reductions in frequency of feelings of loss of control during overeating, suggest that ImpulsePal is potentially able to support changes in eating behaviour for weight loss. This is explored further in the process evaluation reported in Chapter 6.

5.5. Strengths and limitations.

The main strengths of this feasibility study were the use of rigorous methods to assess the feasibility of conducting a full-scale randomised trial of a smartphone app-based intervention using trial procedures planned to closely mirror those to be used in a full-scale trial and the use of objective weight measurements to estimate standard deviations. However, some limitations need to be acknowledged. Firstly, there are limitations that may have influenced the outcomes of this feasibility study. The study had a low uptake rate from the initial intended recruitment route through an existing weight management referral system (3% of those invited), which may be due to the timing of the invitation. People were invited to take part in the feasibility study once they had been referred to existing local weight management groups but prior to commencement of their programme. Therefore, not only was there a limited time window for recruitment, but this population had already been offered another service and may not have felt the need for additional support at the time of invitation. Thus, this study may have failed to recruit a representative sample of the individuals referred to existing weight management interventions via primary care. The study did successfully recruit a volunteer-based sample through additional community-based routes which targeted overweight individuals who wanted to lose weight. However, these self-selected individuals may have been more motivated to change and do well, compared to participants who are referred to weight management services. Due to limited resources blinding of the researcher post randomisation was not feasible. Although objective methods for body measurements (using the same equipment for weight at baseline and follow-up) were used to reduce the risk of bias, blinding of researchers collecting follow-up data would be preferable in a full-scale trial (Schulz, Chalmers, Hayes, & Altman, 1995). This could be achieved by different researchers conducting baseline and follow-up assessments and asking participants not to disclose their group allocation (as well as recording when this does happen). In addition to collecting follow-up data, the researcher also completed the data entry and analysis. To check for errors in data entry, measures of the primary outcome for the full sample were entered in duplicate and for 25% of the remaining data (error rate of less than 1%). Moreover, offering the control group an alternative app with no active components would allow for blinding of the participants as well. This would minimise the potential for social desirability bias affecting self-report assessments differently between groups. It is important to note, that objective measurement of weight (as used in the current study) would not be subject to such bias. Offering an inactive alternative app to the control group would also remove any difference between the groups in motivation to stay in the trial which may have been present in the current study because control participants were told they would receive the ImpulsePal at the end of their study participation (an incentive). Similarly, face-to-face interviews were only conducted with intervention group participants. This qualitative evaluation could have a therapeutic effect which may have influenced these participants over and above the ImpulsePal intervention, resulting in better outcomes in this group. The greater likelihood of a motivation to change and do well in volunteer-based samples, the potential for social desirability bias in the non-blinded self-report assessments, and the potential therapeutic effects from the qualitative interviews may therefore have resulted in an overestimation of the potential effect size and more favourable reports of acceptability.

Secondly, this study used a relatively short follow-up period (three months) compared to evaluations of face-to-face weight management interventions (Greaves et al., 2011). However, similar follow-up periods are often used for self-delivered, internet-based and app-based interventions (e.g., Mateo et al., 2015; Tang et al., 2016). Moreover, the follow-up periods used in this feasibility study extend those used in the original lab-based evaluations of the individual impulse management techniques included in ImpulsePal (van Beurden et al., 2016).

Thirdly, the minimal diversity in this sample is a limitation commonly faced by evaluations of digital weight management interventions (Kozak et al., 2017). Although the prevalence of obesity is similar for men and women, weight management trials tend to recruit samples that are on average 27% male and 73% female (Pagoto et al., 2012). Our study managed to recruit a slightly higher proportion of men (35%), however, women still comprised a substantial majority. Increasing efforts to advertise the study to the male population may provide a further opportunity to extend its reach and uptake. Furthermore, the majority of smartphone interventions targeting obesity have been tested in samples that were predominantly White (Hutchesson et al., 2015) as was the sample in this study, primarily due to its geographical location. Given that obesity and overweight differentially impact ethnic minority populations, it is important to assess the effectiveness of digital weight management interventions in diverse populations (Bennett et al., 2014).

Finally, due to the small sample size and the fact it was a feasibility study, the comparative analysis were only exploratory and therefore no definitive conclusions can be drawn from differences between groups. Therefore, a fully powered randomised controlled trial is required to assess the effectiveness, and ideally cost-effectiveness, of the ImpulsePal intervention.

5.6. Conclusion

This feasibility study demonstrated high levels of satisfaction with both the intervention and study methods. The findings suggest that a randomised controlled trial is feasible, likely to recruit well and to have good rates of follow-up. A full-scale trial is required to conclusively evaluate the effectiveness and cost-effectiveness of ImpulsePal for people who are overweight, but initial findings are in a promising direction.

Chapter 6. Process evaluation of the ImpulsePal intervention

6.1. Introduction

The MRC guidance (Craig et al., 2013) for developing and evaluating complex interventions recognises the value of nested process evaluations in trials and a specific framework for conducting and reporting process evaluation studies has since been developed (Moore et al., 2015). Process evaluations provide valuable insights into why and for whom an intervention is successful or not, and if successful, how it works and how it might be optimised. A process evaluation can focus on exploring the implementation of an intervention (i.e., feasibility and acceptability, fidelity of delivery, receipt, and enactment), clarifying the mechanisms of action (i.e., mediators of outcomes), or identifying how context might affect implementation or be associated with any variation in outcomes (i.e., moderators of effects; Craig et al., 2013; Moore et al., 2015). A process evaluation can be conducted at the feasibility and piloting phase or during an effectiveness evaluation of an intervention (see Figure 6.1) and the primary focus may depend on the stage at which it is conducted.

For example, when conducted at the feasibility stage, a process evaluation focusses primarily on exploring the feasibility of the intervention and optimising its design and methods for evaluation. This may involve testing and refining the logic model, identifying potential mediators and moderators that may need to be captured in a future evaluation, and testing of measures to assess these. A process evaluation conducted during the effectiveness evaluation may use similar methods but there is a shift in focus. Conducting a process evaluation as part of a full-scale trial evaluation focuses on understanding the mechanisms of action, effects of contextual factors and increasing confidence in the study’s conclusion about effectiveness.

The work presented in this chapter was conducted at the feasibility stage of ImpulsePal. Therefore this chapter aims to address the following research question: “*Is the intervention feasible and acceptable to overweight and obese individuals?”* and presents in detail the objectives, methods, and results of the process evaluation conducted within the feasibility randomised controlled trial of ImpulsePal described in Chapter 5.

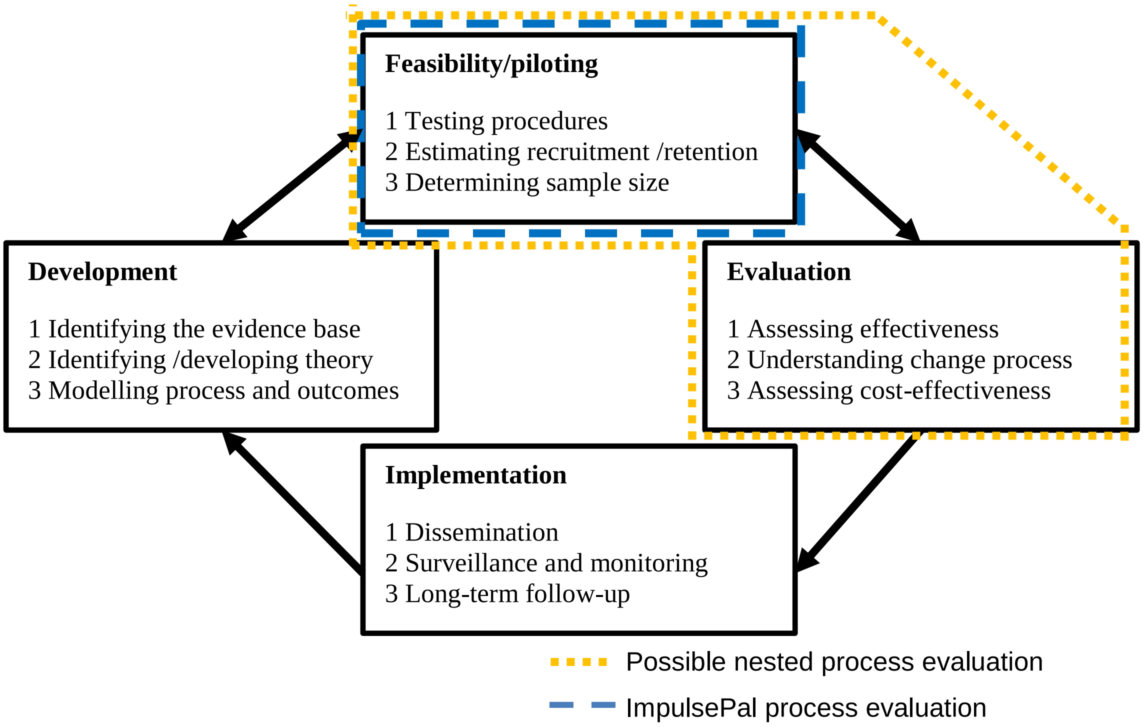


Figure 6.1 Stages during which a process evaluation is recommended and corresponding phase of ImpulsePal, adapted from (Craig et al., 2013)

6.2. Objectives

The aim of this process evaluation was to (a) assess the feasibility and acceptability of the intervention, (b) pilot methods for assessing potential mechanisms of action that could be used as part of a nested process evaluation within a future full-scale trial, (c) explore mechanisms of action (mediators of outcomes), (d) explore contextual factors which may moderate outcomes, and (e) inform refinements to the intervention and trial procedures. To do this, we conducted a used a mixed-methods approach consisting of an analysis of quantitative app usage statistics, exploratory analysis of questionnaire data investigating moderators and mechanisms of action, and a qualitative component employing semi-structured individual face-to-face interviews.

6.2.1. Research questions for the quantitative component.

6.2.1.1. App usage analysis.

(a) To what extent was the ImpulsePal intervention delivered as intended? (*delivery fidelity*)

(b) To what extent were the different components of the ImpulsePal intervention used?

6.2.1.2. Exploratory mediation and moderation analyses.

(a) Is weight loss resulting from receipt of the ImpulsePal mediated by changes in eating behaviour, general impulsiveness, sensitivity to the food environment, food craving, and self-efficacy?

(b) What sample characteristics may be potential moderators of changes in weight?

6.2.2. Research questions pertaining to the qualitative component.

6.2.2.1. Semi-structured interview data.

(a) What were participants' experiences of using the ImpulsePal intervention?

(b) What contextual influences affect engagement with ImpulsePal?

(c) What processes of impulse management and lifestyle behaviour change worked well or not so well?

6.3. Methods

6.3.1. Study design (QUANT + QUAL)

The study was conducted within the feasibility randomised controlled trial described in Chapter 5. To be able to answer the above research questions the process evaluation used a pragmatic mixed methods approach (Yardley & Bishop, 2008) nested within two cycles of intervention delivery and data collection (akin to the iterative action research process described by Whitehead et al., 2003). Simultaneous qualitative and quantitative data collection were undertaken and composite analysis conducted whereby analysis of both components were conducted in isolation, and data were analysed separately but the findings were integrated for discussion (Yardley & Bishop, 2008). The iterative cyclical process of intervention development and evaluation described by Whitehead and colleagues (2003) encompasses formative feedback-loops which consist of (a) systematic data collection, (b) feeding data back to the design, (c) taking action by changing/refining the intervention, and (d) evaluating the result of the changes by collecting more data. This approach is considered an appropriate methodology for use in feasibility studies (Gomm & Davies, 2000) and enables the refinement of the intervention in close collaboration with its intended users.

6.3.2. Participants

Eligibility criteria and study sample characteristics are described in detail in Chapter 5. For the qualitative component, an opportunistic sample of 36 participants took part in the semi-structured interviews and a purposive sample (Murphy et al., 1998) of 22 interviews (11 for each cycle) were transcribed for analysis. Participants were sampled based on age and BMI to give diversity in these characteristics by creating a sampling framework of three BMI categories (25-30, 30-35, and 35+) by three age categories (<40, 40-55, and 50+), and filling as many cells within the framework as possible (See Appendix 14).

6.3.3. Intervention

As described in Chapter 4, ImpulsePal is a theory- and evidence-based self-delivered weight management intervention accessible as an app on Android-based devices, which was systematically developed following the Intervention Mapping protocol (Bartholomew et al., 2011). The development process and intervention content are described in detail in Chapter 4 (and an overview of some of the programme materials can be seen in Appendix 12) but in brief, ImpulsePal provides users with easily accessible techniques to deal with unhealthy eating impulses by: (a) in-the-moment changing the strength of the impulse through urge surfing or watching dynamic visual noise when pressing an emergency button; (b) increasing inhibitory control with an inhibition training task (Brain Training); (c) preventing the initiation of an impulse through changes in the environment or preventing hunger; or (d) overriding the behavioural impulse by initiating a competing impulse using if-then planning and situational cues. In Cycle 1 participants were provided with ImpulsePal v1 and in Cycle 2 participants were provided with ImpulsePal v2 which resulted from the data driven refinements made to the intervention (reported below).

6.3.4. Measures

The assessment methods used in this feasibility stage process evaluation are described below and will be organised as follows (a) quantitative component – app usage data and secondary outcome and process questionnaires, and (b) qualitative component – semi-structured interviews. Figure 6.2 highlights which measures explore components in the logic model.

6.3.4.1. Quantitative component

App usage data

Participants' usage of the ImpulsePal app was automatically collected via the app which sent usage data to the database housed on a secure University of Exeter server. For each occurrence of app access, the participant unique identifier code, with a Unix timestamp, name of screen accessed (See Box 6.1), and duration of time spent on the screen (in milliseconds) was collected and provides an objective measure of how many participants viewed each screen, how many times, and for how long. The data were downloaded at the end of each participant's study participation (after the 3-month assessment visit).

BOX 6.1

-App instructions
-Main menu
-Motivations
-Stats/My resistance
-Brain Training Instructions
-Brain Training Game
-Urge Surfing Instructions
-Urge Surfing Steps
-If-then Planning Instructions
-If-then planning
-Danger Zones Instructions
-Danger zones
-Emergency Button

We expected that (a) the instructions for the app and each of its components would have been accessed by all participants at least once, and (b) the Brain Training game would have been accessed more than once as this was recommended in the app. However, we did not have any hypotheses about how frequently participants might access the other components, and therefore this is mainly an exploratory analysis.

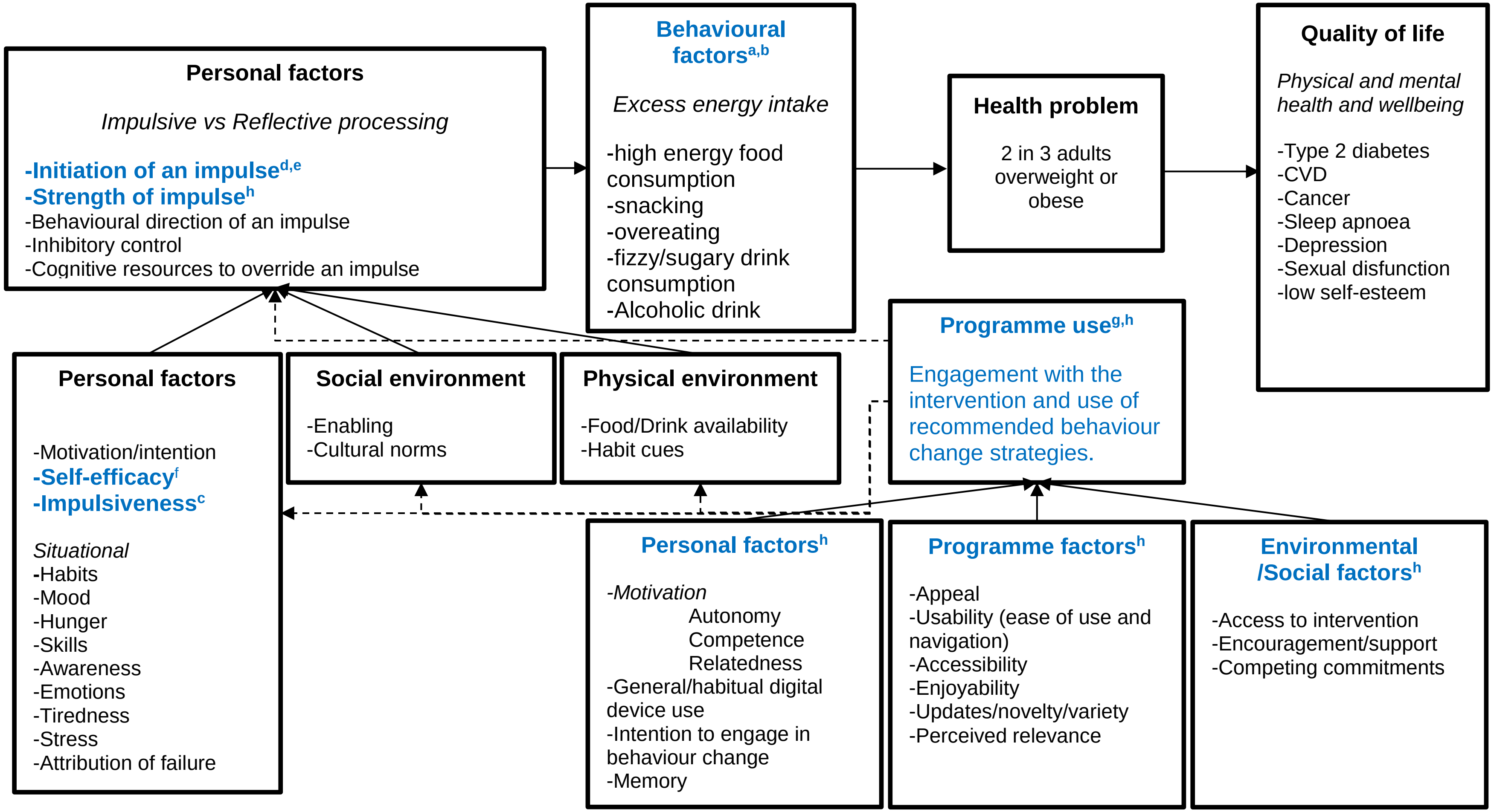


Figure 6.2 Elements of the logic model tested in the feasibility phase process evaluation.
[a] FFQ. [b] frequency of overeating episodes, loss of control during overeating, and number of days uncontrolled overeating. [c]BIS-15. [d]PFS. [e]FCQ-T-r. [f]Self-efficacy questionnaire. [g]App usage statistics. [h]Semi-structured interviews.

Secondary outcome and process questionnaires

Snacking behaviour and overeating episodes

The measures used to assess snacking behaviour and overeating are described in detail in Chapter 5. Briefly, snacking behaviour was measured using a 7-day recall food frequency questionnaire. Overeating was measured using items asking about the frequency of overeating and uncontrolled eating.

Impulsivity

The Barratt Impulsiveness Scale (BIS; Patton, Stanford, & Barratt, 1995)) is one of the most commonly used self-report measures of general impulsivity (general tendency to act on impulses). Its psychometric properties have been well established in both clinical and non-clinical populations (Stanford et al., 2009). It comprises 30 items consisting of three second-order subscales: attentional, motor, and non-planning which collectively represent a total impulsivity score. We used a more recent shorter version, the Barratt Impulsiveness Scale – short form (BIS-15; Spinella, 2007). The BIS-15 consists of 15 items which had been extracted from the original 30-item scale and represent the five items that showed the highest loading in the factor analysis for each of the three subscales. This short form correlates strongly with the original scale (r = 0.94) and retains the same three-factor structure: *attentional impulsivity* (e.g., “I am restless at lectures or talks”), *motor impulsivity* (e.g., “I act on the spur of the moment”) and *non-planning impulsivity* (e.g., “I plan tasks carefully” [inverted scoring]”). Each item is scored on a four-point response scale ranging from *rarely* to *almost always*. The items are summated to produce a score for each subscale and a total score out of 60. Therefore, higher scores represent higher impulsivity.

Sensitivity to the food environment/ food reward sensitivity

The 15-item power of food scale (PFS) assesses the hedonic impact of the obesogenic food environment (Cappelleri et al., 2009; Lowe et al., 2009) and higher scores are associated with a higher drive to consume highly palatable foods in the environment. Factor analysis conducted with the initial pool of 21 PFS items generated by obese women in a weight loss trial indicated that the PFS scale is best represented by a 15-item version with three subscale domains and an aggregated total score (average of three domains). The three domains are based on three levels of food proximity: (a) food availability (e.g., “I find myself thinking about food even when I am not physically hungry”), (b) food presence (e.g., “If I see or smell a food I like, I get a powerful urge to have some”), and (c) food tasted (e.g., “Just before I taste a favourite food, I feel intense anticipation”). Responses to the 15 items are measured using 5-point response scales and the subdomains are calculated as the mean of the items representing the corresponding domain (thus resulting in a score out of 5). The total score has been shown to have good (4-month) test-retest reliability (r = 0.77), is internally consistent (Cronbach’s alpha = 0.91), and has good construct validity (Lowe et al., 2009).

Food Cravings

The 15-item Food Cravings Questionnaire-Trait-reduced (FCQ-T-r) (Meule et al., 2014) was developed and validated in a number of languages (e.g., German, Italian, Spanish) as a short form of the original 39-item FCQ-T which assesses general susceptibility to cravings (as opposed to the FCQ-State version which assesses the strength of a craving at the moment of administration). This has been shown to be sensitive to change following bariatric surgery and behavioural weight loss interventions in obese people (Batra et al., 2013; Rieber et al., 2013). The English version was shown to be a valid and reliable alternative to the original 39-item version (Hormes & Meule, 2016) and has been shown to be sensitive to change following a smartphone app-based mindful eating intervention in people who are overweight or obese (Mason, Jhaveri, Cohn, & Brewer, 2017). This short form assesses essential cognitive and behavioural aspects of food craving such as thinking about food, intending to eat, losing control over intake, and emotional influences. The content of the FCQ-T-r reflects the elaborated intrusion theory (May, Andrade, Kavanagh, & Hetherington, 2012), which proposes that the core components of food cravings are their triggers, the mental imagery and cognitive elaboration that maintain the cravings and their strength, and their potential behavioural consequences (Meule et al., 2014). Items are answered on a 6-point scale from 1 (never) to 6 (always). A total score is computed as the sum (out of 90) of all items, with higher scores indicating greater trait food craving.

Self-efficacy

Following (Bandura, 2006) guidelines, a self-efficacy questionnaire was constructed for this study to specifically reflect the situations where /when temptations to make unhealthy food choices regularly arise. These were identified in the service user consultations held during the needs assessment phase of intervention development (described in Chapter 4). This questionnaire was used to measure the strength of participants' self-efficacy to regulate their eating habits and stick to a healthy diet in a variety of situations. The questionnaire used the phrase "can do" rather than "will do", to elicit judgements of capability rather than intention (i.e., "A number of situations are described below that can make it hard to stick to a healthy eating plan. Please rate in each of the blanks on the column how certain you are that you can stick to a healthy diet on a regular basis. Please rate your degree of confidence by recording a number from 0 to 100 using the scale given below."). Responses were measured on a 100-point scale, ranging from 0 – Cannot do at all, through 50 – Moderately certain can do, to 100 – highly likely can do). There were 9 items about specific situations, "Eating at a restaurant" "when lots of high fat food is available in the house", "Feel a strong urge to eat foods high in fat that you like", "when you are bored", "When faced with unhealthy foods in a supermarket", and one final question asking about confidence in being able to eat healthily in the long term (over at least the next 5 years). A total 0-100 score was produced as the average of the 10 responses.

6.3.4.2. Qualitative component

Semi-structured interviews

Individual semi-structured face-to-face interviews were conducted with intervention group participants who were available and willing to be interviewed at the one-month study visit. The topic guide was based on one used in a previous qualitative study investigating primary care patients' experiences with web-based weight management programmes and the factors influencing engagement with the programmes and use of behaviour change strategies (van Beurden et al., 2018). The topic guide explored participants' experiences of using the ImpulsePal app and its strategies and elicited barriers to engaging with the app and to the use of change strategies recommended in the app (See

Appendix 15). Two participants sent feedback on the app via email and one was interviewed at a different time point. The emailed feedback was not used in the analysis however, as the issues raised were not new compared to those covered in the interviews.

6.3.5. Procedures

Recruitment and detailed data collection procedures are described in Chapter 5. Briefly, (a) app usage was collected via the app (intervention group only), (b) participants in the intervention group and control group were asked to complete the questionnaires described above which may be suitable for use in a nested process evaluation of a full-scale trial, at baseline, one-month and three-months of follow-up (See Table 5.2 in Chapter 5 for the measurement schedule), and (c) qualitative data were collected via semi-structured audio-recorded interviews with intervention group participants only at the one month follow up. Although participants had provided written consent to take part in the feasibility study, which included consent for a recorded interview, participants were asked to verbally confirm consent at the one-month study visit. Those who were not willing/able to be interviewed reported that they did not have the time for an interview. The interviews were conducted by the PhD student who has had training and previous experience in qualitative interviewing and analysis (van Beurden et al., 2018) in a comfortable, private meeting room at the University of Exeter Medical School. No relationship between the student and any of the participants in the analysis existed prior to the feasibility study, however, the PhD student had been able to build a rapport with all participants during the recruitment process and baseline study visit. Respondent validation was conducted during the interview to ensure understanding of the data. The interviews were audio-recorded and a purposive sample (as described above) of interview recordings were transcribed verbatim, anonymised and imported into NVivo 10 to help organise the data.

6.3.6. Analysis

6.3.6.1. Quantitative component

App usage data

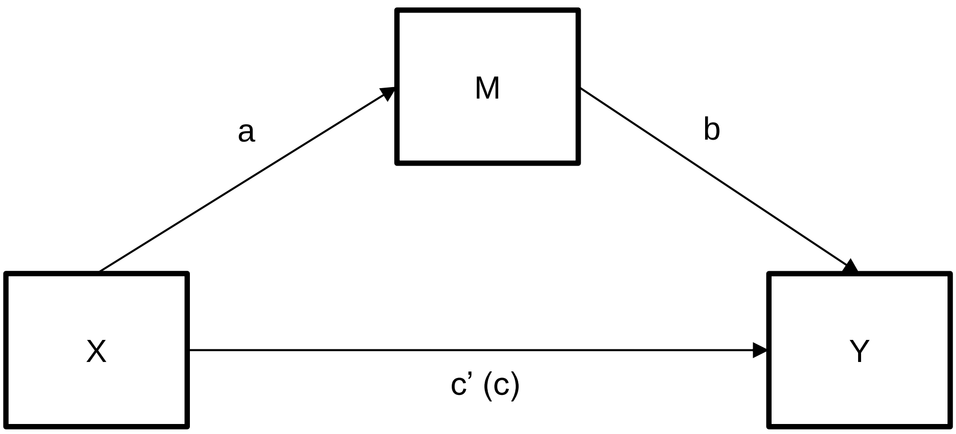
App usage data were summarised using descriptive statistics for the (a) number of participants viewing specific screens, (b) number of times participants viewed specific screens, and (c) the time spent on the ImpulsePal app by each participant (reported in Chapter 5).

Secondary outcome and process questionnaires

The secondary outcomes and process variables were incorporated in a series of analyses. However, fully exploring the mechanisms of action requires a larger sample size than currently available at this feasibility stage, therefore the mediation analyses conducted are exploratory only and will be interpreted accordingly.

Firstly, exploratory mediation analyses were conducted with the process variables described above and the secondary outcomes described in Chapter 5. Simple mediation analysis aims to establish whether (and to what extent) a *predictor* variable (i.e., receiving ImpulsePal) has an effect on the *outcome* variable (i.e., weight loss) through another *mediator* variable (e.g., snacking behaviour; See Figure 6.3). The mediation analyses were conducted in SPSS using the PROCESS macro (Hayes, 2012) that is a freely available computational tool for SPSS which implements mediation analyses using a path-analysis framework (Preacher, Rucker, & Hayes, 2007).

This individual path-analysis estimates the various paths shown in Figure 6.3 (i.e., a-path, b-path, and c (c')-path) using ordinary least squares (OLS) regression (Baron & Kenny, 1986), supplemented with a formal test estimating the significance and size of the indirect effect (a*b). Baseline BMI was entered into the models as a covariate to control for the baseline differences reported in Chapter 5. In the first step (a-path) between group differences in change scores of secondary outcome and process measures were explored. The between group analyses for the primary (i.e., weight loss) and secondary outcomes (i.e., snack consumption and overeating frequency) are reported in detail Chapter 5 but will briefly be summarised in this chapter to facilitate reporting of subsequent mediation analyses. The second step explored the association between changes in process variables and change in weight. The formal test of the indirect effect was conducted by bootstrapping the sampling distribution of the indirect effect (a*b) and deriving a CI for this bootstrapped sampling procedure (MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002; Preacher & Hayes, 2004, 2008). Finally, percent mediation (P_m) was calculated as the indirect effect divided by the total effect in the mediation model, to assess how much of the total effect is accounted for by the mediating variable. As these analyses are exploratory only, no adjustments were made for multiple testing.



direct effect (not via M) = c’ path

indirect effect = a*b path

total effect (including direct and indirect effect) = c path

Figure 6.3 Conceptual model of simple mediation.

Secondly, moderation analyses aimed to establish whether the effect of the predictor variable on the outcome, is influenced by a particular characteristic of the population or context (e.g., gender, or baseline BMI; See Figure 6.4). PROCESS was used to explore simple moderation models of the effect of ImpulsePal on weight change at one-month. For continuous moderators, variables were centralised (removing the mean for the variable from each participant score). Regression models were built using the moderator variable, group allocation, and the interaction between the moderator variable and group allocation. Baseline BMI, age, gender, cognitive restraint, baseline impulsiveness, baseline trait food cravings, were explored as potential moderators in each separate model. To explore potential conditional effects, three levels of the moderators were investigated, low (one SD below the mean, average (the mean), and high (one SD above the mean). The Johnson-Neyman technique (Johnson & Fay, 1950) was used to further explore potential interactions. This technique identifies values where the effect of the predictor moves from significant to non-significant.

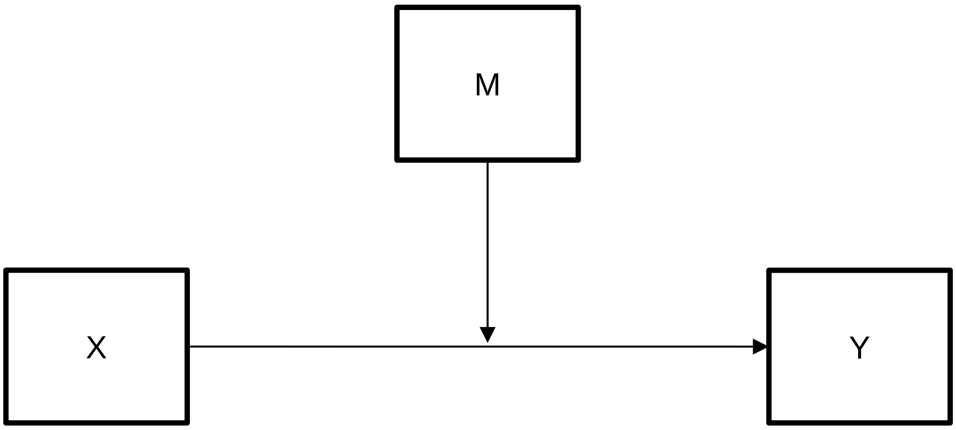


Figure 6.4 Conceptual model of moderation.

6.3.6.2. Qualitative analysis.

Semi-structured interviews.

The interview transcripts were analysed using inductive thematic analysis (Braun & Clarke, 2006) which involved (a) familiarising with the data by reading the transcripts and listening to the interview recordings, (b) coding the content of the interviews into concepts and continuously updating the coding manual to reflect the ongoing analysis, (c) using constant comparison to check coding was consistent throughout the analysis, and updating definitions regularly to better reflect the totality of the data, and (d) merging codes which reflected similar aspects into higher level themes. Final themes and illustrative quotes were agreed by CG.

6.4. Results

6.4.1. Quantitative analysis

6.4.1.1. App-usage data

An overview of the app-usage analysis is provided in Table 6.1 and Table 6.2. The analysis showed that 56 out of the 58 intervention group participants had successfully downloaded and accessed the ImpulsePal app. Of the 56 participants with usage data available, the majority had seen the instructions for the app and its components (i.e., brain training, urge-surfing, if-then planning, emergency button, and the danger zones; See Table 6.1). There was some increase in views (improved fidelity of intervention delivery) seen in Cycle 2, which followed refinements of the instruction screens for the Brain training, urge surfing, and emergency button components, but not for the instruction screen of the Danger zones component. It is important to note that in Cycle 2, three participants had missing data with regard to successfully logging in and one of these had not accessed the welcome screen. However, usage data for these participants were available for the other components accessed. Considering the subsequent components are not accessible until a successful log in has occurred and the user has been guided through the app instructions, this is likely due to an error in data transfer from the device to the server for these participants.

Table 6.1 No. of participants who viewed the ImpulsePal and key component instruction screens (fidelity – *delivery*).

	Cycle 1 N = 26	Cycle 2 N = 30	**Total** **N = 56**
First time -log in N (%)	26 (100%)	27 (90%)	**53 (95%)**
App instructions N(%)	26 (100%)	28 (93%)	**54 (96%)**
Brain Training N(%)	24 (92%)	30 (100%)	**54 (96%)**
Urge Surfing N(%)	22 (85%)	29 (97%)	**51 (91%)**
If-then planning N(15)	24 (92%)	30 (100%)	**54 (96%)**
Emergency Button N(%)	25 (96%)	30 (100%)	**55 (98%)**
Danger zones N(%)	24 (92%)	27 (90%)	**51 (91%)**

During participants' first month of using the ImpulsePal app the brain training game, the if-then plans, and the emergency button were the most accessed key components in Cycle 1 (See Table 6.2) and urge-surfing, if-then plans, and the emergency button in Cycle 2 (See Table 6.3). In Cycle 1, 22 participants (85%) used the Brain Training game as intended (i.e., more than once) and 4 (15%) did not use it at all. In Cycle 2, only one participant (3%) did not use the Brain Training game, five used it only once (17%), and the remaining 24 (80%) used it as intended.

The stacked polar plots in Figure 6.5 and Figure 6.6 show individual usage of the key components (i.e., number of times key screens are viewed for each individual) during the first month of use. These illustrate the difference in use of each of the components within the individual and among the users, but also highlights a number of high users in Cycle 1 and 2.

In terms of continued use after the first month, 70% of the total 56 participants had accessed the app again by the end of their study participation (See Chapter 5). Table 6.2 and Table 6.3 highlight the number of participants accessing the separate components and the total, range, and central tendency (median due to very skewed data) of screen views. Following the first month, the number of participants using the Brain Training game and the Emergency Button dropped the least compared to the other key components, but dropped more in Cycle 2 than in Cycle 1. As reported in Chapter 5, app usage in terms of total time spent using the app was not associated with weight loss.

Table 6.2 ImpulsePal app usage as screen views for participants accessing the main menu, motivations, or stats screens or the five key components in Cycle 1 (N=26)

	Month 1		Month 2		Month 3	
		N (%)		N (%)		N (%)
Main Menu						
Total views	934	26 (100%)	309	15 (58%)	106	10 (39%)
Range	2 – 132		1 – 67		2 – 20	
Median (IQR)	20.0 (30.0)		18.0 (28.0)		8.5 (15.3)	
Motivations						
Total views	197	26 (100%)	38	9 (35%)	16	5 (19%)
Range	1 – 25		1 – 9		1 – 10	
Median (IQR)	4.5 (7.3)		4.0 (6.0)		2.0 (9.0)	
Stats /My resistance						
Total views	39	11 (42%)	27	5 (19%)	0	0
Range	1 – 7		1 – 23			
Median (IQR)	1.0 (3.0)		1.0 (11.0)			
1. Brain Training game						
Total views	248	22 (85%)	193	14 (54%)	75	10 (39%)
Range	2 – 32		1- 63		1 – 28	
Median (IQR)	7.0 (13.0)		7.0 (18.5)		3.0 (12.0)	
2. Urge Surfing						
Total views	134	21 (81%)	27	8 (31%)	6	4 (15%)
Range	1 - 31		1 – 6		1 – 2	
Median (IQR)	4.0 (5.0)		3.0 (4.5)		1.5 (1.0)	
3. If-then planning						
Total views	408	24 (92%)	115	11 (42%)	24	7 (27%)
Range	1– 77		2 – 48		1 – 7	
Median (IQR)	13.5 (29.8)		4.0 (8.0)		4.0 (2.0)	

	Month 1	N (%)	Month 2	N (%)	Month 3	N (%)
4. Emergency Button						
Total views	225	25 (96%)	91	13 (50%)	37	9 (35%)
Range	1 – 24		1 – 21		1- 15	
Median (IQR)	7.0 (10.5)		6.0 (9.5)		3.0 (4.5)	
5. Danger zones						
Total views	128	22 (85%)	37	10 (38%)	12	5 (19%)
Range	1 – 22		1 – 12		1 – 8	
Median (IQR)	3.0 (4.25)		2.0 (5.3)		1.0 (3.5)	

Table 6.3 ImpulsePal app usage as screen views for participants accessing the main menu, motivations, or stats screens or the five key components in Cycle 2 (N=30)

	Month 1	N (%)	Month 2	N (%)	Month 3	N (%)
Main Menu						
Total views	711	30 (100%)	157	17 (57%)	117	15 (50%)
Range	4 – 73		1 – 34		1 – 33	
Median (IQR)	22.0 (23.5)		8.0 (11.0)		3.0 (9.0)	
Motivations						
Total views	123	27 (90%)	17	6 (20%)	12	5 (17%)
Range	1 – 12		1 – 5		1 – 3	
Median (IQR)	4.0 (5.0)		2.0 (3.3)		3.0 (1.5)	
Stats /My resistance						
Total views	28	18 (60%)	3	2 (7%)	4	2 (7%)
Range	1 – 10		1 – 2		2	
Median (IQR)	1.5 (2.0)		1.5 (/)		2 (-)	
1. Brain Training game						
Total views	200	29 (97%)	42	11 (37%)	39	8 (27%)
Range	1 - 36		1 – 14		1 – 22	
Median (IQR)	4.0 (6.5)		3.0 (2.0)		1.0 (6.0)	
2. Urge Surfing						
Total views	208	29 (97%)	46	11 (37%)	12	4 (13%)
Range	2 – 34		1 – 21		2 – 4	
Median (IQR)	6.0 (8.5)		2.0 (3.0)		3.0 (1.5)	
3. If-then planning						
Total views	381	30 (100%)	104	11 (37%)	45	7 (23%)
Range	2 – 49		1 - 26		2 – 19	
Median (IQR)	16.0 (17.3)		6.0 (17.0)		5.0 (5.0)	
4. Emergency Button						
Total views	199	29 (97%)	34	15 (50%)	47	8 (27%)
Range	2 – 20		1 – 8		1 – 16	
Median (IQR)	6.0 (5.0)		2.0 (2.0)		3.5 (10.3)	

	Month 1	N (%)	Month 2	N (%)	Month 3	N (%)
5. Danger zones						
Total views	81	26 (87%)	9	5 (17%)	5	3 (10%)
Range	1– 8		1 – 4		1 – 2	
Median (IQR)	2.0 (2.3)		1.0 (2.0)		2.0 (/)	

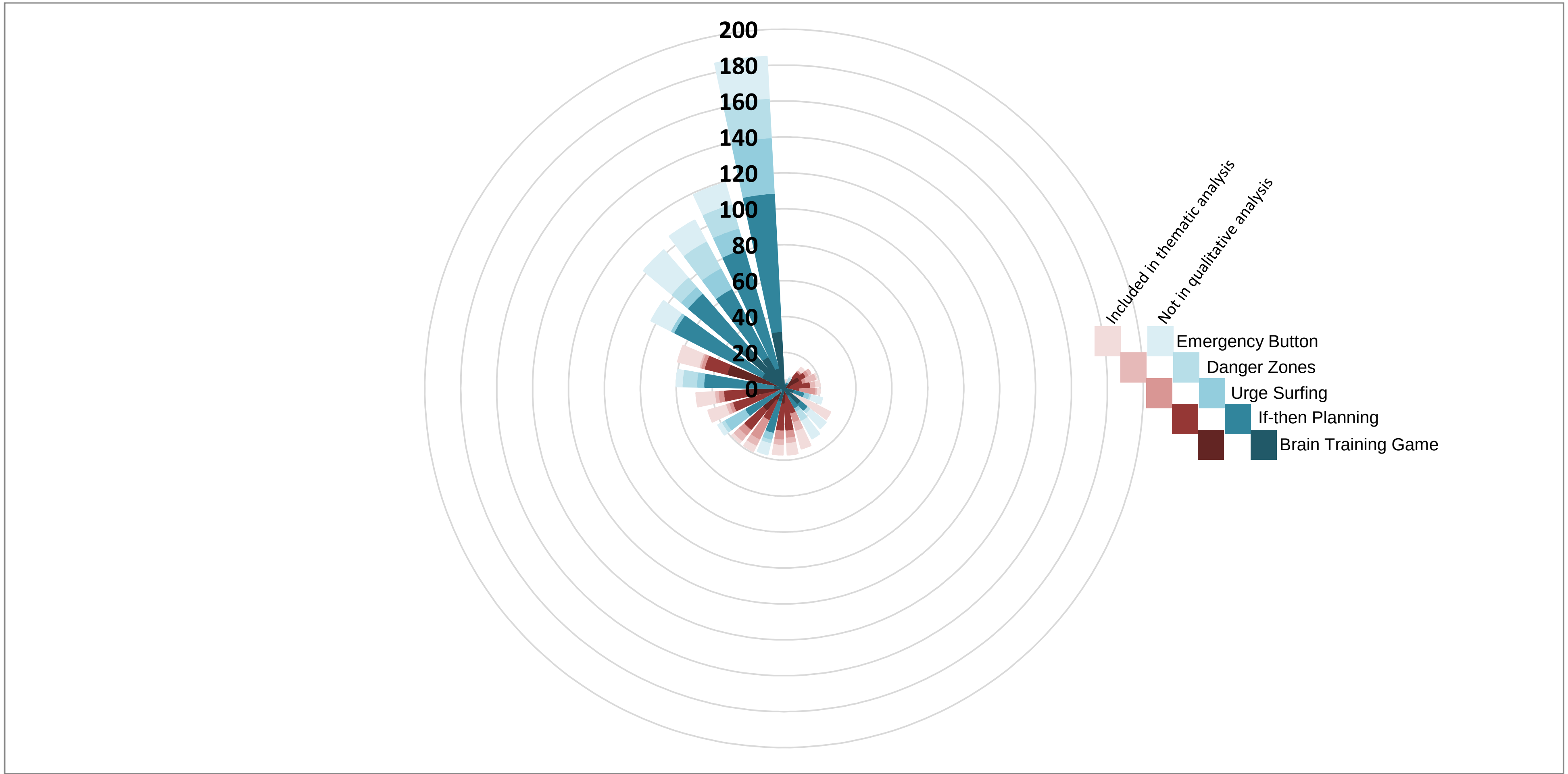


Figure 6.5 Individual usage of ImpulsePal version 1 and key components – Cycle 1*
**Note:* Each stack represents a different participant, the height of the stacks represents the total number (sum) of times the participant accessed the key components of the app, each segment within the stack represents a specific key component (as per the legend). Two different colour gradients are used to distinguish between participants who were included in the thematic analysis, and those who were not.

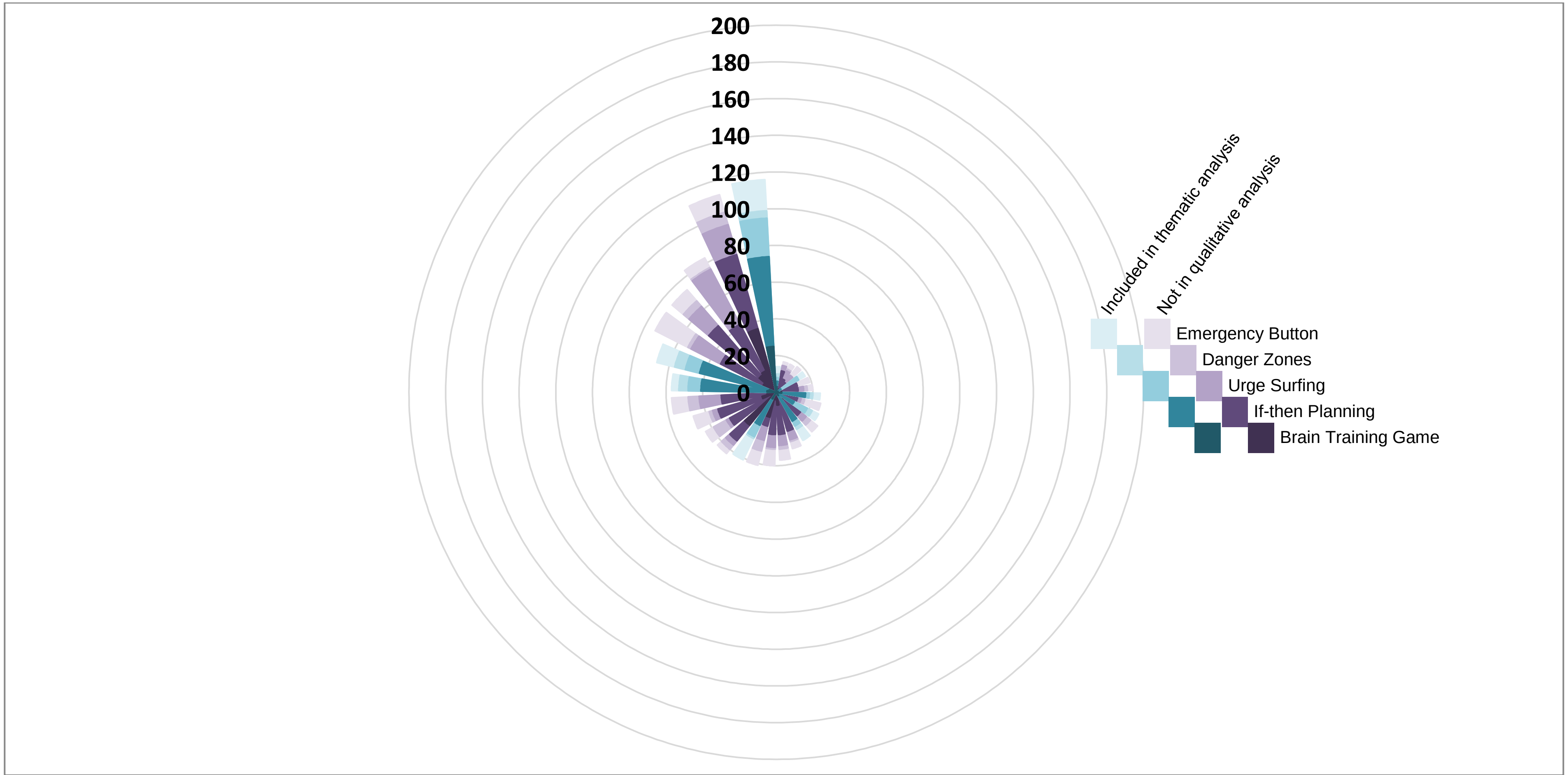


Figure 6.6 Individual usage of ImpulsePal version 2 and key components – Cycle 2*

**Note:* Each stack represents a different participant, the height of the stacks represents the total number (sum) of times the participant accessed a key component of the app, each segment within the stack represents a specific key component (as per the legend). Two different colour gradients are used to distinguish between participants who were included in the thematic analysis, and those who were not.

6.4.1.2. Process questionnaires

Participants

A detailed description of the baseline sample characteristics is presented in Chapter 5. Of the 88 participants randomised, 85 (96.6%) completed process questionnaires at baseline, 71 (80.6%) at the one-month, and 66 (75%) at the three-month follow up.

Exploring changes in process variables associated with ImpulsePal

The change scores for the process variables are presented in Table 6.4. The findings relating to the primary and secondary outcomes are reported in Chapter 5. Briefly, the intervention group showed significantly greater weight loss at one-month, but not at three months. Changes in a positive direction were seen in nearly all secondary measures. Reflecting reductions in snacking and overeating behaviour, from baseline to up to three-months in both groups, with significantly greater reductions in frequency of loss of control during overeating and number of uncontrolled overeating in the intervention group. In terms of the process variables, both groups reported improvements for all variables but impulsiveness, at both time points. The change scores suggests that the measures used to assess sensitivity to the food environment, trait food cravings, and self-efficacy are sensitive to change, whereas the measure used to assess impulsiveness may not be. The control group reported (non-significantly) better improvements in terms of greater reductions in impulsiveness, sensitivity to the food environment, and food cravings, and greater increases in self-efficacy at both time points.

Table 6.4 also shows the associations between the potential mediators and weight change (b-path) and the indirect effect (a*b) of receipt of ImpulsePal on weight via these variables. At one-month, significant associations with weight change were found for changes in all secondary outcomes and sensitivity to the food environment. At three months, only the associations between weight change and changes in sensitivity to the food environment and trait food cravings were significant. The indirect effects of receipt of ImpulsePal on weight change, through changes in the frequency of loss of control, a*b = -0.39 (BCa 95% -0.68 to -0.14), and in the number of days loss of control during overeating, a*b = -0.30 (BCa -0.55 to -0.09) were significant at one-month, suggesting mediation occurred. These mediators could account for roughly half of the effect, $P_m = 0.45$ and $P_m = 0.46$ respectively. Although the effect of ImpulsePal on change in overeating episodes was not significance, the indirect effect on weight via change in overeating episodes did reach significance.

The same path analyses were conducted to explore the effects of ImpulsePal via the process variables on the secondary outcomes. As the initial path analyses show, there were no significant effects of receipt of ImpulsePal on change in the process variables (a-path). However, there were significant associations between some of the process variables and the secondary outcomes (b-path). At one-month, there were significant associations between change in total snacking behaviour and changes in, sensitivity to the food environment, b = 0.36 (0.15 to 0.57), trait food craving, b = 0.01 (0.00 to 0.03), and self-efficacy, b = -0.01 (-0.02 to -0.00). At three months these associations were significant for trait food cravings b = 0.02 (0.01 to 0.03) and self-efficacy, b = -0.01 (-0.01 to -0.00). Change in frequency of overeating episodes was significantly associated with changes in sensitivity to the food environment, b = 3.74 (0.72 to 6.78) and self-efficacy, b = -0.14 (-0.24 to 0.03) at one month, and trait food craving, b = 0.16 (0.01 to 0.31) at three months. Change in frequency of loss of control during overeating (as number of times experienced over 28 days) was significantly associated with change in sensitivity to the food environment, b = 3.01 (0.35 to 5.8) at one month. Finally, change in the number of days uncontrolled overeating occurred was significantly associated with change in self-efficacy at both one- and three-month follow-up, b = -0.11 (-0.20 to -0.02) and b = -0.10 (-0.17 to -0.02) respectively. However, no indirect effects (a*b) of receipt of ImpulsePal via these potential mediators reached significance.

Table 6.4 Exploratory analysis of change scores of process variables and between group comparisons and mediation (path) analyses of the effect of receipt of ImpulsePal on weight loss

	ImpulsePal M (SD)	N	Control M (SD)	N	A-path ImpulsePal - variable Coefficient and 95% CI	B-path Variable – weight change Coefficient and 95% CI	Indirect (a*b-path) effect of receipt of ImpulsePal on weight change (Bootstrapped 95% CI)
Food frequency							
One-month	-0.36 (0.50)	47	-0.20 (0.45)	24	-0.16 (-0.41 to 0.08)	1.00 (0.34 to 1.65)*	-0.16 (-0.47 to 0.06)
Three-months	-0.34 (0.46)	43	-0.40 (0.58)	23	0.07 (-0.20 to 0.33)	0.85 (-0.56 to 2.27)	0.06 (-0.23 to 0.51)
Snack index							
One-month	-0.42 (0.51)	47	-0.23 (0.60)	24	-0.19 (-0.46 to 0.08)	0.77 (0.18 to 1.37)*	-0.15 (-0.53 to 0.05)
Three-months	-0.43 (0.46)	43	-0.35 (0.53)	23	-0.09 (0.34 to 0.17)	0.59 (-0.91 to 2.08)	-0.05 (-0.47 to 0.22)
Drink index							
One-month	-0.20 (0.79)	47	-0.11 (0.68)	24	-0.09 (-0.47 to 0.29)	0.44 (0.01 to 0.88)*	-0.04 (-0.24 to 0.12)
Three-months	-0.09 (0.75)	43	-0.55 (1.01)	23	0.47 (0.02 to 0.91)*	0.59 (-0.25 to 1.43)	0.28 (-0.18 to 1.09)
Overeating episodes							
One-month	-4.99 (7.75)	45	-1.67 (4.27)	24	-3.33 (-6.69 to 0.02)	0.08 (0.03 to 0.13)*	-0.26 (-0.56 to -0.04)*
Three-months	-4.87 (7.47)	43	-2.89 (4.52)	22	-2.33 (-5.79 to 1.12)	0.08 (-0.02 to 0.18)	-0.19 (-0.65 to 0.09)
Loss of control							
One-month	-4.60 (7.19)	44	0.25 (2.94)	24	-4.85 (-7.86 to -1.85)*	0.08 (0.03 to 0.14)*	-0.39 (-0.68 to -0.14)*
Three-months	-3.76 (7.41)	43	-0.66 (3.27)	22	-3.31 (-6.65 to 0.03)	0.07 (-0.03 to 0.17)	-0.24 to (-0.82 to 0.92)
No. days uncontrolled overeating							
One-month	-4.14 (6.85)	45	-0.33 (2.76)	24	-3.82 (-6.73 to -0.90)*	0.07 (0.02 to 0.14)*	-0.30 (-0.55 to -0.09)*
Three months	-3.85 (7.31)	43	-1.07(4.56)	23	-3.02 (-6.40 to 0.35)	0.10 (-0.01 to 0.21)	-0.29 (-0.84 to 0.10)
Impulsivity							
One-month	0.82 (3.48)	47	-0.49 (3.73)	24	1.31 (-0.49 to 3.10)	0.01 (-0.09 to 0.10)	0.01 (-0.16 to 0.16)
Three-months	-0.07 (3.18)	42	0.05 (6.22)	23	-0.01 (-2.36 to 2.34)	0.02 (-0.15 to 0.18)	-0.00 (-0.18 to 0.30)

	ImpulsePal M (SD)	N	Control M (SD)	N	A-path ImpulsePal - variable Coefficient and 95% CI	B-path Variable – weight change Coefficient and 95% CI	Indirect (a*b-path) effect of receipt of ImpulsePal on weight change (Bootstrapped 95% CI)
Sensitivity to food environment							
One-month	-0.18 (0.51)	47	-0.25 (0.53)	24	0.07 (-0.19 to 0.33)	0.29 (0.37 to 0.94)*	0.02 (-0.11 to 0.17)
Three-months	-0.27 (0.83)	43	-0.37 (0.56)	23	-0.07 (-0.31 to 0.45)	1.02 (0.06 to 1.97)*	0.07 (-0.29 to 0.47)
Food cravings							
One-month	-3.80 (7.77)	46	-5.96 (12.91)	24	2.14 (-2.69 to 6.98)	0.02 (-0.02 to 0.05)	0.04 (-0.11 to 0.24)
Three-months	-5.83 (11.51)	43	-5.00 (9.65)	23	-1.41 (-7.08 to 4.27)	0.07 (0.01 to 0.14)*	-0.10 (-0.57 to 0.34)
Self-efficacy							
One-month	5.83 (11.51)	46	6.04 (19.87)	24	-0.16 (-7.51 to 7.19)	-0.02 (-0.04 to 0.00)	0.00 (-0.23 to 0.18)
Three-months	4.82 (17.0)	42	8.37 (23.05)	23	-1.99 (-11.65 to 7.67)	-0.02 (-0.06 to 0.02)	0.04 (-0.15 to 0.54)

* Confidence Interval does not include zero.

Exploring potential moderators of the effect of ImpulsePal on weight

Baseline BMI

The overall simple moderation model, including baseline BMI, was significant F (3, 70) = 4.67, p < 0.01, R^2 = 0.17. Consistent with findings reported in Chapter 5, receipt of ImpulsePal significantly predicted weight change at one-month, b =-1.04, (95% CI -1.75 to -0.43). Neither BMI nor the interaction between group allocation and BMI were significant. However, among people with a low BMI (-1SD from the mean, 26.7kg/m^2), people who received ImpulsePal significantly lost 1.5kg more than the control group (95% CI 0.51 to 2.49). Among those with an average BMI (M = 32.1) those receiving ImpulsePal significantly lost 1.0kg more than the control group (95% CI 0.34 to 1.75). However, for people with a high BMI (+1SD from the mean, 37.5kg/m^2) there was no significant difference. Within our sample, ImpulsePal significantly predicts weight change for those with a BMI of up to 35.4kg/m^2, b = -0.79 (95% CI -1.58 to -0.00). As baseline BMI decreases, the effect of ImpulsePal on weight may become more positive (i.e., more weight loss).

Age

The overall simple moderation model including baseline age was not significant. Although, ImpulsePal still predicted weight change, baseline age, and the interaction did not. However, among older people (59.8years) and average aged people (M = 45.6years) in our sample, those receiving ImpulsePal significantly lost 1.18kg (95% CI 0.16 to 2.20) and 1.0 kg (-0.26 to 1.71) more than those in the control group. There was no significant difference in weight loss for younger people (31.4). Within our sample, ImpulsePal significantly predicts weight change for those older than 36 years of age. As age increases, the effect of ImpulsePal on weight may become more positive.

Gender

The simple moderation model including gender was significant, F (3,70) = 2.71, p = 0.05, R^2= 0.10. Neither gender nor the interaction between gender and group allocation significantly predicted weight change. Men in using ImpulsePal significantly lose 1.49kg (95% CI 0.12kg to 2.86) more, than men in the control group. There was no difference among women using ImpulsePal or women in the control group.

Cognitive restraint

The overall simple moderation model including cognitive restraint was significant, F (3,70) = 3.0, p = 0.04, R^2 = 0.11. Cognitive restraint and the interaction between cognitive restraint and group allocation were not significant. Among people who were less restrained (i.e., less likely to consciously restrict their food intake in order to control body weight; scoring around 18.2) and those who were average in their cognitive restraint (M = 37.2) those receiving ImpulsePal significantly lose 1.45kg (95% CI 0.42 to 2.47) and 0.97kg (0.25 to 1.70) more than similar people in the control group, respectively. ImpusePal did not significantly predict weight loss for people high in cognitive restraint (57.1). Within our sample, ImpulsePal significantly predicts weight change for those with a cognitive restraint score of up to 44.8 (out of 100), b = -0.79 (-1.58 to -0.00). As baseline cognitive restraint decreases, the predicted effect of ImpulsePal on weight may become more positive.

Impulsiveness

The overall simple moderation model including baseline impulsiveness was significant, F (3,70) = 2.96, p = 0.4, R^2 = 0.11. Neither baseline impulsiveness nor the interaction between impulsiveness and group allocation reached significance. Among people who were less impulsive (25.7), ImpulsePal did not significantly predict weight change. However, among people who were averagely impulsive (M = 32.8) or highly impulsive (39.9), people receiving ImpulsePal lose 0.99kg (95% CI 0.26 to 1.71) and 1.40kg (95% CI 0.40 to 2.40) more than those in the control group, respectively. As baseline impulsiveness increases, the effect of ImpulsePal on weight may become more positive.

Trait food cravings

The overall model including trait food cravings was significant, F (3,70) = 4.18, p < 0.01, R^2 = 0.15. Neither trait food cravings nor the interaction significantly predicted weight change. Among people who are highly affected by food cravings, scoring high on the are less affected by cravings FCQ-T-reduced

(67.3) and those scoring about average (50.4), those receiving ImpulsePal significantly lose 1.58kg (95% CI 0.58 to 2.57) and 0.97kg (95% CI 0.26 to 1.68) more than those in the control group. However, among those scoring lower in trait food craving (33.5) there was no difference between those receiving ImpulsePal and those who do not.

6.4.2. Qualitative analysis

Of the 48 participants invited for a recorded interview, 36 took part. All 36 interviews were used to immediately identify key areas for improvement in terms of app navigation, textual content, and barriers to engagement. Notes were taken by the interviewer which directly informed changes to be implemented for version 2 of ImpulsePal. A purposive sample of 22 interviews (11 for each Cycle) (as described above) was used for the in-depth thematic analysis. This analysis identified all key areas for improvement that had been highlighted in the interviewer notes for the remaining interviews. All interviews took place during the one-month study visit and lasted between 16 and 40 minutes. The analysed sample had a BMI of 33.3 (SD = 4.8) and had an average age of 50.0 (SD = 13.3). Other individual participant characteristics are provided in Table 6.5. The participants included in the qualitative analyses were similar to the remainder of the participants in the intervention group in terms of BMI, weight change, and changes in snacking behaviour, but included a higher percentage of female participants and were slightly older.

Findings are presented under four overarching themes: “Participants’ perceptions and use of ImpulsePal”, “Perceptions and use of the specific impulse management strategies”, “Impact of ImpulsePal on behaviour change and attitudes”, “Factors influencing engagement and enactment.” Quotes (from transcripts used in the in-depth thematic analysis only) are presented to illustrate and support the analysis and are labelled using pseudonyms (to protect confidentiality and anonymity), gender, age, BMI, and weight change.

Table 6.5 Qualitative analysis sample characteristics

Pseudonym	Gender	Age (years)	BMI (kg/m^2)	Weight change (kg)	Eating behaviour change (out of 7)
ImpulsePalV1					
Anna	Female	34	39.9	-3.2	-0.9
Lisa	Female	46	31.3	-2.5	-0.1
Alexandra	Female	49	31.6	0.7	-0.2
Isabelle	Female	53	33.2	1.1	0.2
Alice	Female	53	35.5	0	-0.4
Tracey	Female	54	28.8	-0.8	0
Rosie	Female	65	41.5	-0.5	0
Sarah	Female	65	29.4	-1.2	-0.3
Kathryn	Female	71	33.9	-1.8	-0.1
Theo	Male	30	28.0	0.25	0.1
Matthew	Male	69	38.0	0.4	0.3
ImpulsePalV2					
Rachel	Female	31	44.3	0.5	-0.2
Hollie	Female	33	31.6	2.8	0.1
Megan	Female	35	39.5	-0.3	0.4
Kate	Female	50	31.1	-0.8	-0.3
Georgina	Female	50	34.4	-2.0	-1.1
Louise	Female	65	29.8	-0.6	-0.4
Eleanor	Female	70	28.2	-1.1	-0.5
Harry	Male	40	30.1	-2.5	-0.8
Lewis	Male	43	26.1	-2	0
Toby	Male	47	36.3	-0.5	-1.5
Robert	Male	50	30.5	-2	-0.4
Interviewees in analysis (N=22)	*72.7 % female*	*50.1 (13.1)*	*33.3 (4.8)*	*-0.7 (1.4)*	*-0.3 (0.5)*
Other participants (N=36)	*58.3% female*	*44.6 (13.7)*	*32.5 (6.1)*	*N=26 -1.0 (1.3)*	*N=25 -0.5 (0.5)*

6.4.2.1. Participants' perceptions and use of ImpulsePal.

Most participants in both Cycle 1 and Cycle 2 reported finding the ImpulsePal app easy to use and easy to navigate, although one participant felt that the user interface did not flow well and made interacting with specific components difficult.

> "*well I think as apps go, I'm not, I'm not a super technophile and I'm not great with apps and I do sometimes find myself kind of say, but it is, I quite like the*

way it's laid out, it's quite simple and nice, and quite easy, I found it quite easy to use." (V1 Lisa, F, 46yrs, 31.3kg/m^2, -2.5kg)

"*Initial interaction with it was clunky, clunky enough to just make me just not use it. And at that point, it's completely failed then because there's no interaction at all. So, app now taking up space on the phone and I'm using Google Fit, and that's that.*" (V2, Lewis, M, 43yrs, 26.1kg/m^2, -2kg)

One participant reported changing phones and had tried to access the app using a new phone. After initial issues with being able to download the app on the new phone (at the time of the study the app had to be downloaded with a study specific password) they noted a frustration with having to set up reminders and plans again.

"all my other apps on my phone just sort of…it let me login or they're already done, whereas that one, you know, I think it's almost a week maybe where I wasn't using that because I haven't logged in. And I find it as well a really frustrating thing, was like I had to do it all again, like all my plans are gone and everything are gone." (V2, Megan, F, 35yrs, 39.5kg/m^2, -0.3kg)

Some participants in Cycle 1 highlighted that they may have not read, or had misread the instructions which resulted in not understanding what to do and in some cases resulted in no longer using the app.

"*there were some instructions, but... just trying to think, no I don't... For me I got into using it, but that could well be. because I sort of, if it says you know, next page or something like that, you know [taps table] go straight on and see what happens and I, then I got to the point where I don't know what happened, so don't I use it now."* (V1 Matthew, M, 69yrs, 38kg/m^2, +0.4kg).

Some participants mentioned that they initially couldn't find the app icon, or did not realise there was an additional icon, and were therefore accessing ImpulsePal via the Emergency Button.

"*when it installed, the actual main, the main logo, y'know, the main app symbol that appeared in my file, whereas the Emergency symbol actually appeared on my main page on my phone. So at first I was a bit confused 'cause I, so I just kept clicking. Everytime I wanted to go in it, I kept clicking that [emergency button] haha, but then I worked out that they were actually two separate ones*." (V1 Anna, F, 34yrs, 39.9 kg/m^2, -3.2kg)

Participants' views about the ImpulsePal app varied; Most participants described the app and its strategies as "*a useful tool*" (V2, Rachel, F, 31yrs, 44.3kg/m^2, +0.5kg) that "*helps to understand and deal with why an individual eats the way that they do*" (V1 Anna, F, 34yrs, 39.9kg/m^2, -3.2kg) providing support at critical times. However, one participant noted that the app wasn't meeting expectations in providing immediate answers to deal with the in-the-moment issue.

> *"Well, it was something where I press it and it basically comes up with the same. So, are you struggling? Da-da-da. I'm thinking, 'Right. Now what?' And it didn't do anything for me which said "you've just been offered a bunch of birthday cake. You're not going to have any. There's a really good reason why not". And it's just not that."* (V2, Lewis, M, 43yrs, 26.1kg/m^2, -2kg)

> "*I showed them the app and I said, "brilliant because I have my emergency button and I can use that if I'm really feeling, you know, I might fail*."" (V2, Georgina, F, 50yrs, 34.4kg/m^2, -2.0kg)

6.4.2.2. Factors affecting engagement with the ImpulsePal intervention

A number of sub-themes came up which relate to the overarching theme of factors influencing engagement with ImpulsePal app. These included (a) general app/phone use, (b) intention or motivation to change dietary and lose weight, and (d) competing commitments.

General digital device use

Most participants mentioned that they were drawn to the study because it involved testing a novel weight management app.

> "*Just to see if there was an app which was useful in helping people to lose weight*" (V2, Toby, M, 47yrs, 36.3kg/m^2, -0.5kg)

> *"That it was an app on the phone and so it was instantly available to you. You know, you could be in any location and it wasn't a book you were supposed to read at home. And so that appealed to me."*
> (V1, Kathryn, 71yrs, 33.9kg/m^2, -1.8kg)

However, some participants noted that they do not always carry their phone with them, are not regular app users, or wouldn't want to use their phone to help manage their eating in a social situation. In some cases, regular access to the app was felt to be necessary to effectively make use of the ImpulsePal app. However, other participants highlighted that they no longer needed access to the app at all times once they had learnt to implement specific strategies.

> "*Because of my very limited use, I mean I rarely carry a phone with me... if I do it's because I want to contact somebody, or I'm expecting somebody to contact me or when I'm travelling I tend to carry it in case I'm going to break down or something or you're going to be late for an appointment... but um I don't, I wouldn't habitually walk around the supermarket with my phone in my hand um, so I'm not sure it would really work for me unless I have to change my habitual use of the phone quite significantly*..."(V1 Matthew, M, 69yrs, 38kg/m^2, +0.4kg).

> "*I don't need to go on to it to remember how to do the Urge Surfing, I can, I remember how to do it, so I can sit there and I can just do it and people will be around me talking and I'm sat there and y'know, listening intently, but at the same time sort of thinking about my Urge Surfing hahaha, and yeah, I find so, I find that really helps so I don't need to use it all the time."* (V1 Anna, F, 34yrs, 39.9kg/m^2, -3.2kg)

A few participants were using the app on an Android-based tablet instead of a smartphone, or on a partner's smartphone instead. Although they were able to access the app and learn from some of the strategies, because they were not using these devices in the same way as their (own) smartphone, this affected in-the-moment use of the intervention.

> "*because it's on my tablet instead of on a phone, I don't always have my tablet with me at times. And last night, I could've done with it, and the battery was flat and I had it on charge so (Laughs) it was sort of, "Mm…" you know. But yeah, I think it would be better if I had it on my phone, I would think I would use it more than on the tablet. But obviously, I mean it would be great if you had it on an app that I could have on my iPhone, but you haven't, so I can't*." (V2, Eleanor, F, 70yrs, 28.2kg/m^2, -1.1kg)

Intention or motivation to change eating behaviour

Although participants had been recruited into the study based on a desire or motivation to lose weight, some participants reported that their weight management efforts were not focussed on changes in eating behaviour, or that they did not experience temptations or struggles in managing their eating behaviour.

> "*The part of the app that I think you're supposed to use when you're feeling you want to break the regime that you should be on….hasn't really felt entirely relevant. 'Cause my weight loss program is more about increased physical*

exercise than avoidance of, other than the common-sense advice, on avoidance of certain specific foods." (V1 Matthew, M, 69kg/m^2, 38yrs, +0.4kg).

Those who wanted to lose weight and did try to change their eating behaviour reported situational changes in intentions which affected engagement with the intervention. For example, for some of the participants the first month of using ImpulsePal coincided with the Christmas period.

"*Yeah, yeah, and I did do that a couple of times, but, again sort of Christmas it was just, well I was resigned that I was gonna y'know eat what I want and what ever, so, within reason*" (V1, Alice, F, 53yrs, 35.5 kg/m^2, 0kg)

Some also reported losing motivation over time and struggling to maintain their motivation. Some participants mentioned they liked to be able to record their weight to maintain motivation.

"The thing that actually motivates me more is Google Fit simply because I can put in my weight and I can see how it's going up or I can see it going down." (V2, Lewis, M, 43yrs, 26.1kg/m^2, -2kg)

Competing commitments/activities.

Some participants mentioned that other commitments or activities could get in the way of engaging with ImpulsePal.

"*because I was always watching TV or doing something else, I didn't want to sort of sit there and like half-heartedly do it. So I think I ended up… So I didn't do it rather than doing like a half attempt at it, if that makes sense."* (V1, Theo, M, 30yrs, 28.0kg/m^2, +0.25kg)

One participant highlighted that there are many apps available (not necessarily health apps) which draw attention and can therefore get in the way of engaging with ImpulsePal.

"*Yeah, I mean, but you know, as I say, you're up against Candy Crush, you know, which is my sort of new thing, I'm totally addicted to it. I also got a fishing app that I've come across and I just started fishing and then I'm like I don't really like fishing. But I'm doing this on an app. And I'm much more challenged with these apps*." (V2, Robert, Male, 50yrs, 30.5kg/m^2, -2kg)

6.4.2.3. Perceptions and use of specific impulse management strategies.

Much of the data focused on the use of the specific components of ImpulsePal and the strategies learnt. Most participants noted that they liked the Brain Training game and reported that this was the component of the app that they used most when accessing ImpulsePal. However, participants also reported using techniques learnt from the intervention in their everyday lives and adapting them to suit their needs (e.g., if-then planning and urge surfing). For clarity and to support identification of component specific refinements, this theme will be presented using the following structure: (a) Brain training, (b) if-then planning, (c) urge surfing, (d) danger zones, and (e) emergency button.

Brain Training

Participants' views about the brain training game were fairly consistent. In Cycle 1 many enjoyed the game play element, although not everyone understood the game, and most felt it became boring and tedious over time.

> "*But I couldn't really understand it. I thought it would probably have food that… It's all the other items like the lampshade and everything, I thought it might have had, for your brain, foods that were okay to eat when you're trying to lose weight and foods that aren't."* (V1, Rosie, F, 65yrs, 41.5 kg/m^2, -0.5kg)

> "*You know, quite enjoyed the process. But it was quite long time to play it. And I think my motivation to want to keep playing did start to die off after if I'm honest."* (V1, Theo, M, 30yrs, 28 kg/m^2, +0.25kg)

Participants also liked to be reminded to do their brain training session which facilitated engagement with this technique.

> "*I think that's going to get into that habit, which is why I like it comes up with this little thing saying: "don't forget to do your brain training" and it's like: "oh yeah, I'll do my brain training!"* (V1 Lisa, F, 46yrs, 31.3kg/m^2, -2.5kg)

Following changes to the brain training component which included three split blocks which enabled the user to stop after a block if they wanted to but retain their score (therefore reducing the duration of the session), healthy food items in the "go" trials, different image banks, and the option to personalise the trained food items, the repetitive nature of the task remained a barrier.

"*Yeah, you know, one of the things that interest me about the app was the brain training, but I just found it boring after a while…well it's just the same thing. You know, the same thing. I mean, I changed it, I adapted it to biscuits and cheese, and this is my little weakness, but then using it, it's the same thing…"* (V2, Robert, M, 50yrs, 30.5kg/m^2, -2kg)

If-then planning

All participants reported having used the if-then component to set initial plans and although most found it useful to create if-then plans and look at suggested plans, one participant reported that it required too much effort.

"*And I liked the bespoke, you know, you could adapt your responses to what you found challenging yourself."* (V2, Robert, M, 50yrs, 30.5kg/m^2, -2kg)

"*And it was the difficulty and the effort of putting something in that I know is going to or I strongly suspect is going to fail that really kind of push me back out of the app. So that was a problem*." (V2, Lewis, M, 43yrs, 26.1kg/m^2, -2kg)

Participants in Cycle 1 highlighted issues with creating plans for infrequently encountered situations, which required having to fall back on memory.

"*I've got to remind myself that those actually…because that isn't a part of the app* [reminders]. *But for some reason, I seem to forget about…*" (V1, Tracey, F, 54yrs, 28.8kg/m^2, -0.8kg)

"*So I haven't been in a restaurant where I might say to a friend, "Oh look, this is the menu, what could I choose? You know I'm on the diet, what do you think would be best?" I mean, I think that's a good method, but I haven't sort of had to use that. But it's good to know you've made a plan and that's what you want to stick to*." (V1, Kathryn, F, 71yrs, 33.9kg/m^2, -1.8kg)

Although Cycle 2 had the option of setting reminders for their if-then plans, only few had made use of them. Some still reported that they would have liked to have had the option of setting a reminder, indicating that they had not noticed this function.

"*So for example, I do reminders for controlling the portion size, and reminder for not… certainly if I'm feeling a bit bored or a bit like down, like I start thinking about maybe I eating something. These are the two main reminders I got…. because sometimes, you know, you don't think but then you keep getting reminders on your phone, it beeps or vibrates, whatever you choose the setting, and then you stop and think about it. It's quite nice, so yeah.*" (V2, Hollie, F, 33yrs, 31.6kg/m^2, +2.8kg)

"*I've set them all up [plans] but like I said, it'd be nice if it had a little reminder like pop up sometimes.*" (V2, Harry, Male, 40yrs, 30kg/m^2, -2.5kg).

Urge Surfing

Those who were using urge surfing were very positive about the technique, although one participant reported some difficulties. Moreover, people quickly learnt how to use it, no longer needed their phone to be able to apply it, and adapted the technique to fit their lifestyle.

"*Well it just, I, I really really like the Urge Surfing! I have to say, I really like that, erm... never would it have crossed my mind to actually sit there and think about the urges to eat, I, usually you do anything to sort of distract yourself from it, which is great if you're in a situation when you can distract yourself from it…..but that's* [Urge Surfing] *actually good because you can use that in any situation and you can, sitting there and focusing on it, I don't know why it works, but it does seem to really help, yeah, it's strange, but, yeah, it's good I like that, it's very good.*" (V1 Anna, F, 34yrs, 39.9kg/m^2, -3.2kg)

"*I did try the the Urge Surfing, but I found that bit more difficult..., only because I'm just, I find it hard just to... relax and, empty my thoughts, y'know and do all this."* (V1, Alice, F, 53yrs, 35.5 kg/m^2, 0kg)

Cycle 2 had the addition of audio-guided urge surfing, which was used by some, but others felt the text-based steps were enough.

"*I think surfing the wave one, I used to spend a bit more time on, where I go on with sort of headphones, had a bit of time away somewhere*." (V2, Harry, Male, 40yrs, 30kg/m^2, -2.5kg).

"*And the urge surfing has been really useful just to focus my mind as well. The only thing I haven't done with it is the audio music because generally I've been in the office and just trying sneakily just have a quick look*." (V2 Rachel, F, 31yrs, 44.3kg/m^2, +0.5kg)

Danger Zones

In Cycle 1 only few reported using this technique, most participants reported that the Danger Zones function was not easy to use and some participants mentioned either not understanding what they could do with this component or technological issues with the notifications going off without being in the selected location or at the right time. Very few participants reported effective use of the danger zones.

"Oh I didn't use that, no, because I didn't know what it was going to tell me. Because it's got the map on it… what it's supposed to do because I didn't work that one out?" (V1, Rosie, F, 65yrs, 41.5kg/m^2, -0.5kg)

"*It'd say remember your diet, or whatever, so I'd, y'know I would er y'know definitely didn't go into McDonalds haha to eat. So yeah I think that was helpful…Yeah 'cause normally I'd go in there for like breakfast and that, and so I wasn't doing that*." (V1, Alice, F, 53yrs, 35.5kg/m^2, 0kg)

For version 2 the distance from the location to trigger a notification was reduced, a search bar was added to be able to search for postcode specific locations, and changes to the instructions were made to clarify the use of time boundaries to enable the reminders to be as situationally specific as possible. More appropriate use was reported in Cycle 2, although some participants noted that they did not feel the need to use this function.

"I've since discovered the danger zones which is quite good. A couple of my little messages in there and it sounds quite [the notification sound]*… which helped a great deal actually, yeah. In fact I sort of moved away from the brain training and carried on with the danger zones considering I'd get it somewhere I think, so that my little messages, you know, steer clear of the pasties, step away from the fridge that sort of thing, it helps a great deal, yeah*" (V2, Toby, M, 47yrs, 36.3kg/m^2, -0.5kg)

"*I've looked at it and I've thought about it. Should I put the supermarket? But because I felt that I've had the will power not to succumb to treats and things, so what we used to see as treat, so I haven't, no. I mean, I've not sort of ruled it out but, yeah, I haven't used that bit."* (V2, Louise, F, 65yrs, 29.8kg/m^2, -0.6kg)

Emergency Button

This was considered to be a useful function to fall back on at critical times "*if I'm really feeling, you know, I might fail*."" (V2, Georgina, F, 50, 34.4, -2.0) and for some served as a constant reminder with its prominent position on the phone's home screen. However, when participants moved the location of the button on their phone it was easily forgotten.

"*It's just brilliant to have I think it's a novelty having the emergency button to be able…and to know that you've got that there because it is an instantaneous reminder of what you…of what you're trying to do, I suppose, for me anyway. Because it's on my…the first page."* (V2 Georgina, F, 65yrs, 29.8kg/m^2, -2.0kg)

"And having the emergency button on the phone, very useful. The first two weeks I was using it quite a bit. The next couple of weeks it was just, I didn't

think about using it. I think I moved it to a different screen on my phone." (V2, Harry, M, 40yrs, 30.1kg/m^2, -2.5kg)

Participants also noted that they liked receiving the question and message following an emergency button event.

"*I like the little messages it comes out with, they're kind of encouraging like, y'know, you've resisted that one and it's gonna get easier, and it's like "oh is it?" 'cause I actually literally thought that was it, I just thought it was gonna be continuous struggle but it's like no. and then it comes, so the message it comes up with, I think they're written really nicely, they're quite encouraging and erm yeah, reassuring, so that, when you've, when you've hit the emergency button and then it asks you afterwards how you did and you haven't done very well, then it does make it sort of clear that that's ok you just, y'know, carry on"* (V1, Lisa, 46yrs, 31.3kg/m^2, -2.5kg)

"*I think for me, just having "press the emergency button", it's almost like trying to get the gold star at school. It's almost like if I'm a good girl for the next quarter of an hour, I will get that message that tells me I've been good. And I think it's trying to get those gold stars as many times as I can."* (V1, Tracey, F, 54yrs, 28.8kg/m^2, -0.8kg)

Some participants also noted not needing to use the emergency button, because they did not feel tempted or were using other strategies straight away to deal with the situation.

"*No, just because I was using the brain trainer most of the time."* (V1, Isabelle, F, 53yrs, 33.2kg/m^2, +1.1kg)

"Yeah, the first couple of weeks but I haven't used it much at all since then. And I thought about why and maybe it's because it's the most important. The first thing I did in the plan as I say was to remove things in the house and, so they're not there…But I haven't needed to use the button. Whether it's because it's in my mind that I've got this thing I could do it, but I don't need to because I'm not tempted." (V2, Louise, F, 65yrs, 29.8kg/m^2, -0.6kg)

6.4.2.4. Impact of ImpulsePal.

Using the ImpulsePal app was reported to have an impact on users in a number of ways such as (a) increased awareness of influences on eating behaviour and in-the-moment conscious awareness of food choices, (b) fewer strong cravings or feelings of being tempted and changes in snacking behaviour, and (b) strengthened feelings of control or ability to resist temptation.

> *"Yeah, that's right, the only time.. this sort of thing would, you know, demolish a bag of crisps or something, you just sort of get that out and it's by the time you finished with it, it's taking it* [Craving] *away and I can say I've actually moved off of that now and because I feel that I can and I know how to manage my cravings now and whenever I go into a shop now or that, you know, what are the ones that's on my list, it actually takes away… it makes me think about what I buy rather than just impulse buying snacks and things."* (V2, Toby, M, 47yrs, 36.3kg/m^2, -0.5kg)

Most participants reported being more aware of their in-the-moment food choices and eating behaviour as well as learning and knowing more about the factors that influence their own eating behaviour, and identifying and engaging in strategies to avoid, or manage the situation.

> "*it helps me to stay on the right path, rather than give in so, yeah, and also avoiding those situations as well, erm y'know, if you recognise, where you're more likely, I'd never really thought about it. Where I was more likely, and when I was more likely to overeat, or to eat the wrong foods*." (V1, Anna, F, 34yrs, 39.9kg/m^2, -3.2kg)

> *"it's hard to describe but it made me think twice before I went for it because I just keep on seeing these red circles. (Laughter) In my head, I kind of sort of vision, I'm going, "No it's red, no. I'm going to get the apple, that's green." So there was something there that just help me had an extra step in my thinking of to, I shouldn't be going for that crisp or something like that. So that part of the game I really enjoyed.* (V2, Harry, M, 40yrs, 30.1kg/m^2, -2.5kg)

Some participants reported noticing reduced frequency of habitual craving or desire to snack, or a reduction in the strength of cravings.

> *"But something is definitely making me not have the craving or the automatic because I can't believe it's will power alone. It's…there's got to be a little switch must have gone the right way in my brain. Because I just I don't need it and I'm a completely different person to the person I was when I was here that day*." (Georgina, F, 50yrs, 34.4kg/m^2, -2.0kg)

In terms of behavioural impact, participants also reported making healthier food choices, reducing unhealthy snacking, making changes in portion sizes, and actively engaging in self-identified strategies to manage tempting situations.

> "*I've set the danger zone to anywhere around the* [location mentioned] *which basically everything is. And to kind of remind me until half past nine which is when obviously I should be willing to work. And you know I have been a couple of times where I kind of overwritten it and got some breakfast but it's been*

a…the healthiest option I could possibly find if I sort of overslept and just need something.” (V2 Rachel, F, 31yrs, 44.3kg/m^2, -0.5kg)

“*Well I did, I don't know, maybe it's just in my brain, but I didn't eat masses of chocolate, over Christmas, I didn't eat masses of biscuits. and I actually threw biscuits away... on Monday. That's never happened!”* (V1, Isabelle, F, 53yrs, 33.2kg/m^2, +1.1kg)

“*I brought my coffee down with me* [to work coffee and cake morning] *so I had something to hold as well so I wasn’t tempted to grab something because my hands are free. So I think I am more aware*.” (V2, Rachel, F, 31yrs, 44.3kg/m^2, +0.5kg)

Participants also reported instances of increased feelings of control or ability to resist temptation, when temptations or cravings arise.

“*I did find also, that often when I had an impulse to eat something I didn't use the app, but I just thought: "I've got that app, I can go and use the app!" Which worked better if my phone was with me, than when it did when I was in the kitchen and the phone was upstairs. Like: "ah it's upstairs, I can't use it." Which is stupid 'cause… I'm in the kitchen… I'm not actually using it, I'm thinking about it and it's having the effect*.” (V1, Lisa, 46yrs, 31.3kg/m^2, -2.5kg)

“*I had that stop thing in my head from having practised it that week. And it made me just think, “No, I’ll just have a slimming drink, and I know those are very fattening foods, so it would spoil everything if I had that.” So that made me think it is helpful*.” (V1, Kathryn, 71yrs, 33.9kg/m^2, -1.8kg)

However, although ImpulsePal is meant to support people in managing impulsive processes, some participants reported struggling in situations where a desire to eat resulted in active avoidance of the intervention.

“*if you want to eat something and you know it's not good for you so you've got this app that you can go to that will help but then you really really want to eat it, so maybe I'm not going to go to that app because I want to eat it and that's going to stop me.”* (V1 Lisa, F, 46yrs, 31.3kg/m^2, -2.5kg)

6.5. Discussion

This chapter described a mixed-methods process evaluation (a) exploring usage of the ImpulsPal app, (b) exploring mediators and moderators of outcomes, and (c) piloting measures to evaluate potential mechanisms of action in a process evaluation at the full-scale evaluation stage, and (d) and exploring participants’ experiences with using the app and the specific impulse management components to help identify necessary refinements. The most used components of ImpulsePal were the brain training game, the if-then plans, and the emergency button. However, this is not surprising since these components require access to the app more so than the urge surfing component or the danger zones. The usage analysis demonstrated good intervention fidelity in terms of *delivery* and the majority of the participants used the Brain Training component as intended. The qualitative analysis highlighted misunderstanding of (or missed) instructions and misuse (brain training component) in Cycle 1. However, this was no longer a problem in Cycle 2, suggesting improvements in receipt and enactment had been achieved.

The mediation analyses suggest that changes in weight following receipt of ImpulsePal may be mediated by changes in frequency of feelings of loss of control during overeating and that baseline habitual food cravings and cognitive restraint potentially moderate the effects of ImpulsePal. Moreover, the overall patterns of the secondary outcomes and the associations between the process variables and eating behaviour and weight change, suggest there may be support for the logic model. Although no significant differences in change in impulsivity, sensitivity to the environment, habitual food cravings, and self-efficacy were found between the intervention group and the control group, the control group seemed to report greater improvements. Considering the increased awareness of influences on eating behaviour and feelings of being in control as reported by interviewees, it could be that the intervention group is self-reporting more accurately than the control group. Nonetheless, these analyses were conducted in the context of a feasibility study with a small sample size and therefore the results reported should be viewed with caution. As all analyses were underpowered, only confidence intervals were reported rather than p-values. A fully powered trial is required to fully explore these mechanisms. The moderation analyses suggest there may be differences in who might benefit most from ImpulsePal. Interactions were not significant at this feasibility stage, but the patterns suggest that particularly, men, people who are older, more impulsive, or less likely to restrain their dietary intake for weight management are more likely to benefit from the ImpulsePal intervention. However, this would have to be formally investigated in a full-scale trial.

Within the qualitative analysis, participants reported finding ImpulsePal easy to use and its content acceptable. As found in other qualitative studies about digital behaviour change interventions, participants particularly liked being reminded to use their strategies (Dennison, Morrison, Conway, & Yardley, 2013; Tang et al., 2015; van Beurden, Simmons, et al., 2018). Reports also support the quantitative usage analysis suggesting that the brain training game, if-then plans, and emergency button are the most “accessed” components. Although usage (metrics) of digital interventions have been associated with outcomes (e.g., Hwang, Ning, Trickey, & Sciamanna, 2013; Strecher et al., 2008; van Gemert-Pijnen, Kelders, & Bohlmeijer, 2014) there was no association between ImpulsePal app use (as measured by time spent using the app) and weight loss (See Chapter 5). However, the qualitative analysis indicates that urge-surfing was considered easy to use, adaptable to individual lifestyles, and did not require access to the phone and could therefore be (and was) used on-the-go and in situations where individuals could not access their phone. Moreover, some participants highlighted no longer needing to access the app because they either no longer felt tempted over time, or where temptations did arise, felt they were in control and capable of resisting temptations, or were actively using in-the-moment strategies such as urge-surfing, or alternative responses in their if-then plans (sufficient mastery of the techniques). Contrastingly, the Danger Zones component does not require regular access once locations and reminders had been set up and notifications may still have been sent out, further supporting the participants. However, no data on notifications were collected, therefore this cannot be supported by usage data. The qualitative analysis indicated that few participants made use of the Danger Zones component however.

The mediation analyses and qualitative analysis suggest that ImpulsePal had an impact on people in a variety of ways. Although not all participants reported changes in eating behaviour in terms of the type or amount of food eaten, or pattern of eating, most participants valued being more aware of their own eating behaviour, food choices, and the influences on behaviour, felt more in control (supported by the mediation analysis), and felt reassured by the easy access to support if they wanted/ or needed it. Participants also highlighted a variety of factors which affect engagement with the intervention, such as general device and app use, intentions to change eating behaviour, motivation to lose weight, and competing commitments which may have further influenced weight loss outcomes associated with ImpulsePal.

Participants reported changes in motivation over time which influenced engagement with the intervention. ImpulsePal v1 used in Cycle 1 of the trial, included strategies to facilitate engagement such as scoring in the Brain Training task, the prominent location of the emergency button, the reminders, and encouraging notifications which were well received by the participants. The qualitative interviews in Cycle 1 also suggested that participants require reminders for their self-selected or created if-then plans which is a function that was made available in version two. The use of reminders for if-then plans is further supported by research suggesting that plan reminders may be an important moderator of the effects of implementation intentions. It is suggested that reminders increase the salience of the trigger cues and reinforce the mental link between the ‘if’-situation and ‘then’-response which in turn should enhance the impact of the implementation intention on behaviour (Prestwich & Kellar, 2014). Further refinements were identified to improve engagement and incorporated in version 2. These include locking of content to guide the user through the app stepwise and avoid overwhelming users with too many choices, presentation of the instructions in the form of a dialogue to facilitate reading, postcode searching for the danger zones, personalisation of the trainable foods reduced duration of brain training sessions, and addition of audio-guided urge surfing (See Appendix 16).

Most people liked the fact that the intervention is delivered via an app, being able to choose from a variety of support tools and enjoyed the game play element of brain training. However, many felt that the brain training game was repetitive and boring after some time. This perception remained after refinements had been made to improve continued engagement which included personalisation of the trainable food items and reducing the duration of a training session. Gamification (i.e., the use of game elements such as points and difficulty levels (Deterding, Dixon, Khaled, & Nacke, 2011) is increasingly used in digital interventions and has been shown to be effective in increasing engagement with the intervention (Looyestyn et al., 2017). Some suggestions for improvement concerning the brain training component were increasing levels of difficulty, introducing leader-boards for social competition, and incorporation of additional games. However, the brain training component consists of an inhibition training task (i.e., food specific go/no-go task) which has been shown to be effective in reducing snack intake (Lawrence, O’Sullivan, et al., 2015) and weight loss (Lawrence, O'Sullivan, et al., 2015) and it is not yet known how further "gamification" principles may influence the potential effects. Although giving the user what they want may enhance engagement, there is a potential risk that the use of the task would no longer positively affect behaviour change and health outcomes. This could, potentially be detrimental to effective engagement (Yardley et al., 2016).

Although the use of smartphone sensors has been advocated to be useful for in-the-moment intervention (also referred to as just-in-time intervention; Nahum-Shani et al., 2016) and service users had noted a need for such prompted intervention (Chapter 4) there was an initial worry about the DangerZones potentially prompting unhealthy eating rather than preventing it. However, no participant reported this happening, and those who actively used this component said it was helpful in reminding them of what they had intended to do in that particular location.

6.5.1. Strengths and limitations

This process evaluation of ImpulsePal has some key strengths. Firstly, by adopting a pragmatic mixed-methods approach, we were able to gather much richer data than would have been the case if a single method had been used. The value of a mixed-methods approach is highlighted in this study. For example, although limited use was identified, the qualitative analysis suggested that this does not necessarily reflect a disengagement from the intervention. Others have also highlighted this apparent disconnect between usage statistics and effective intervention engagement (Yardley et al., 2016). Therefore, usage data should not be seen as a comprehensive measure of engagement in isolation. Secondly, the iterative cycles of intervention delivery and evaluation enabled further intervention development in close collaboration with its intended users. Third, two iterations of the intervention have been tried and tested and a third iteration incorporating further refinements based on the process evaluation findings can now go to full-scale trial, thus enhancing the likelihood of intervention effectiveness. Finally, the exploratory mediation analyses and the qualitative analyses highlighted various mechanisms of action that potentially support the logic model, which will help inform the planning of the process evaluation, and measures to be used in a future full-scale trial.

Some limitations need to be acknowledged. Firstly, there is potential for missing quantitative usage data. The data suggest that some participants did not see the log in page, or the welcome screen, although their data show they were able to access the other components. As the log in page and the welcome screen are the first screens the user is guided through, it is not possible that these have been missed. Therefore, this clearly indicates that some quantitative usage data are missing likely resulting from an error in data transfer. It is unclear how much more app usage data could be missing.

Secondly, the impulsiveness measure used in this study was not sensitive to change in either the intervention or control group and would therefore not be appropriate to use as a process measure in a full scale trial process evaluation. It is important to note that the impulsivity measure used in this trial (Spinella, 2007) measures a general tendency to act on impulses. Although general impulsivity is associated with unhealthy eating (e.g., Guerrieri, Nederkoorn, & Jansen, 2007a) a trait measure is less likely to show change over time. However, the use of this measure is still appropriate to assess baseline characteristics. As suggested by the exploratory moderation analysis, impulsiveness may moderate the effects of the intervention on weight loss in that people who are more impulsive may benefit more.

Another limitation is that the interviewer (SvB) is also the researcher who conducted the feasibility trial assessments and voiced the audio-guided urge surfing. It is possible that a social desirability effect may have occurred where participants may have felt they wanted to provide a positive account of their experiences with the intervention (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). Thus, although a large purposive sample was included in the qualitative analysis to capture as much of a variety of experiences as possible and the results suggest that the app and its strategies are acceptable to the participants, the potential for such a social desirability effect should be taken into account. The direct monitoring of app usage on the other hand, provided an objective measure of intervention use and was able to highlight discrepancies in use between the self-reported accounts and actual app access. The study did not purposively sample on app usage statistics in addition to age, gender, and BMI. However, in a future trial with a larger sample size this should be considered.

As stated above, the use of mixed-methods provides a much deeper insight into use of and experiences with the intervention.

Finally, this process evaluation was conducted in the context of a feasibility randomised controlled trial of ImpulsePal and therefore is limited by the small sample size. While a large number of tests were undertaken, due to the exploratory nature of the study none of the quantitative analyses were adequately powered and no corrections for multiple tests were made (e.g., Bonferroni). This introduces a strong risk of both type I error (finding spurious effects due to the number of tests) and type II error (not finding significance while a genuine effect may be present). There were a total of 60 path analyses conducted to investigate mediation with a 1 in 20 chance of finding a false positive (Type 1 error), so three positive findings would be anticipated to have occurred by chance. In actuality, 15 (25%) of the path analyses resulted in a positive finding (i.e., the confidence interval did not include zero) including the indirect effects of ImpulsePal on weight change via changes in overeating episodes, loss of control, and the number of days overeating occurred. This rate of positive findings is much higher than the estimated false positive error rate (likelihood of falsely rejecting the null hypothesis; Ranganathan, Pramesh, & Buyse, 2015). The pattern of findings, therefore, still indicates some support for the logic model of ImpulsePal. However, the confidence intervals are relatively wide in relation to their respective standard deviations and some of these confidence intervals have a lower or upper bound very close to zero. Thus, should this study be replicated, it is possible that these analyses would not reach significance. In any case, this feasibility study was underpowered to find any significant effects and therefore a full-scale trial is required to investigate these potential mechanisms further. None of the six interaction terms in the moderation analyses were significant, which is likely due to the small sample size of this feasibility study. These analyses were underpowered and need to be repeated in a larger sample of people receiving the ImpulsePal intervention.

6.6. Conclusion

In conclusion, ImpulsePal in its current form seems acceptable to overweight and obese people and areas for further refinement have been identified. Furthermore, interviews with participants revealed a variety of mechanisms by which ImpulsePal may have had an impact (e.g., through increased awareness of eating behaviour and of situational influences on eating behaviour, increased ability to resist temptations, and reduced snacking behaviour) which is tentatively supported by the exploratory analysis of the process questionnaires. An adequately powered study is needed to explore these mechanisms more fully.

Chapter 7. General Discussion

This programme of research aimed to specifically address the following overarching thesis question: “Can we develop, delivery, evaluate an intervention that helps modify or otherwise manage impulsive processes related to eating behaviour, to facilitate weight loss”. The doctoral work involved an iterative process which has been positioned within the MRC Framework (Craig et al., 2013),. Figure 7.1 provides an overview of the thesis which illustrates how the chapters feed in to each other and how they fit with the framework.

The four studies included in the thesis are:

1. A systematic review of techniques used and evaluated to modify or otherwise manage impulsive processes related to unhealthy eating;

2. A study focused on developing a self-delivered smartphone app-based weight management intervention that targets impulsive processes to facilitate dietary change, with a view to supporting weight loss;

3. A feasibility randomised controlled trial of the developed smartphone app-based weight management intervention;

4. A mixed-methods feasibility stage process evaluation with two cycles of intervention delivery and evaluation, nested within the feasibility randomised controlled trial exploratory investigation of mechanisms of action of the intervention with.

This chapter summarises and integrates the findings from the above research in an overall discussion. It provides an overview of the main findings, discussion of strengths and limitations, and implications and directions for future research.

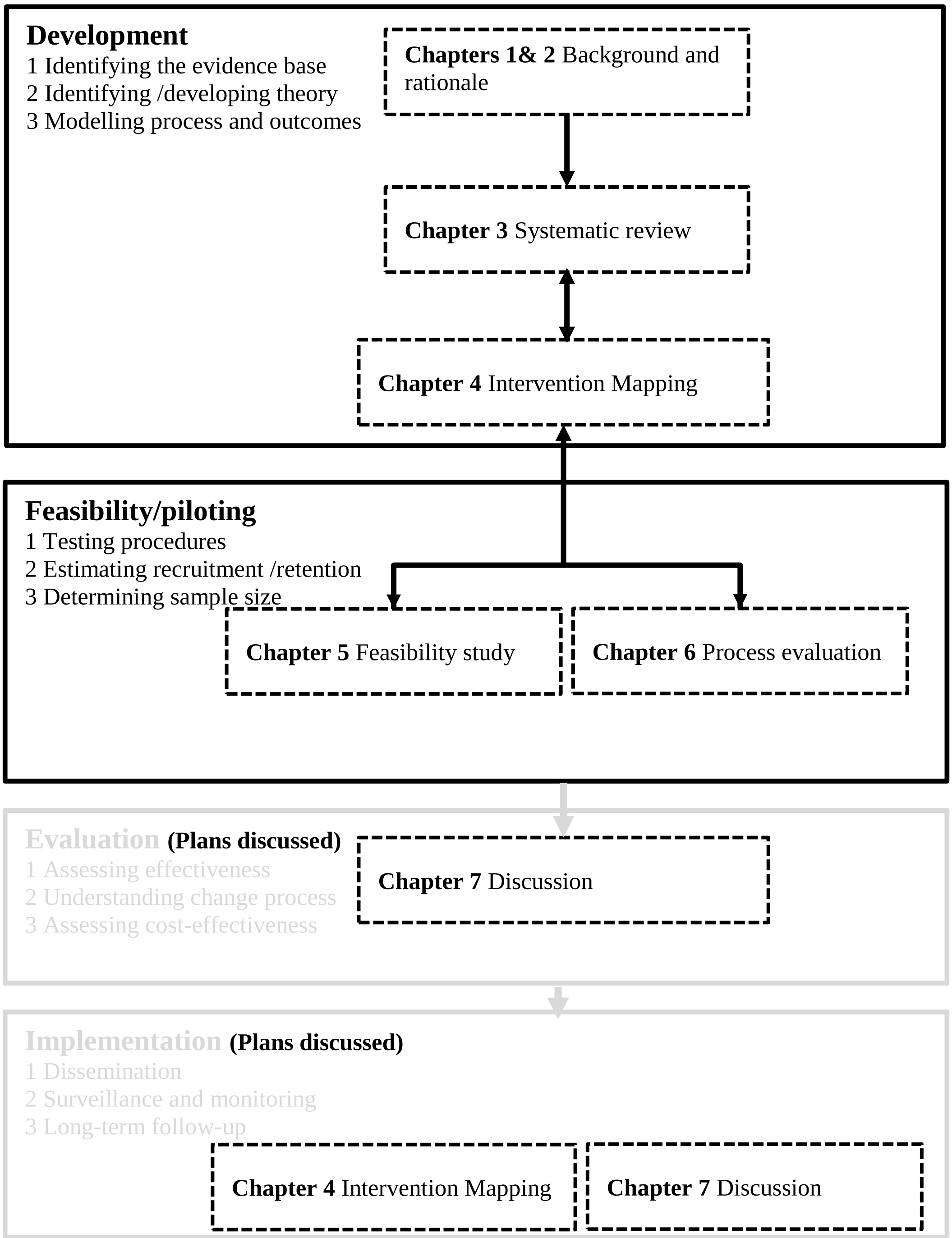


Figure 7.1 Thesis overview embedded within the MRC Framework.

7.1. Overview of main findings

How can impulsive processes be modified or otherwise managed to support healthier eating and/or weight loss? - Chapter 3

The systematic review in Chapter 3 identified seventeen distinct techniques which were categorised as (a) impulse-focused techniques (n=6), (b) reflective techniques, (n=9), or (c) unclear mechanism (n=2). The evidence for effectiveness within each technique category was narratively synthesised and categorised as "promising", "mixed" or "insufficient" using the criteria specified in Table 3.1. Overall, this systematic review highlighted the rapid growth of research concerning impulsive processes and health behaviour change, with a particular increase in studies evaluating impulse-focused techniques in the last decade. The review highlighted several "promising" techniques that could be used in an intervention to support people in modifying cravings and changing their eating behaviour. These were: visuospatial loading, physical activity, and if-then planning.

The review also highlighted several limitations to the evidence base such as the primarily lab-based settings, use of healthy student, predominantly female samples, small sample sizes and short-term evaluations (most of the evidence pertained to effects lasting only a few minutes post-treatment). Thus, further research is needed in the form of high-quality, adequately-powered RCTs to determine longer-term effectiveness (and cost-effectiveness) of impulse management interventions to modify eating behaviour and weight in real world, community-based or clinical samples.

How can people be supported to manage impulsive processes to facilitate eating behaviour change and weight management, using a self-delivered intervention? - Chapter 4

The intervention development study reported in Chapter 4 resulted in a novel, practical intervention to facilitate weight loss that is easily accessible in-the-moment. It builds on dual-process models of behaviour and key evidence-based impulse management techniques identified in the systematic review reported in Chapter 3, alongside strategies that aimed to enhance engagement identified in further literature searches, a qualitative study, and service user and expert involvement. In addition to the structured reporting of the intervention development steps, Chapter 4 provides a detailed, replicable description of the ImpulsePal app intervention that follows intervention reporting guidelines (i.e., TIDieR; Hoffmann et al., 2014).

Is an effectiveness evaluation using a randomised controlled trial design with objective measurement of weight, completion of questionnaires, and semi-structured interviews feasible? - Chapter 5

The feasibility randomised controlled trial reported in Chapter 5 found that conducting a randomised controlled trial of the ImpulsePal app with objective body measurements, questionnaire completion, and interviews (intervention group only) at baseline and up to three months follow-up, was feasible. A total of 88 overweight and obese adults were randomised into the study, with 74 (84%) retained at one month and 67 (76%) at three months. The findings of this feasibility study indicate that a fully-powered RCT would need to recruit a total of 457 participants, assuming a pooled standard deviation of 3.1 kg (as found in our sample) and the lower bound CI of retention (67%). This would have 80% power to detect a 1.0 kg difference (as found in this study) between groups at three months of follow up at the 5% significance level. However, longer term follow up may require larger sample sizes as these findings suggest that the standard deviation for weight loss increases over time.

Is the intervention feasible and acceptable to overweight and obese individuals? - Chapter 6

The process evaluation of ImpulsePal reported in Chapter 6 highlighted a number of potential improvements to be made. Cycle 1 highlighted areas for improvement to ImpulsePal v1 in: (a) receipt and understanding of the instructions for the various technique; (b) ongoing engagement with the inhibitory control training task (Brain Training component); and (c) engagement with the implementation intentions (if-then plans), situation specific diet reminders (Danger Zones) and the mindfulness-based strategy (Urge Surfing). The refinements made resulting in ImpulsePal v2 included: (a) locking of content to guide the user through the app and its components in a sequence of manageable chunks of information to limit overwhelming users with choices, and presentation of the instructions in the form of a dialogue to facilitate reading; (b) personalisation of the trainable foods, incorporation of training towards healthy foods (in addition to inhibiting responses towards unhealthy foods) and reduced duration of brain training sessions; and (c) the ability to set and amend reminders for the if-then plans, postcode searching for the danger zones, and addition of audio-guided urge surfing. Cycle 2 highlighted further potential improvements to ImpulsePal v2 including: (a) development of ImpulsePal to use across other platforms and devices; (b) an easier sign up process; (c) greater image banks; and (d) a self-monitoring (outcome) function in the form of a weight tracker. These refinements are currently being programmed for ImpulsePal v3.

7.2. Strengths and limitations

The main strengths of the doctoral research presented in this thesis were the systematic and comprehensive approach taken in line with recommended frameworks (Bartholomew et al., 2011; Craig et al., 2013; Moore et al., 2015) to meet the overall thesis aim. Although not published when development of the intervention commenced, the approach taken was broadly in line with the more recent guidance for the development of digital behaviour change interventions (Michie et al., 2017; West & Michie, 2016).It incorporated some user input and qualitative elements to elicit user perspectives to help inform intervention development. However, more extensive and in-depth use of such elements in the formative stages of intervention development and evaluation has since been recommended with clear guidance and examples of how to do this provided by the person-based approach (Yardley, Ainsworth, et al., 2015; Yardley, Morrison, et al., 2015). Rigorous methods were used at each stage. These include: (a) The use of a systematic review to identify and synthesise evidence (van Beurden et al., 2016); (b) The use of the Intervention Mapping protocol (Bartholomew et al., 2011), an iterative process of intervention development and evaluation (Whitehead et al., 2003) and mixed-methods (O'Cathain et al., 2010) data collection and analyses for the development (and feasibility evaluation); and (c) the use of objective measurements and conduct of a randomised controlled feasibility study in line with guidelines (Eldridge et al., 2016). Moreover, the transparent reporting of the work presented in the thesis (and related papers) is in line with recognised reporting guidance (Eldridge et al., 2016; Hoffmann et al., 2014; Moher, Liberati, Tetzlaff, Altman, & PRISMA Group, 2009). This systematic and comprehensive approach to development and evaluation, as well as the clear reporting is unusual for app-based behaviour change interventions (Bardus, Smith, Samaha, & Abraham, 2015).

The work progressed from identifying a primary outcome, establishing targets for change, and the identification of techniques that could be used to achieve change, to the practical operationalisation of identified techniques within a self-delivered smartphone app intervention. The research also evaluated feasibility of the intervention for wider implementation and assessed trial procedures to lay the foundation for a future full-scale effectiveness evaluation. This feasibility study showed that the app was well-received with high satisfaction among users and initial findings indicate that it has the potential to influence weight loss. Moreover, the mixed-methods process evaluation highlights that users were engaging with the intervention strategies, regardless of whether they continued to use the app or not. It also suggests that achievement of the intended changes in behaviour and processes (e.g., reductions in snacking and overeating, cravings, and conscious awareness of behaviour) is feasible (i.e., effective engagement; Yardley et al., 2016). All research projects have been written up for publication in peer-reviewed journals. The research presented in Chapter 3 has been published (van Beurden et al., 2016) and has been selected for inclusion in NICE Evidence Search, and the work presented in Chapter 5 has been submitted (van Beurden, Smith, Lawrence, Abraham, & Greaves, 2018), demonstrating that key elements of the thesis content are of publishable quality.

A number of limitations that are specific to each piece of work have already been reported within the respective chapters. For example, the systematic review chapter acknowledged the potential for missed literature and shortcomings of the identified evidence base (e.g., small primarily female student samples investigating short-term effects). The intervention development chapter acknowledged the use of convenience sampling methods in the recruitment of a service user group resulting in a consultation with a primarily highly educated women, the limited number of think-a-loud interviews conducted, and the difficulties resulting from the different levels of specificity when considering modifiable determinants during intervention development. The feasibility study and process evaluation chapters acknowledged the minimal diversity in, and small size of, a volunteer-based sample used, the non-blinded self-report assessments, and the large number of quantitative analyses.. However, there are some additional limitations to the work presented in this thesis that warrant further acknowledgment. Firstly, due to resource limitations, the additional literature review undertaken as part of the needs assessment to identify (a) factors affecting eating behaviour, (b) factors influencing engagement with interventions, and (c) current national guidance for weight management interventions, was not a rigorous systematic review. However, existing systematic reviews were used where available.

Secondly, as a dual-process approach underpinned both the development and feasibility stages of the intervention, the work may have benefitted from the inclusion of implicit measures specifically designed to objectively assess impulsive processes (e.g., implicit association task; Greenwald, McGhee, & Schwartz, 1998) in addition to the use of self-report questionnaires. The questionnaires rely on self-report and are therefore limited by recall bias social desirability bias (Althubaiti, 2016), but also rely on the reflective system (participants' awareness of their behaviour as well as the influence of food on their behaviours and cravings) to make judgements about the impulsive processes. Future research evaluating the ImpulsePal intervention could better account for the role of the impulsive system by objectively measuring implicit attitudes towards unhealthy (and healthy) foods. This would help to establish the influence of impulsive processes on eating behaviour and whether the use of the ImpulsePal intervention in turn affects this.

Thirdly, the ImpulsePal app intervention was only programmed for Android devices due to a limited PhD research budget and to minimise time pressures which would result from the stringent process of submitting an iOS version to the AppStore. At the time of intervention development this would have involved a lengthy (several weeks) app review based on a set of technical, content, and design criteria. The benefit of Android was that the intervention could be refined and made available swiftly within the action-research approach. However, this limitation resulted in approximately a third of potential participants being ineligible to take part in the feasibility study and slowed the recruitment rate (i.e., no of participants recruited per month). This potentially reduces the generalisability of the findings of the feasibility and process evaluation studies.

Finally, although a 1kg weight loss is comparable to other app-based weight management interventions (Mateo et al., 2015), it may not be considered clinically meaningful at the individual level. The generally accepted criteria are that weight loss is considered clinically meaningful if 5% of one's initial bodyweight is lost and the loss is maintained up to at least 12 months following treatment (Williamson et al., 2015). This definition relates to cardiovascular disease risk where a 5% weight loss benefits blood pressure and cholesterol. However, lesser weight loss demonstrates benefits in other risk factors. For example, in people with impaired glucose tolerance (i.e., prediabetes), 1kg of weight loss has been associated with a 16% reduction in the risk of progression to diabetes (Hamman et al., 2006). In line with this, the US Task force on Community Preventative Services has defined effectiveness of strategies for weight control as achieving a mean weight loss of at least four pounds (2kg) that is measured at least six months after starting a weight management programme. This definition is used to make recommendations for the commissioning of (albeit face-to-face group-based) weight management interventions. Unfortunately, one of the limitations of the feasibility study (highlighted in Chapter 5) is the short-term follow-up, which did not exceed three months due to time and financial restrictions. If the pattern of weight change found in the feasibility study continues at the same rate, a greater weight loss of 2kg (compared to a control group) may be feasible. Nonetheless, this would have to be addressed in a full-scale trial with longer follow-up period.

7.3. Implications and future directions

The work presented in this thesis has both theoretical and practical implications. With regards to implications for theory, the systematic review presented in Chapter 3 built on dual-process approaches (Hofmann et al., 2008; Strack & Deutsch, 2004). This is important as impulsive (automatic) processes are postulated to play an important role in the intention-behaviour gap (Marteau et al., 2012; Sheeran et al., 2013). The findings from the systematic review add to the conceptual frameworks reviewed in Chapter 2 by postulating that impulsive processes which can trigger unhealthy eating can be targeted in diverse ways. Firstly, impulse-focused techniques target the impulsive system directly by attempting to modify the generation or strength of impulses triggered by specific stimuli (e.g., food cues). On the other hand, reflective techniques engage the reflective system or cognitive resources in identifying and suppressing or otherwise managing impulsive urges or cravings before they are acted on. So, although the impulsive processes are automatic and mostly unconscious, they can be modified or managed via the reflective system. Thus, the systematic review suggests that although the two systems may be qualitatively distinct, it is possible that they do not operate entirely in isolation and interactions are possible. For example, formation of implementation intentions in the form of if-then planning is a conscious, reflective act, however, the mechanism by which they operate is hypothesised to become automatic and unconscious over time (Gollwitzer & Sheeran, 2006). The notion of an interaction between the processes is in line with the theories presented by Hofmann et al., (2008) and Strack & Deutsch (2004), but the work presented builds on these by providing proposals of more specific mechanisms involved. This systematic review has impacted the work of other researchers, resulting in the development of a conceptual framework of automatic processes and underlying techniques to bridge the intention-behaviour gap in food parenting (Larsen et al., 2018).

7.3.1. A theory-, evidence-, and user perspective based approach to development

There are several practical implications of this doctoral research. A first practical implication concerns the methodology and dissemination of intervention development studies. The importance of providing clarity and transparency in the development and description of an intervention is increasingly recognised (Hoddinott, 2015). The Intervention Mapping protocol (Bartholomew et al., 2011) provided a rigorous and systematic approach to development. However, it also provided a clear structure for reporting which enabled clarity and transparency concerning key decisions made during the development of ImpulsePal. Moreover, the intervention map which combines the output of several steps facilitated a clear description of the intervention and its underlying change processes. This rigorous and structured approach enhanced the likelihood of programme success and facilitated the design of the effectiveness and process evaluations. Moreover, this approach enhanced the likelihood of successful replication of the intervention, and therefore serves as a good example of conducting and reporting intervention development studies. Several studies have been published in recent years which have adopted similar, comprehensive and structured approaches to intervention development and this is a crucial advancement in the field (e.g., Gray-Burrows et al., 2016; Lambert, Greaves, Farrand, Haase, & Taylor, 2017; Lloyd et al., 2011).

One of the strengths highlighted above is that the approach taken in this work aimed to incorporate theory, evidence as well as the intended user's perspective in the development of a novel intervention. Although the Intervention Mapping protocol (Bartholomew et al., 2011) emphasises the importance of involving the target population during the development and that qualitative research is useful in the creation of programme materials, it does not provide clear guidance how to use this in the development of digital interventions. The work incorporated a systematic approach to eliciting and incorporating user perspectives. For example, a think-aloud process supported the creation of programme materials (Pagoto & Schneider, 2014; See Chapter 4) during the development stage of the MRC framework. In addition, the use of mixed-methods and a cyclical approach to intervention delivery and data collection (Whitehead et al., 2003) during the feasibility stage enabled data-driven refinements to be made to the intervention. In particular, the use of qualitative interviews during phases of the study. These helped elicit perspectives of ImpulsePal's intended users on use of the app overall as well as its behaviour change techniques, both online (while using the app, such as with the 'Braining Training' task or 'Danger Zones') or offline (without the physical use of the app, such as with the implementation intentions and urge surfing). These gave insight into how, where, when, and why users may or may not use ImpulsePal or the learned strategies, and why these strategies may, or may not, help in changing dietary behaviour. The use of qualitative research in this manner is a step towards the more recently described person-based approach which grounds the development of interventions in an in-depth understanding of its intended users' perspectives and social contexts, gained through the use of iterative qualitative methods (Yardley, Ainsworth, et al., 2015; Yardley, Morrison, et al., 2015). This study therefore enhanced the use of the theory-and evidence-based Intervention Mapping approach and could therefore be considered as an exemplar for future development of digital interventions, that provides a detailed account of where and how theory, evidence, and user perspectives have been identified and incorporated during intervention development.

7.3.2. Trial design and procedures.

The feasibility study presented in Chapter 5 suggests that a two-arm RCT of the ImpulsePal app intervention is feasible and would require randomisation of 457 participants, to detect a significant between group difference of 1kg weight loss at three-months with 80% power. A larger sample size may be required should a longer-term follow-up be considered. The feasibility study findings and other weight loss interventional research studies including multiple follow-up time points suggest (e.g., Greaves et al., 2015) that the standard deviation may increase over time. However, when taking into consideration a potential meaningful weight loss of 2kg that may be possible if the rate of weight loss continues (as described above) a smaller sample size may be sufficient. However, this would require estimation of standard deviations using existing similar trials (Jebb et al., 2011; Little et al., 2016) with longer term follow-up.

On the basis of the research presented here, a number of changes to the trial procedures attempted so far (reported in Chapter 5) could be considered. Firstly, in addition to the implicit association task (Greenwald et al., 1998) mentioned above, a measure of intentions may need to be considered. Although intentions were not the focus of this doctoral work since impulsive processes are postulated to partly explain the intention-behaviour gap, a future trial could incorporate measures of current intention. The feasibility study included the cognitive restraint subscale of the TFEQ-R18 (Karlsson et al., 2000) which measures the tendency and general intent to consciously restrict food intake in order to control body weight or promote weight loss. However, this is not a measure of current intentions. Therefore, a future effectiveness trial could consider inclusion of items asking participants how much they plan and intend to change their dietary intake in the next 6 months (e.g., Hattar, Hagger, & Pal, 2015; Luszczynska, Scholz, & Sutton, 2007)).

Secondly, the ImpulsePal app also provides a great platform to potentially conduct Ecological Momentary Assessment (EMA; Shiffman, Stone, & Hufford, 2008), which involves repeated sampling of the participants' current behaviours and experiences (e.g., strength of eating impulses) in real-time and natural environments. Texted prompts, or in-app notifications, asking about frequency and strength of cravings at periodic intervals may provide a better measurement of craving (referred to as the conscious awareness of impulsive processes in Chapter 3), compared to the currently used FCQ-T-r (Hormes & Meule, 2016; Meule et al., 2014). The latter measures trait food craving rather than craving strength. Due to the repeated sampling within the individual, EMA also allows investigation of processes that may influence behaviour in real-world settings and is therefore well-suited to a process evaluation nested within the full-scale trial of a digital behaviour change intervention.

Thirdly, with regards to recruitment, enabling users of iOS devices (and other operating systems) to access the ImpulsePal app would allow for changes to be made to participant eligibility criteria which should increase recruitment rate and study uptake. To address this, ImpulsePal is currently being programmed as a hybrid app (a web app built using HTML5 and JavaScript inside a thin native container which provides access to native platform features) which will work across a range of operating systems. This not only enables more participants to be eligible to take part, it also allows for refinements to be made in one app as opposed to several native apps and is therefore less resource intensive. Moreover, as highlighted in Chapter 5, the initial primary recruitment route (i.e., HPD) had begun to phase out during the recruitment and was no longer being commissioned to provide Tier 2 weight management services in Devon by the end of the study. Although, the additional routes were able to achieve recruitment of a volunteer-based overweight or obese sample, this is not necessarily representative of a population actively seeking weight management support. Since conducting the feasibility study, further potential recruitment routes have been identified. For example, four Clinical Commissioning Groups (CCG) in the UK currently commissioned to deliver the UK's National Diabetes Prevention Programme (NHS DPP; NHS England, n.d., 2014) have expressed interest in using ImpulsePal as an adjunct to their programme. This offers the opportunity for further evaluation in a more representative population. Furthermore, future research following the full-scale trial may consider the evaluation of ImpulsePal amongst different clinical and community samples such as people with cardiovascular disease or people with a healthy BMI (to prevent weight gain).

Finally, in light of the suggested changes to the trial procedures described above, a further change to the design of a future trial would be required. Since the newly proposed measures and procedures and retention rates for a longer-term follow-up have not been assessed in the feasibility study presented in Chapter 5, piloting of the amended procedures would be necessary. Therefore, the next step for ImpulsePal, would be to conduct a full-scale randomised controlled trial with a nested/internal pilot study. However, full-scale evaluations require substantial funding and they may not always progress after the nested pilot. As mentioned above, existing providers delivering the NHS DPP have shown an interest in ImpulsePal. Should there be no funding for a full-scale trial, this opportunity would still allow for, albeit less rigorous (e.g., no randomisation), a large scale observational evaluation.

7.3.3. Further avenues for research

If deemed effective, due to the relatively low cost of maintaining the intervention (compared to face-to-face interventions), ImpulsePal would likely provide a cost-effective method of facilitating weight loss. For example, the economic modelling conducted for the NICE guidance on lifestyle weight management services for overweight or obese adults estimated that a 1kg weight loss is cost-effective at £100, if maintained for life. However, it would not be cost-effective if, on average, people regain lost weight within three years or less (National Institute for Health and Care Excellence, 2014). However, cost-effectiveness would need to be formally assessed. A point for consideration, as no facilitator costs are involved in the ImpulsePal intervention (e.g., staffing and training), costs primarily consist of the fixed rate of the maintenance of ImpulsePal as an operational app (See Appendix 12). Therefore, delivery cost per person using ImpulsePal will invariably depend on the reach of the intervention.

A separate avenue for future research derives from the range of impulse management techniques currently provided via ImpulsePal. An RCT would be able to answer questions concerning direct comparisons between ImpulsePal and a control group or another intervention. It would not be able to investigate the effects of the individual impulse management techniques, unless sub-group analyses are conducted based on usage of components. However, this approach would not benefit from randomisation and may lack power. Factorial experimental designs however, could be used to assess the impact of individual and combined sets of impulse management techniques that are delivered via a digital platform (Collins, Dziak, Kugler, & Trail, 2014).

As the work presented suggests, not everyone engages or benefits from a digital behaviour change intervention. Future research may consider how engagement could be improved to enhance effectiveness. For example, facilitation in the form of brief remote telephone support has been shown to improve engagement (i.e., website usage) when compared to the standalone intervention (Dennison et al., 2013). The addition of facilitation to ImpulsePal could be possible and relatively inexpensive where the app is provided alongside existing services. Relatedly, ImpulsePal could be evaluated as a potential inexpensive enhancement to existing programmes considering some participants in the feasibility study took part in concurrent weight management interventions.

An additional direction for future research concerns the use of impulse management techniques for other behavioural problems where impulsive processes may hinder successful behaviour change. For example, inhibitory control training has also been shown to have positive influences in changing alcohol consumption (Allom et al., 2015) and visuospatial loading may help tackle cravings in smokers who are trying to quit (May, Andrade, Panabokke, & Kavanagh, 2010). Moreover, although the systematic review found insufficient evidence on the effect of approach/avoidance training, this technique is more established within the domain of alcohol consumption (Eberl et al., 2013; Wiers et al., 2011). The general systematic approach taken during development of ImpulsePal can be applied to adapting the digital intervention to addressing impulsive processes in these other behaviours.

7.3.4. Implementation

With regards to taking ImpulsePal forward to the implementation stage in the MRC framework (Craig et al., 2013) as described in Chapter 4, accreditation and clinical endorsement strongly influence the adoption and implementation of digital technologies. A future direction for ImpulsePal would therefore be to apply for adoption on the NHS Digital Apps Library (NHS Digital, n.d.-a) and Mobile Health space for developers (NHS Digital, n.d.-b) under the label “being tested in the NHS”. Once the ImpulsePal evaluation is complete, we could then apply for the label “NHS approved” should the full-scale trial demonstrate effectiveness (although observational data from an evaluation within NHS settings may be sufficient). Once implemented, further monitoring could be undertaken to detect adverse events, such as unintended prompting of unhealthy eating, that may not have been identified during the feasibility and evaluation stages as well as to assess long term outcomes that could not be observed within the full-scale trial period (Craig et al., 2013). One advantage of an app-based weight management intervention is the opportunity for further data collection, which enables ongoing monitoring during implementation and beyond. With the inclusion of a weight tracker function in ImpulsePal v3, it is possible to collect self-reported data via the app. Moreover, if the app is implemented alongside the NHS DPP or other health promotion services, routinely collected weight data by providers could be used for monitoring purposes.

7.4. Overall conclusion

Overall, the work presented in this thesis represents a systematic and comprehensive programme of research on the development and evaluation of complex digital interventions for weight management that support the management of eating impulses. It has highlighted several methods for impulse management for which current available evidence provides some positive support, including visuo-spatial loading, if-then planning, physical activity, mindfulness-based strategies and inhibition training. The work has successfully developed an intervention which is feasible to deliver and evaluate and may potentially deliver small but meaningful changes in weight. The work has suggested several ideas for future evaluation and implementation research. The results of the doctoral research presented also provide additional avenues for future research such as the investigation of independent impulse management techniques, and the use of these techniques in other behavioural domains such as alcohol consumption, to assess the potential for adaptation of the intervention. Thus, a concrete output from this doctoral work is the ImpulsePal app that may be able to help people manage unhealthy eating impulses, that is feasible and acceptable to users, is a potentially promising approach in supporting weight loss, and is now ready for evaluation in a full-scale evaluation.

Appendices

Appendix 1 Search strategy

No.	Search Term
1.	IMPULS$.TI,AB,KW.
2.	(SELF ADJ CONTROL).TI,AB,KW.
3.	WILLPOWER.TI,AB,KW.
4.	(AUTOMAT$ ADJ AFFECT$ ADJ REACT$).TI,AB,KW.
5.	(AUTOMAT$ ADJ BEHAV$).TI,AB,KW.
6.	CRAV$.TI,AB,KW.
7.	URGE.TI,AB,KW.
8.	URGES.TI,AB,KW.
9.	TEMPT$.TI,AB,KW.
10.	**1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9**
11.	TRAIN$.TI,AB,KW.
12.	PROGRAM$.TI,AB,KW.
13.	TREAT$.TI,AB,KW.
14.	STRATEG$.TI,AB,KW.
15.	TECHNIQUE$.TI,AB,KW.
16.	INTERVENTION$.TI,AB,KW.
17.	TASK$.TI,AB,KW.
18.	EXPOSURE.TI,AB,KW.
19.	EXPERIMENT$.TI,AB,KW.
20.	**11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19**
21.	CONSUM$.TI,AB,KW.
22.	EAT$.TI,AB,KW.
23.	SNACK$.TI,AB,KW.
24.	FOOD$.TI,AB,KW.
25.	(ENERGY ADJ INTAKE).TI,AB,KW.
26.	WEIGHT.TI,AB,KW.
27.	BMI.TI,AB,KW.

28.	(BODY ADJ MASS ADJ INDEX).TI,AB,KW.
29.	(WAIST ADJ CIRCUMFERENCE).TI,AB,KW.
30.	(WAIST ADJ5 HIP).TI,AB,KW.
31.	(BEHAV$ ADJ3 CHANG$).TI,AB,KW.
32.	(LIFESTYLE ADJ3 CHANG$).TI,AB,KW.
33.	DIET$.TI,AB,KW.
34.	CALORIES.TI,AB,KW.
35.	NUTRITION.TI,AB,KW.
36.	**21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35**
37.	**10 AND 20 AND 36**

N.B. Unless otherwise stated, search terms were free text terms; MeSH terms: Medical subject heading (MEDLINE medical index term); the dollar sign (*) stands for any character and a number directly after a star sign denotes the maximum number of additional letters after the word-stem. The strategy for MEDLINE using the appropriate truncation and wildcards is presented. This strategy was adapted for each database used.

Appendix 2 References and justification code for excluded articles at full text screening

References	Reason(s) for exclusion*
Ackerman, J.M., Goldstein, N.J., Shapiro, J.R., & Bargh, J.A. (2009). You wear me out: the vicarious depletion of self-control. *Psychological Science, 20*(3), 326-332	A
Agras, W.S., Crow, S.J., Halmi, K.A., Mitchell, J.E., Wilson, G.T., & Kraemer, H.C. (2000). Outcome predictors for the cognitive behaviour treatment of bulimia nervosa: Data from a multisite study. *The American Journal of Psychiatry, 157*(8), 1302-1308.	D
Agrawal, N., & Wan, E.W. (2009). Regulating risk or risking regulation? Construal levels and depletion effects in the processing of health messages. *Journal of Consumer Research, 36*(3), 448-462.	A
Alberts, H.J.E.M, Martijn, C., Greb, J., Merckelbach, H., & de Vries, N.K. (2007). Carrying on or giving in: The role of automatic processes in overcoming ego depletion. *British Journal of Social Psychology, 46*, 383-399.	A
Alberts, H.J.E.M., Martijn, C., Nievelstein, F., Jansen, A., & De Vries, N.K. (2008). Distracting the self: Shifting attention prevents ego depletion. *Self and Identity, 7*(3), 322-334.	A
Allen, H.N., & Craighead, L.W. (1999). Appetite Monitoring in the Treatment of Binge Eating Disorder. *Behaviour Therapy, 30*(2), 253-272.	B
Andrade, J., May, J., & Kavanagh, D. (2012). Sensory imagery in craving: From cognitive psychology to new treatments for addiction. *Journal of Experimental Psychopathology, 3*(2), 127-145.	F
Anton, S.D., Gallagher, J., Carey, V.J., Laranjo, N., Cheng, J., Champagne, C.M., . . . Williamson, D.A. (2012). Diet type and changes in food cravings following weight loss: findings from the POUNDS LOST Trial. *Eating & Weight Disorders: EWD, 17*(2), e101-108.	B
Appelhans, B.M., Waring, M.E., Schneider, K.L., Pagoto, S.L., DeBiasse, M.A., Whited, M.C., & Lynch, E.B. (2012). Delay discounting and intake of ready-to-eat and away-from-home foods in overweight and obese women. *Appetite, 59*(2), 576-584.	B
Appelhans, B.M., Woolf, K., Pagoto, S.L., Schneider, K.L., Whited, M.C., & Liebman, R. (2011). Inhibiting Food Reward: Delay Discounting, Food Reward Sensitivity, and Palatable Food Intake in Overweight and Obese Women. *Obesity, 19*(11), 2175-2182.	B

References	Reason(s) for exclusion*
Batra, P., Das, S.K., Salinardi, T., Robinson, L., Saltzman, E., Scott, T., . . . Roberts, S.B. (2013). Relationship of cravings with weight loss and hunger. Results from a 6 month worksite weight loss intervention. *Appetite, 69*, 1-7.	B
Beintner, I., & Jacobi, C. (2011). Internet-based follow-up care for bulimia nervosa. *Psychotherapeut, 56*(6), 516-521.	D
Boehm, G., Bracharz, N., & Schoberberger, R. (2011). Evaluation of the sustainability of the Public Health Program "Slim without Diet (Schlank ohne Diat)". *Wiener Klinische Wochenschrift, 123*(13-14), 415-421.	C
Brown, A.J., Smith, L.T., & Craighead, L.W. (2010). Appetite awareness as a mediator in an eating disorders prevention program. *Eating Disorders, 18*(4), 286-301.	D
Bulik, C.M., Sullivan, P.F., Joyce, P.R., Carter, F.A., & McIntosh, V.V. (1998). Predictors of 1-year treatment outcome in bulimia nervosa. *Comprehensive Psychiatry, 39*(4), 206-214.	B
Cameron, M.J., Maguire, R.W., & McCormack, J. (2011). Stress-Induced Binge Eating: A Behaviour Analytic Approach to Assessment and Intervention. *Journal of Adult Development, 18*(2), 81-84.	E
Chang, K.T., Lampe, J.W., Schwarz, Y., Breymeyer, K.L., Noar, K.A., Song, X., & Neuhouser, M.L. (2012). Low glycemic load experimental diet more satiating than high glycemic load diet. *Nutrition & Cancer, 64*(5), 666-673.	B
Courbasson, C., Nishikawa, Y., & Dixon, L. (2012). Outcome of dialectical behaviour therapy for concurrent eating and substance use disorders. *Clinical Psychology & Psychotherapy, 19*(5), 434-449.	A
De Ridder, D.T.D., Ouwehand, C., Stok, F.M., & Aarts, F.J. (2011). Hot or not: Visceral influences on coping planning for weight loss attempts. *Psychology &Health, 26*(5), 501-516.	B
Fagundo, A.B., Santamaria, J.J., Forcano, L., Giner-Bartolome, C., Jimenez-Murcia, S., Sanchez, I., . . . Fernandez-Aranda, F. (2013). Video game therapy for emotional regulation and impulsivity control in a series of treated cases with bulimia nervosa. *European Eating Disorders Review, 21*(6), 493-499.	D
Forzano, L., & Corry, R. (1998). Self-control and impulsiveness in adult human females: Effects of visual food cues. *Learning and Motivation, 29*(2), 184-199.	B

References	**Reason(s) for exclusion***
Forzano, L.B., Chelonis, J.J., Casey, C., Forward, M., Stachowiak, J.A., & Wood, J.. (2010). Self-control and impulsiveness in non-dieting adult human females: Effects of visual food cues and food deprivation. *The Psychological Record, 60*(4), 587-608.	B
Gailliot, M.T., Baumeister, R.F., DeWall, C.N., Maner, J.K., Plant, E.A., Tice, D.M., . . . Schmeichel, B.J. (2007). Self-control relies on glucose as a limited energy source: willpower is more than a metaphor. *Journal of Personality & Social Psychology, 92*(2), 325-336.	A
Gailliot, M.T. (2013). Hunger and reduced self-control in the laboratory and across the world: Reducing hunger as a self-control panacea. *Psychology, 4*(1), 59-66.	A
Giesen, J.C., Havermans, R.C., Nederkoorn, C., & Jansen, A. (2012). Impulsivity in the supermarket. Responses to calorie taxes and subsidies in healthy weight undergraduates. *Appetite, 58(1),* 6-10.	B
Goodrick, G. (1999). Inability to control eating: Addiction to food or normal response to abnormal environment? *Drugs & Society, 15*(1-2), 123-140.	F
Gorin, A.A., Raynor, H.A., Niemeier, H.M., & Wing, R.R. (2007). Home grocery delivery improves the household food environments of behavioural weight loss participants: Results of an 8-week pilot study. International Journal of *Behavioural Nutrition and Physical Activity*, 4:58	B
Harvey, J., Wing, R.R., & Mullen, M. (1993). Effects on food cravings of a very low calorie diet or a balanced, low calorie diet. *Appetite, 21*(2), 105-115.	B
Hassan, L.M., Shiu, E.M., & Michaelidou, N. (2010). The influence of nutrition information on choice: The roles of temptation, conflict and self-control. *Journal of Consumer Affairs, 44*(3), 499-515.	B
Hetherington, M.M., & Boyland, E. (2007). Short-term effects of chewing gum on snack intake and appetite. *Appetite, 48*(3), 397-401.	B
Hetherington, M.M., & Regan, M.F. (2011). Effects of chewing gum on short-term appetite regulation in moderately restrained eaters. *Appetite, 57*(2), 475-482.	B
Hopkinson, J.B. (2007). How people with advanced cancer manage changing eating habits. *Journal of Advanced Nursing, 59*(5), 454-462.	B
Houben, K., Nederkoorn, C., Wiers, R.W., & Jansen, A. (2011). Resisting temptation: decreasing alcohol-related affect and drinking behaviour by training response inhibition. *Drug & Alcohol Dependence, 116*(1-3), 132-136.	A

References	Reason(s) for exclusion*
Houben, K., Schoenmakers, T.M., & Wiers, R.W. (2010). I didn't feel like drinking but I don't know why: the effects of evaluative conditioning on alcohol-related attitudes, craving and behaviour. *Addictive Behaviours*, *35*(12), 1161-1163.	A
Houben, K., Wiers, R.W., & Jansen, A. (2011). Getting a grip on drinking behaviour: training working memory to reduce alcohol abuse. *Psychological Science*, *22*(7), 968-975.	A
Hsu, L.K.G., Rand, W., Sullivan, S., Liu, D.W., Mulliken, B., McDonagh, B., & Kaye, W. H. (2001). Cognitive therapy, nutritional therapy and their combination in the treatment of bulimia nervosa. *Psychological Medicine*, *31*(5), 871-879.	D
Jansen, A. (1998). A learning model of binge eating: cue reactivity and cue exposure. *Behaviour Research & Therapy*, *36*(3), 257-272.	F
Kemps, Eva, & Tiggemann, Marika. (2010). A cognitive experimental approach to understanding and reducing food cravings. *Current Directions in Psychological Science*, *19*(2), 86-90.	F
Kristeller, J.L., & Wolever, R.Q. (2011). Mindfulness-based eating awareness training for treating binge eating disorder: the conceptual foundation. *Brunner-Mazel Eating Disorders Monograph Series*, *19*(1), 49-61.	F
Kroese, F.M., Adriaanse, M.A., & De Ridder, D.T. (2013). Are self-management interventions suitable for all? Comparing obese versus nonobese type 2 diabetes patients. *Health Education & Behaviour*, *40*(5), 552-558.	B
Lally, P., Wardle, J., & Gardner, Bn. (2011). Experiences of habit formation: A qualitative study. *Psychology, Health & Medicine*, *16*(4), 484-489.	B
Maas, J., de Ridder, D.T., de Vet, E., & de Wit, J.B. (2012). Do distant foods decrease intake? The effect of food accessibility on consumption. *Psychology & Health*, *27* Suppl 2, 59-73.	B
Martijn, C., Alberts, H.J., Merckelbach, H., Havermans, R., Huijts, A., & De Vries, N.K. (2007). Overcoming ego depletion: The influence of exemplar priming on self-control performance. *European Journal of Social Psychology*, *37*(2), 231-238.	A
Martijn, C., Tenbult, P., Merckelbach, H., Dreezens, E., & de Vries, N.K. (2002). Getting a grip on ourselves: Challenging expectancies about loss of energy after self-control. *Social Cognition*, *20*(6), 441-460.	A
Martin, C.K., O'Neil, P.M., & Pawlow, L. (2006). Changes in food cravings during low-calorie and very-low-calorie diets. *Obesity*, *14*(1), 115-121.	B

References	**Reason(s) for exclusion***
Masicampo, E., & Baumeister, R.F. (2008). Toward a physiology of dual-process reasoning and judgment: Lemonade, willpower, and expensive rule-based analysis. *Psychological Science, 19*(3), 255-260.	B
May, J., Andrade, J., Kavanagh, D., & Penfound, L.. (2008). Imagery and strength of craving for eating, drinking, and playing sport. *Cognition and Emotion*, *22(*4), 633-650.	B
Meule, A., Lukito, S., Vogele, C., & Kubler, A. (2011). Enhanced behavioural inhibition in restrained eaters. Eating *Behaviours, 12*(2), 152-155.	B
Muraven, M., Baumeister, R.F., & Tice, D.M. (1999). Longitudinal improvement of self-regulation through practice: building self-control strength through repeated exercise. *Journal of Social Psychology*, *139*(4), 446-457.	A
Muraven, M., Gagne, M., & Rosman, H. (2008). Helpful self-control: Autonomy support, vitality, and depletion. *Journal of Experimental Social Psychology, 44*(3), 573-585.	A
Muraven, M., & Shmueli, D. (2006). The self-control costs of fighting the temptation to drink. *Psychology of Addictive Behaviours, 20*(2), 154-160.	B
Myrseth, K.O.R., Fishbach, A., & Trope, Y. (2009). Counteractive Self-Control. *Psychological Science, 20*(2), 159-163.	B
Oakes, M.E., & Slotterback, C.S. (2000). Nutritional habits and motivations to eat after a palatable pre-load. Current *Psychology, 19*(4), 329-337.	B
Oaten, M., & Cheng, K. (2006). Improved self-control: The benefits of a regular program of academic study. *Basic and Applied Social Psychology, 28*(1), 1-16.	A
Oza, N., Eguchi, Y., Mizuta, T., Ishibashi, E., Kitajima, Y., Horie, H., . . . Fujimoto, K. (2009). A pilot trial of body weight reduction for nonalcoholic fatty liver disease with a home-based lifestyle modification intervention delivered in collaboration with interdisciplinary medical staff. *Journal of Gastroenterology, 44*(12), 1203-1208.	B
Papies, E. K., & Hamstra, P. (2010). Goal priming and eating behaviour: enhancing self-regulation by environmental cues. *Health Psychology*, *29*(4), 384-388. http://dx.doi.org/10.1037/a0019877	G
Papies, E. K., & Veling, H. (2013). Healthy dining. Subtle diet reminders at the point of purchase increase low-calorie food choices among both chronic and current dieters. *Appetite, 61*(1), 1–7.	G

References	Reason(s) for exclusion*
Pearson, M.R., Kite, B.A., & Henson, J.M. (2013). Predictive effects of good self-control and poor regulation on alcohol-related outcomes: Do protective behavioural strategies mediate? *Psychology of Addictive Behaviours, 27(*1), 81-89.	B
Quinn, J.M., Pascoe, A., Wood, W., & Neal, D.T. (2010). Can't control yourself? Monitor those bad habits. *Personality & Social Psychology Bulletin, 36*(4), 499-511.	B
Radu, P.T., Yi, R., Bickel, W K., Gross, J.J., & McClure, S.M. (2011). A medchanism for reducing delay discounting by altering temporal attention. *Journal of the Experimental Analysis of Behaviour, 96*(3), 363-385.	A
Reuter, T., Ziegelmann, J.P., Wiedemann, A.U., & Lippke, S. (2008). Dietary planning as a mediator of the intention-behaviour relation: An experimental-causal-chain design. Applied Psychology-an *International Review-Psychologie Appliquee-Revue Internationale*, 57, 194-207.	B
Riebe, D., Blissmer, B., Greene, G., Caldwell, M., Ruggiero, L., Stillwell, K. M., & Nigg, C. R. (2005). Long-term maintenance of exercise and healthy eating behaviours in overweight adults. *Preventive Medicine*, *40*(6), 769-778.	B
Rieger, E., Dean, H.Y., Steinbeck, K.S., Caterson, I.D., & Manson, E. (2009). The use of motivational enhancement strategies for the maintenance of weight loss among obese individuals: a preliminary investigation. *Diabetes, Obesity & Metabolism, 11*(6), 637-640.	B
Sanders, M.A., Shirk, S.D., Burgin, C.J., & Martin, L.L. (2012). The gargle effect: Rinsing the mouth with glucose enhances self-control. Psychological Science, 23(12), 1470-1472.	A
Schwarzer, R., & Luszczynska, A. (2008). How to overcome health-compromising behaviours - The health action process approach. *European Psychologist, 13*(2), 141-151.	B
Shapiro, J.R., Bauer, S., Andrews, E., Pisetsky, E., Bulik-Sullivan, B., Hamer, R.M., & Bulik, C.M. (2010). Mobile therapy: Use of text-messaging in the treatment of bulimia nervosa. *International Journal of Eating Disorders, 43*(6), 513-519.	D
Singh, N.N., Lancioni, G.E., Singh, A.N., Winton, A.S., Singh, A.D., & Singh, J. (2011). A mindfulness-based health wellness program for individuals with Prader-Willi syndrome. *Journal of Mental Health Research in Intellectual Disabilities, 4*(2), 90-106.	A
Singh, N.N., Lancioni, G.E., Singh, A.N., Winton, A.S., Singh, J., McAleavey, K.M., . . . Joy, S.D. (2008). A mindfulness-based health wellness program for managing morbid obesity. *Clinical Case Studies, 7*(4), 327-339.	E
Steel, Z.P., Farag, P.A., & Blaszczynski, A.P. (1995). INTERRUPTING THE BINGE-PURGE CYCLE IN BULIMIA - THE USE OF PLANNED BINGES. *International Journal of Eating Disorders, 18*(3), 199-208.	D

References	Reason(s) for exclusion*
Turner, S.A., Luszczynska, A., Warner, L., & Schwarzer, R. (2010). Emotional and uncontrolled eating styles and chocolate chip cookie consumption. A controlled trial of the effects of positive mood enhancement. *Appetite, 54*(1), 143-149.	C
Udo, T., Grilo, C.M., Brownell, K.D., Weinberger, A.H., Dileone, R.J., & McKee, S.A. (2013). Modeling the effects of positive and negative mood on the ability to resist eating in obese and non-obese individuals. *Eating Behaviours, 14*(1), 40-46.	B
Van Gucht, D., Baeyens, F., Hermans, D., & Beckers, T. (2013). The inertia of conditioned craving. Does context modulate the effect of counterconditioning? *Appetite, 65,* 51-57.	C
Van Gucht, D., Vansteenwegen, D., Beckers, T., & Van den Bergh, O. (2008). Return of experimentally induced chocolate craving after extinction in a different context: divergence between craving for and expecting to eat chocolate. *Behaviour Research & Therapy, 46*(3), 375-391.	C
van Kleef, E., Kavvouris, C., & van Trijp, H. C. (2014). The unit size effect of indulgent food: how eating smaller sized items signals impulsivity and makes consumers eat less. *Psychology & Health, 29*(9), 1081-1103	B
van Koningsbruggen, G.M., Stroebe, W., & Aarts, H. (2013). The rise and fall of self-control: Temptation-elicited goal activation and effortful goal-directed behaviour. *Social Psychological and Personality Science, 4*(5), 546-554.	B
Coelho, J.S., Polivy, J., Herman, C.P., & Pliner, P. (2009). Wake up and smell the cookies. Effects of olfactory food-cue exposure in restrained and unrestrained eaters. *Appetite, 52*(2), 517-520	B
Coelho, J.S., Polivy, J., Herman, C.P., & Pliner, P. (2008). Effects of food-cue exposure on dieting-related goals: A limitation to counteractive-control theory. *Appetite, 51*(2), 347-349.	B
Papachristou, H., Nederkoorn, C., Beunen, S., & Jansen, A. (2013). Dissection of appetitive conditioning. Does impulsivity play a role? *Appetite, 69*, 46-53.	B
Van Gucht, D., Baeyens, F., Vansteenwegen, D., Hermans, D., & Beckers, T. (2010). Counterconditioning reduces cue-induced craving and actual cue-elicited consumption. *Emotion, 10*(5), 688-695.	C
Baumeister, R.F., Vohs, K.D., & Tice, D.M. (2007). The strength model of self-control. Current *Directions in Psychological Science, 16*(6), 351-355.	F
Veling, H. van Koningsbruggen, G.M., Aarts, H., & Stroebe, W. (2014) Targeting impulsive processes of eating behaviour via the internet. Effects on body weight. *Appetite, 78,* 102-109	C

References	Reason(s) for exclusion*
Durkin, K., Hendry, A., & Stritzke, W.G. (2013). Mixed selection. Effects of body images, dietary restraint, and persuasive messages on females' orientations towards chocolate. *Appetite, 60*(1), 95-102.	C
Durkin, K., Rae, K., & Stritzke, W.G. (2012). The effect of images of thin and overweight body shapes on women's ambivalence towards chocolate. *Appetite, 58*(1), 222-226.	C
Halford, W.K., Goodall, T.A., & Nicholson, J.M. (1997). Diet and diabetes .2. A controlled trial of problem solving to improve dietary self-management in patients with insulin dependent diabetes. *Psychology & Health, 12*(2), 231-238.	C
McClelland, A., Kemps, E., & Tiggemann, M. (2006). Reduction of vividness and associated craving in personalized food imagery. *Journal of Clinical Psychology*, *62*(3), 355-365	C
Olstad, D.L., Goonewardene, L.A., McCargar, L.J., & Raine, K.D. (2014). Choosing healthier foods in recreational sports settings: A mixed methods investigation of the impact of nudging and an economic incentive. *The International Journal of Behavioural Nutrition and Physical Activity*, *11*, 6.	C
Veling, H., & Aarts, H.. (2009). Putting behaviour on hold decreases reward value of need-instrumental objects outside of awareness. *Journal of Experimental Social Psychology, 45*(4), 1020-1023.	A
Wei, W.& Miao, L. (2013). Effects of calorie information disclosure on consumers' food choices at restaurants. *International Journal of Hospitality Management, 33*, 106-117.	B
Yokum, S., & Stice, E. (2013). Cognitive regulation of food craving: effects of three cognitive reappraisal strategies on neural response to palatable foods. *International Journal of Obesity*, *37*(12), 1565-1570.	C
Maas, J., Hietbrink, L., Rink, M., & Keijsers, G.P.J. (2013) Changing automatic behaviour through self-monitoring: Does overt change also imply implicit change? *Journal of Behaviour Therapy & Experimental Psychiatry, 44,* 279-284	B

*A: Not eating behaviour (18); B: No evaluation of an Impulse Modification Technique (42); C: Includes under 18s (12); D: Focus on eating disorders (7); E: Case studies (2); F: Review/ Theoretical overview (6); G: Not an Individual Level Technique.

Appendix 3 Detailed extracted evidence data for each separate unique study within the three technique categories

Extracted data of studies evaluating impulse-focused techniques

Reference	Study design	Comparisons (n)	Sample Size	Outcome	Follow-up	Results	Potential Biases
1.1 Priming							
1.1.1 Effects on food consumption							
Raska and Nichols (2012) Study 3	2-arm RCT	-Companionate love reminder -Sexual love reminder	45	Observed Snack choice	Post-treatment	Participants exposed to Abraham Lincoln (companionate love) were more likely to choose a healthy snack (61.9%) than those exposed to Marilyn Monroe (29.2%), $\chi^2(1)=4.86$, $p< .05$	Student sample No sample size calculation Very small sample* Potential differential appeal of love symbols by gender (which was not accounted for)
Laurin et al. (2012) Study 4	Non randomised controlled trial	-God (speech) prime -Planet Pluto (speech) control	23	Observed number of cookies consumed	After (filler task) wash-out period	Participants who were primed with reminders of God, ate fewer cookies than controls (M Diff=4.85 cookies, SMD=-1.24, p<.01).	Student sample No sample size calculation No randomisation Very small sample*

Reference	Study design	Comparisons (n)	Sample Size	Outcome	Follow-up	Results	Potential Biases
Stillman et al (2009) Study 3	Factorial design	2(Psychological presence of family (photo of loved ones), Control) x 2(depletion, no depletion)	66	Observed cookie consumption	Post-treatment	Participants in the psychological presence of family ate fewer cookie quarters than those in the control condition (M Diff= .23, SMD=-.09) however, this only reached significance when controlling for restrained eating (p=.05, partial η^2=.62) When controlling for restraint, cookie consumption of depleted participants was unaffected, but for participants in the non depletion condition, those who received the family prime ate fewer cookies than those who received no prime (M Diff= 1.36, SMD= -0.67, p=0.06.	Student sample No sample size calculation No randomisation Small sample*
1.1.2 Effects of priming on food preferences /hypothetical food choice							
Raska and Nichols (2012) Study 1	3-arm RCT	-Companionate love symbol background (hearts) -Sexual love symbol background (kisses) -Simple white background control	97	Hypothetical Snack choice	Post-treatment	Participants exposed to subtle reminders of companionate love were more likely to choose a healthy snack (70.2%) compared to those exposed to reminders of sexual love (48.6%), $\chi^2(1)$=3.95, p = .04, SMD=0.41, and those in the control condition (40%) $\chi^2(1)$=4.45, p=.03, SMD=0.44.	Student sample No sample size calculation Self-report measures Small sample*
Raska and Nichols (2012) Study 2	2-arm RCT	-Companionate love reminder -Sexual love reminder	70	Hypothetical Snack choice	Post-treatment	Participants exposed to Abraham Lincoln (companionate love) were more likely to choose a healthy snack (60%) than those exposed to Marilyn Monroe (28.6%), $\chi^2(1)$=7.01, p< .01, SMD=0.67.	Student sample No sample size calculation Self-report measures Small sample*

Reference	Study design	Comparisons (n)	Sample Size	Outcome	Follow-up	Results	Potential Biases
Hare et al. (2011)	Non randomised crossover trial	-Health cue -Taste cue -Natural control	33	Hypothetical dietary choices	Post-treatment	The health cue group were significantly less likely to eat unhealthy-tasty ($p<.005$), unhealthy-untasty ($p<.005$), but significantly more likely to eat the healthy-untasty foods ($p<.05$), compared to controls. No difference between the conditions for healthy-tasty foods, nor any differences between the taste consideration condition, and natural condition were found.	No sample size calculation No randomisation Self-report measures Very small sample*
Laran (2010) Study 1	Mixed factorial design	3 (construal-between: control, concrete, abstract) x 2 (information prime-between: neutral vs self-control) x 2 (time frame-within: present vs future)	400	Present and future Snack choice (choice shares healthy vs unhealthy)	Post-treatment	There was a significant construal x information prime x time frame interaction (Wald $\chi^2(7)=36.27$, $p<.01$). In the control condition, there was an interaction between information prime and time frame (Wald $\chi^2(1)=5.97$, $p<.05$). In the neutral prime, participants were equally likely to choose a healthy snack for the present as they were for the future. When primed with self-control, present snack choice was more likely to be healthy in either construal condition (no construal 61.2%; concrete construal 61.9%) than when the choice was made for a future snack (no construal 34.3%, $\chi^2(1)=9.69$, $p<.01$, SMD=0.32; concrete construal 41.3%, $\chi^2(1)= 5.37$, $p<.05$, SMD=0.23) For the abstract construal condition, similar patterns as above were found, but when primed with neutral information, the healthy snack choices were more likely $\chi^2(1)=8.12$, $p<.01$, SMD=0.29. There was no difference in choice shares between the two construal conditions for the self-control prime.	Student sample No sample size calculation (but large sample) Self-report measures

Reference	Study design	Comparisons (n)	Sample Size	Outcome	Follow-up	Results	Potential Biases
Laran (2010) Study 2	Mixed factorial design	2 (information prime-between: indulgence vs self-control) x 2 (time frame-between: present vs future) x 2 (word type: self-control vs neutral)	213	Self-reported present and future snack choice (healthy vs unhealthy) & information accessibility (reaction times)	Post-treatment	In the indulgence prime condition, participants in the present time frame condition were slower to recognize words related to self-control than neutral words (M Diff= 75ms p<.05) Participants in the future time frame condition were faster to recognize words related to self-control than neutral words (M Diff=81ms, p=.05). In addition, participants were less likely to list healthy snacks in the present time frame (35.5%) than in the future time frame (61.1%, p=.01) In the self-control prime condition, the present time frame participants were faster to recognize words related to self-control than neutral words (M Diff=60ms, p<.04), whereas the future time frame participants were slower to recognize self-control than neutral words (M Diff=73, p=.05). In addition, participants were more likely to list healthy snacks in the present time frame (80.6%), than in the future time frame (41.9%, p<.01).	Student sample No sample size calculation (but large sample) Self-report measures
1.1.3 Effects of priming on automatic evaluations							
Laurin et al. (2012) Study 3	3-arm RCT	-God prime -Positive prime -Neutral prime	37	Implicit evaluations (IAT)	Post treatment	Participants who were primed with God through forming grammatically correct sentences containing words related to the concept of God, had more negative automatic associations with junk food than did participants primed with neutral words (M Diff=.40, SMD= -1.03, p<.04) and those with positive words (M Diff=.42, SMD=-1.03, p<.03). No difference in automatic evaluations was found between the Positive and Neutral primed participants.	Student sample No sample size calculation Very small sample*

Reference	Study design	Comparisons (n)	Sample Size	Outcome	Follow-up	Results	Potential Biases
Laran (2010) Study 2	Mixed factorial design	2 (information prime-between: indulgence vs self-control) x 2 (time frame-between: present vs future) x 2 (word type: self-control vs neutral)	213	Self-reported present and future snack choice (healthy vs unhealthy) & information accessibility (reaction times)	Post-treatment	In the indulgence prime condition, participants in the present time frame condition were slower to recognize words related to self-control than neutral words (M Diff= 75ms p<.05) Participants in the future time frame condition were faster to recognize words related to self-control than neutral words (M Diff=81ms, p=.05). In addition, participants were less likely to list healthy snacks in the present time frame (35.5%) than in the future time frame (61.1%, p=.01) In the self-control prime condition, the present time frame participants were faster to recognize words related to self-control than neutral words (M Diff=60ms, p<.04), whereas the future time frame participants were slower to recognize self-control than neutral words (M Diff=73, p=.05). In addition, participants were more likely to list healthy snacks in the present time frame (80.6%), than in the future time frame (41.9%, p<.01).	Student sample No sample size calculation (but large sample) Self-report measures (snack choice only)
1.2 Cue exposure							
1.2.1 Effects on food consumption							

Reference	Study design	Comparisons (n)	Sample Size	Outcome	Follow-up	Results	Potential Biases
Kroese et al. (2013) Study 2	2-arm RCT	-Strong temptation (one large bowl of crisps) -Weak temptation (three small bowls of crisps)	39	Self-reported calorie estimates & Observed consumption	Post-treatment	With weight concern as a covariate, strong temptations yielded higher calorie estimates compared to weak temptations (β=.39, p=.01), which was associated with lower consumption (β=-.33, p=.05). Bootstrapping analyses suggest that there was a significant indirect effect of temptation strength on consumption through calorie estimates (95% CI[-4.44 to -.15])	Student sample No sample size calculation Very small sample* Self-report measures (calorie estimates only)
Kroese et al. (2009) Study 2	2-arm non randomised controlled trial	-Temptation exposure -Control (flower)	54	Actual Snack choice (healthy vs unhealthy) & Goal intention (2-item 7-point Likert scale)	Post-treatment	Participants who were exposed to temptation had stronger goal intentions than controls (M Diff=.8,SMD=.80). A marginally significant difference in snack choice was reported (p=.056) in which the temptation group more often chose a healthy snack than an unhealthy snack compared with controls.	Student sample No sample size calculation No randomisation Self-report measures (goal intention only) Very small sample*

Reference	Study design	Comparisons (n)	Sample Size	Outcome	Follow-up	Results	Potential Biases
Coelho et al. (2009a)	Mixed factorial design	-Olfactory food cue present -Control (no cue)	104	Observed cookie and chocolate cookie consumption	Post-treatment	No between group differences were reported. There was a significant interaction of food cue and restraint on chocolate cookie consumption F(1,99) =4.47, $p<.05$, partial $\eta^2=.38$. Chocolate cookie consumption was reduced in restrained eaters in the cue compared to restrained controls, $t_{48}=2.34$, $p<.03$. Intake was reduced in unrestrained controls compared to restrained controls $t_{49}=2.36$, $p<.03$. No difference between groups was found for unrestrained eaters. For total cookie intake the pattern was the same, but did not reach significance.	Student sample No sample size calculation Baseline differences (controlled for) Small sample*
Buckland et al. (2013)	Mixed factorial design	-Prior diet-congruent cue exposure -Prior temptation cue exposure	58	Observed food consumption	Post-treatment	Total energy intake of snack food did not differ between conditions. Significant two-way interaction between diet-status and condition on total energy intake, F(1,32)=6.45, p=.02, partial $\eta^2=.17$. Restrained dieters consumed fewer total calories in the diet condition, compared to the tempting condition, F(1,12)=7.46, p=.02, partial $\eta^2=.38$, but for unrestrained non dieters total energy intake did not differ.	Student sample No sample size calculation No randomisation Unequal diet-status group sizes Very small sample*

Reference	Study design	Comparisons (n)	Sample Size	Outcome	Follow-up	Results	Potential Biases
Geyskens et al. (2008) Study 3b	Mixed factorial design	3(temptation: Actionable Food Temptation, Non Actionable Food Temptation, control) x 2(convenience: high, low)	184	Observed snack consumption	Post-treatment	There was a significant main effect on observed snack consumption between the AFT, NAFT, and control groups, F(2,177)=6.81, p<.01) with liking for the used chocolates as a covariate, however, no contrasts were reported. No significant two-way interaction between convenience and temptation. However, post-hoc analyses were still conducted, as follows:- Participants in the control condition consumed more in the high convenience condition, than in the low convenience condition (M Diff=6.53grams, SMD=.55, p<.05). In the low convenience condition, consumption was lower in the control condition (M Diff=6.85, SMD=-.61, p<.01) and the AFT condition (M Diff=6.12, SMD=-.59, p<.01) than the NAFT condition. No differences between the control and AFT condition. In contrast, in the high convenience condition, consumption was higher in the control condition (M Diff=6.62, SMD=.61., p<.05) and the NAFT condition (M Diff=8.22 SMD=.79, p<.01) than the AFT condition. No differences between the control and NAFT condition.	Student sample No sample size calculation No randomisation
1.2.2 Effects of cue exposure on craving							

Reference	Study design	Comparisons (n)	Sample Size	Outcome	Follow-up	Results	Potential Biases
van Gucht et al. (2008)	2-arm non randomised controlled trial	-Repeated cue exposure (40) -Control (18)	58	Self-reported craving strength (online 0-100 scale), saliva secretion	1-3 days.	Cravings reduced over time more for the cue exposure group than for controls (Group x Time interaction F(1,56)= 11.91, p<.01). No significant effect of cue exposure on salivation (Group x Time interaction n.s.)	Student sample No sample size calculation No randomisation Self-report measures (cravings only) Very small sample*
1.2.3 Effects of cue exposure on goal activation							
Geyskens et al. (2008) Study 1	3-arm non randomised controlled trial	-Actionable food temptation (AFT) -Nonactionable food temptation (NAFT) -Control	70	Diet-goal activation (Response time for the word 'diet')	Post-treatment	Significant main effect of temptation F(2,66)=5.87, p<.01. Compared with controls, "diet" was recognized significantly faster in the non actionable condition (M Diff=89.35ms, SMD=-.88, p<.01), and in the actionable condition (M Diff=57.75ms, SMD=-..56, p<.05). No differences in activation among the two food temptation conditions were found, suggesting that both non actionable, as well as actionable food temptations activate the goal to restrict food intake.	Student sample No sample size calculation No randomisation Very small sample*

Reference	Study design	Comparisons (n)	Sample Size	Outcome	Follow-up	Results	Potential Biases
Geyskens et al. (2008) Study 2	Mixed factorial design	3 (temptation: AFT,NAFT,Control) x 2 (food opportunity; subsequent eating opportunity, no eating opportunity)	129	Eating-goal activation (Response time for the word 'eating')	Post-treatment	Main effect of temptation only marginally significant F(2,122)=2.8, p<.07. The eating goal was activated more strongly in the NAFT condition than the AFT condition (M Diff=32.74, SMD=-.51, p<.05) but no difference compared to controls. There was a Subsequent eating opportunity x Temptation interaction F(2,122)= 6.5, p<.01, η^2 = .10. In controls, the presence of sweets in the subsequent eating opportunity condition activated the eating goal compared to the no subsequent eating opportunity condition (M Diff=61.31ms, SMD=-.66, p<.01). In the no subsequent eating opportunity the eating goal was activated in the NAFT condition (M Diff=55.42, SMD=-.56, p<.01) and the AFT (M Diff=51.03, SMD=-.53, p<.05) compared to controls. This implies that Non actionable as well as actionable temptations activate the desire to eat the cued food. In the subsequent eating opportunity group, the eating goal was activated in the controls (M Diff=60.63, SMD=-1.0, p<.01) and in the NAFT condition (M Diff=61.07, SMD=-.97, p<.05) compared to the AFT condition. The presence of the sweets induced a desire to eat in the control and NAFT condition but not after exposure to the AFT. Consistently, in the AFT condition, the SEO condition showed a suppressed eating goal activation in comparison with the NSEO condition (M Diff=50.35, SMD=.76, p<.01)	Student sample No sample size calculation No randomisation Small sample*
1.2.4 Effects of cue exposure on goal importance and goal intentions							

Reference	Study design	Comparisons (n)	Sample Size	Outcome	Follow-up	Results	Potential Biases
Kroese et al. (2009) Study 1	2-arm non randomised controlled trial	-Temptation exposure -Control (flower)	73	Goal-importance (1-item 7-point likert scale)	Post-treatment	For participants in the temptation condition the weight watching goal was more important than for controls (M Diff=.8, SMD=.64, p<.05).	Student sample No sample size calculation No randomisation Self-report measures Small sample*
Kroese et al. (2009) Study 2	2-arm non randomised controlled trial	-Temptation exposure -Control (flower)	54	Goal intention (2-item 7-pooint Likert scales) & Actual Snack choice (healthy vs unhealthy)	Post-treatment	Participants who were exposed to temptation had stronger goal intentions than controls (M Diff=.8,SMD=.80). A marginally significant difference in snack choice was reported (p=.056) in which the temptation group more often chose a healthy snack than an unhealthy snack compared with controls.	Student sample No sample size calculation No randomisation Self-report measures (goal intentions only) Very small sample*
1.2.5 Effects of cue exposure on attention processing							

Reference	Study design	Comparisons (n)	Sample Size	Outcome	Follow-up	Results	Potential Biases
Geyskens et al. (2010)	3-arm RCT with additional 2 (Cue type: food/jewels; within-subjects) x 2 (Cue validity: valid/invalid; within-subjects) factors	-Actionable food temptation -Nonactionable food temptation -Control	59	Attention processing (using a pictorial exogenous cueing task)	Post-treatment	Main effect of treatment group not reported. When controlling for restraint, BMI, and disinhibition there was a significant cue type x cue validity x group interaction (F(1,52)=3.19, p=.05). In the NAFT condition, participants reacted more quickly to the invalid food trials compared to the valid food trials (M Diff=20ms, SMD=-.44, p=.01) and the valid jewel trials (M Diff=13ms, SDM=-.32, p=.0003), but no different from the invalid jewel trials (p=.07). The same pattern was found for the AFT condition, but here reactions were quicker than to invalid jewel trials as well (p=.05). No difference in reaction times between trial types was found in the control condition. These findings indicate that attention may have been drawn away from the food cues after exposure to non actionable and actionable food temptations in comparison to the control condition.	Student sample No sample size calculation Very small sample*
1.3 Inhibition Training							
1.3.1 Effects on food consumption							
Guerrieri et al. (2012)	3-arm RCT	-Inhibition (21) -Impulsivity (20) -Control (20)	61	Observed snack food consumption	Post-treatment	Inhibition training led to reduced consumption compared to impulsivity promotion ($p < 0.05$, $\eta_p^2 = 0.08$), but not compared to controls ($p > 0.30$)	Student Sample No sample size calculation Very small sample*

Reference	Study design	Comparisons (n)	Sample Size	Outcome	Follow-up	Results	Potential Biases
Houben & Jansen (2011)	3-arm RCT	-Chocolate/no-go condition (21) -Chocolate/go condition (20) -Control (22)	63	Observed chocolate consumption	Post-treatment	Inhibition training led to reduced chocolate intake compared to controls $t(60) = -3.07$, $p < .01$. Impulsivity promotion did not differ from the controls or inhibition training $p = .12$ and $p = 1.43$	Student Sample No sample size calculation Very small sample*
Veling et al. (2011) Study 2	2-arm RCT	-No-go -Control	46	Observed sweets consumption	1-day	No significant effect of no-go treatment compared with controls. There was a significant group x dieting interaction $F(1,42)=6.01$, $p<.02$, partial $\eta^2= .13$.Chronic dieters with inhibition training consumed less compared to chronic dieter controls, however non dieter 252ehaviour was unaffected by the training.	Student Sample No sample size calculation Very small sample*
Houben (2011)	Non randomised crossover trial	-Stop food -Go food -Control	29	Observed snack food consumption	Post-treatment	No significant effect of no-go treatment compared with controls. Increasing inhibition toward a 'stop food' decreased consumption compared to the control foods, but only in participants with weak baseline inhibitory control (interaction $F(2,26)=4.92$, $p= .02$, partial $\eta^2= .27$)	Student Sample No sample size calculation No randomisation Very small sample*

Reference	Study design	Comparisons (n)	Sample Size	Outcome	Follow-up	Results	Potential Biases
van Konings-bruggen et al. (2014) Study 1	2x2 factorial experiment	-Only No-go (24) –Only II (20) -II and No-go (23) -Control (22)	87	Ad libitum food-serving behaviour	Post-treatment	No main effects of the go/no-go or II tasks. However, the interaction effect between the two tasks was significant, $F(1, 85) = 4.32$, $p = .041$, $\eta_p^2 = .05$. The go-no go training only decreased food serving in those who received the control implementation intentions $F(1,85)= 8.12$, $p = .005$, $\eta_p^2= .09$. Implementation intentions only decreased food-serving for those receiving the control go/nogo $F(1,85)= 5.06$, $p=.027$, $\eta_p^2= .06$. Post-hoc pairwise comparisons showed that food-serving 253ehaviour in the control group was significantly higher than the other conditions ($p = .031$ to .005).	Student Sample Small sample*

Reference	Study design	Comparisons (n)	Sample Size	Outcome	Follow-up	Results	Potential Biases
van Konings-bruggen et al. (2014) Study 2	2x2 factorial experiment	-Only No-go (24) -Only II (23) -II and No-go (19) -Control (22)	88	Task performance (button holding) to receive chocolate	Post-treatment	No main effects of the go/no-go or II tasks. However, the interaction effect between the two tasks was significant ($F(1, 84) = 5.72$, $p = .019$, $\eta_p^2=.06$). The go-nogo task decreased button holding 254ehaviour compared to controls when control implementation intentions were used, as compared to the control condition, but not when diet implementation intentions were used. (Interaction $F(1, 84) = 8.20$, $p = .005$, $\eta_p^2=.09$). Implementation intention significantly decreased button-holding 254ehaviour vs controls, when control no-go was used (Interaction $F(1, 84) = 7.84$, $p = .006$, $\eta_p^2=.09$). Pairwise comparisons showed that controls held the button down significantly longer than either the no-go training, implementation intentions, or combined treatment groups (p=.039- to 005).	Student Sample Small sample*
1.3.2 Effects of inhibition training on food preferences/ hypothetical food choice							

Reference	Study design	Comparisons (n)	Sample Size	Outcome	Follow-up	Results	Potential Biases
Veling et al. (2013) Study 1	2-arm RCT	-No-go -Control	79	Food choices healthy & unhealthy	Post-treatment	Main effect of training condition $F(1,75)=4.35$, $p<.05$ partial $\eta^2= .06$ Inhibition training reduced palatable food choices in participants compared to controls in participants with high appetite $p<.01$, $\eta_p{}^2=.14$. but not those with low appetite (Interaction $F(1,75)=5.83$, $p<.05$, partial $\eta^2=$ .07) Inhibition training increased healthy food choice compared to controls in participants with high appetite $p< .01$, $\eta_p{}^2=.12$, but not low appetite (Interaction F(1,75(=4.40, $p<.05$, partial $\eta^2= .06$).	Self-report measures No sample size calculation Small sample*
Veling et al. (2013) Study 2	2-arm RCT	-No-go -Control	44	Food choices healthy & unhealthy	Post-treatment	Main effect of training condition $F(1, 40)=6.90$, $p<.05$, partial $\eta^2= .36$ Inhibition training reduced the choice of palatable unhealthy foods compared to controls for those with relatively high frequency past behaviours towards those foods $p <.01$, $\eta_p{}^2= .26$ but not for those low frequency of past 255ehaviour. (Interaction $F(1,40)=7.18$, $p<.05$, $p<.01$, partial $\eta^2=.15$). People with high frequency of past 255ehaviour who received inhibition training chose more healthy foods compared to high frequency controls $p<.05$, partial $\eta^2=.12$ (Interaction only marginally significant $F(1,40)=3.58$, $p=.07$, partial $\eta^2=.09$).	Self-report measures No sample size calculation Very small sample*
1.3.3 Effects of Inhibition training on other outcomes							

Reference	Study design	Comparisons (n)	Sample Size	Outcome	Follow-up	Results	Potential Biases
Veling et al. (2011) Study 1	Non randomised crossover trial	2 (control objects vs food objects) x 2 (go vs no go) within	38	Slowed responses on Go/no go task	Post-treatment	Presentation of palatable foods with no-go cues caused slower responding to the action probes compared to presentation of control objects with no-go cues $p < .05$, $\eta_p^2 = .10$. This effect of stop signals was particularly strong for chronic dieters as opposed to non dieters (Interaction $F(1,36)=4.15$, $p<.05$, partial $\eta^2=.10$)	Student Sample No sample size calculation No randomisation Very small sample*
1.4 Physical Activity							
1.4.1 Effects on Food consumption							
Oh & Taylor (2012)	Factorial experiment	-15min Exercise +high cognitive demand (20) -Exercise +low (19) -Rest +high (20) -Rest +low (19)	78	Observed chocolate consumption	Post-treatment	Those in the exercise conditions ate less chocolate compared to the passive control conditions (M Diff=13.2g, SMD=-.61). Load task had no effect on chocolate consumption and did not influence the effect of exercise on chocolate.	No sample size calculation Very small sample*
Thayer et al. (1993) Study 2	Randomised crossover trial	-Five min brisk walk -Sedentary control	18	Time until next snack	Post-treatment	The time until eating the next snack was significantly extended by walking by almost 50% (M Diff=5min, $p<.01$).	No sample size calculation Very small sample*
1.4.2 Effects of physical activity on craving							

Reference	Study design	Comparisons (n)	Sample Size	Outcome	Follow-up	Results	Potential Biases
Oh & Taylor (2013)	Randomised crossover trial	-Two-min warm-up + 15min brisk walk -Passive control	58	Self-reported craving	Mid-treatment Post-treatment, 5-min, 10-min	Time x Group interaction for craving F(2.34,133.9)=14.44 (no p-value reported). Craving was significantly reduced after exercise, compared with rest: In the exercise condition chocolate craving dropped from baseline during exercise (p<.001), post-treatment (p<.001), at 5-min (p=.001), and 10-min (p<.001).	Small sample* (close to 60 however and based on a sample size calculation) Self-report measures
Oh and Taylor (2014)	Randomised crossover trial	-Low-moderate intensity exercise -Vigorous intensity exercise -Passive control	23	Self-reported craving (3-item 5-point scale adapted from the FCQ-S)	Mid-treatment, Post-treatment, 5-min, and 10-min	Immediately after treatment desire to snack was significantly lower after vigorous (MDiff=4.04, 95% CI[2.16, 5.93], d=1.11), and moderate exercise (M Diff=1.56, 95% CI[0.24, 2.89], d=.42). Mid-treatment, desire to snack was significantly lower in the vigorous (M Diff=4.08, 95% CI[2.43, 5.38], d=1.16), and moderate exercise (MDiff=2.22, 95% CI[0.31, 3.60], d=.53) than in the control condition. Ten minutes after treatment, desire to snack was only lower after vigorous exercise (M Diff=2.56, 95% CI[1.01, 4.12], d=.78).	Very small sample* (sample size calculation assumed a high effect size (SMD =0.88)) Self-report measures
Taylor & Oliver (2009)	Randomised crossover trial	-Two-min warm-up + 15min brisk walk -Passive control	25	Self-reported craving (FCQ-S adapted for chocolate)	Mid-treatment Post-treatment, 10-min	Time x Group interaction for chocolate craving F(2,48)=21.5, p<.001. Compared with controls, cravings were significantly lower in the exercise condition both immediately and 10min after treatment.	No sample size calculation. Self-report measures Very small sample*

Reference	**Study design**	**Comparisons (n)**	**Sample Size**	**Outcome**	**Follow-up**	**Results**	**Potential Biases**
Thayer et al. (1993) Study 2	Randomised crossover trial	-Five min brisk walk -Sedentary control	18	Self-reported urge to snack	Post-treatment	Interaction effect indicated that walking significantly decreased urges to snack compared to not walking F(1,17)=12.32, p<.01.	No sample size calculation Self-report measures Very small sample*
1.4.3 Effects of physical activity on attentional bias							
Oh & Taylor (2013)	Randomised crossover trial	-Two-min warm-up + 15min brisk walk -Passive control	58	Attentional Bias (IAB and MAB)	Mid-treatment Post-treatment, 5-min, 10-min	Initial Attentional Bias (IAB) was significantly greater in the passive control, compared with the exercise condition at post-treatment , t(57)= 2.78, p<.01, 95% CI[5.53,34.21], d= 0.42. Time x Group Interaction for IAB F(1,57)=6.39, p<.05. IAB in the passive condition was significantly increased as compared with baseline, [M Diff=20.78ms, p<.01, 95% CI[-35.43, -6.14], d=0.42. There was no difference in IAB from baseline to post-treatment for the exercise treatment condition.	Small sample* (close to 60 however and based on a sample size calculation)

Reference	Study design	Comparisons (n)	Sample Size	Outcome	Follow-up	Results	Potential Biases
Oh and Taylor (2014)	Randomised crossover trial	-Low to moderate intensity exercise -Vigorous intensity exercise -Passive control	23	Attentional bias	Mid-treatment Post-treatment, 5-min, and 10-min	Attentional bias towards snacking video clips was lower in the moderate exercise (M Diff=27.35%; 95% CI[16.63, 38.08], d=1.04), and the vigorous exercise,(M Diff=27.14, 95% CI [18.20, 36.09], d=1.42), compared with the passive control condition. There were significant reductions in initial IAB from baseline to post- treatment for both the moderate (M Diff=21.01, 95% CI[6.67, 35.37], d=.77) and vigorous exercise (M Diff= 15.91, 95% CI[3.32, 28.49], d=.68). For maintained attentional bias, only vigorous exercise was significantly lower than controls (M Diff=12.67, 95% CI[4.79, 20.54], d=.63).	Very small sample* (sample size calculation assumed a high effect size (SMD =0.88))
1.5 Attentional bias training							
1.5.1 Effects on food consumption, craving, and attentional bias							

Reference	Study design	Comparisons (n)	Sample Size	Outcome	Follow-up	Results	Potential Biases
Kemps et al. (2014) Study 1	2-arm RCT	-Attend training (55) -Avoid training (55)	110	Attentional bias & self-reported chocolate craving (VAS) & observed consumption	Post-treatment	There was a significant time x group interaction F(1,108)=27.48, p<.001.Attend training significantly increased attentional bias scores from baseline to post-treatment t(54)=4.10,p<.001,d=.69, 95% CI[.15,1.23] and Avoid training significantly decrease in the avoid group, t(54)=3.31, p<.01, d=.64, 95%. There was no significant difference in craving scores (time x group) between the attend and avoid groups. In the taste test the avoid group ate significantly less of the chocolate muffin than those in the attend group, p < .01, d=0.67, 95%CI = [.28, 1.05]. In contrast, blueberry muffin consumption did not differ between the two training conditions.	Student sample No sample size calculation Small sample* Self-report measures (craving only)
Hardman et al. (2013)	3-arm non randomised controlled trial	-Attend training -Avoid training -No training	60	Self-reported appetite (VAS) & observed calories consumed	Post-treatment	No significant differences in attentional bias were found between groups. For food intake there was no evidence for a main effect of group [F(2,54) = 0.89, p = .42] indicating no overall effect of training group on food intake.	Student sample Very small sample* No sample size calculation No randomisation (alternate allocation) Self-report measures (appetite only)
1.6 Approach/Avoidance training							
1.6.1 Effects on craving and approach bias							

Reference	Study design	Comparisons (n)	Sample Size	Outcome	Follow-up	Results	Potential Biases
Kemps et al. (2013) Study 2	2-arm RCT	-Approach Training (48) -Avoidance Training (48)	96	Self-reported chocolate craving (VAS) & Approach Bias	Post-treatment	Significant time x group interaction $F(1,94)=8.32$, $p<.01$, partial $\eta^2 = .08$. Approach training significantly increased approach bias scores from baseline to post-treatment, $t(47)=2.08$, $p<.05$, $d=.43$, whereas avoidance training significantly decreased approach bias score from baseline to post-treatment, $t(47)=2.03$, $p<.05$, $d=.45$. Significant group x time interaction for cravings $F(1,94)=4.41$, $p<.05$, partial $\eta^2 = .05$, with cravings increasing after approach training relative to baseline and decreasing after avoidance training.	Student sample No sample size calculation Self-report measures (craving only) Small sample*

Abbreviations: RCT = Randomised Controlled Trial. SMD= Standardized Mean Difference. BMI= Body Mass Index (kg/m^2). SD= Standard Deviation. PA= Physical Activity. FCQ-S= Food Craving Questionnaire-State. FCQ-T= Food Craving Questionnaire Trait. PFS= Power of Food Scale. IAB= Initial Attentional Bias. MAB= Maintained Attentional Bias. AFT = Actionable Food Temptation. NAFT = Non Actionable Food Temptation. VAS= Visual Analogue Scale.

* A small sample is defined here as less than 64 people per group (the number needed to have an 80% chance of detecting a SMD of 0.5, i.e. a medium effect size, with $p<0.05$). A very small sample is defined here as less than 30 per group. For factorial designs the smallest factor-group size was used (e.g., in a 2x3 factor design, the total sample size was divided by 3).

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Reference	Study design	Comparisons (n)	Sample size	Outcome	Follow-up	Results	Potential Biases
2.1 Mindfulness-based strategies							
2.1.1 Effects on weight							
Forman et al. (2013a)	2-arm RCT	-Acceptance-based treatment (74) -Standard behavioural treatment (54)	128	Weight (%body weight)	Treatment period, Post-treatment, 6-month follow-up.	No significant difference in weight loss between treatments. Subgroup analyses: those treated by experts in the ABT condition (n=28) lost significantly more weight than the SBT participants at post-treatment (M Diff=5.63%, SMD=.65, p= .01), and follow-up (M Diff=6.15%, SMD= 0.74, p<.01).	Completers only analysis (and 32% drop out at 6 months)
Alberts et al. (2010)	2-arm RCT	- Acceptance-based treatment (10) -Standard treatment (9)	19	Weight &)	Post-treatment	No significant difference in weight loss between the treatment groups.	No sample size calculation Very small sample*
Alberts et al. (2012)	2-arm RCT	-Mindfulness (12) -Waitlist control (14)	26	BMI	Post-treatment	No significant difference in weight loss between groups.	No sample size calculation. Very small sample*
Forman et al. (2009)	Uncontrolled study	- Acceptance-based treatment	14	Weight	Post-treatment (19) 6-month (14)	Participants lost an average of 6.6% of their body weight between baseline and post-treatment (SMD= .42) and an average of 9.6% of their baseline body weight by 6-month follow-up (SMD= .58).	No sample size calculation. Drop-out rate 31%, lost to follow-up 51%. No control group. Very small sample*

Reference	Study design	Comparisons (n)	Sample size	Outcome	Follow-up	Results	Potential Biases
2.1.2 Effects of Mindfulness-based strategies on food consumption							
Jordan et al. (2014) Study 3	2-arm RCT	-Mindfulness (incl. body scan) -Control	56	Observed calorie consumption	Post-treatment	The mindfulness induction group ate 24% fewer calories than controls (M Diff= 48.41, SMD=.60, p =.029).	Student Sample. No sample size calculation. Very small sample*
Hooper et al. (2012)	3-arm non randomised controlled trial	-Defusion (16) -Thought suppression (17) -Control (14)	47	Observed chocolate consumption & Self-reported consumption	Post-treatment	The defusion group ate significantly fewer chocolates than the thought suppression group (M Diff=11.28, SMD= -1.69, p<.05), and controls (M Diff=7.62, SMD= -.99, p<.05). The thought suppression group ate significantly more than controls (M Diff=3.66, SMD=.37, p<.05). No significant difference between the groups for self-reported chocolate consumption.	Student sample No sample size calculation No randomisation Very small sample*
Jenkins & Tapper (2014)	3-arm non randomised controlled trial	-Cognitive Defusion (45) -Acceptance (44) -Control relaxation (45)	134	Observed 'marked' chocolate consumption (returned bag) & Observed chocolate consumption taste test & Self-reported consumption	Experimental period, Post-treatment	The defusion group ate significantly fewer chocolates compared to controls (M Diff= .67, SMD= -0.45, p=.046. There was no significant difference between the acceptance group and controls. No significant differences in self-reported consumption.	Student sample No sample size calculation Small sample*

Reference	Study design	Comparisons (n)	Sample size	Outcome	Follow-up	Results	Potential Biases
Moffitt et al. (2012)	3-arm RCT	-Cognitive Defusion (38) -Cognitive restructuring (36) -Waitlist Control (36)	110	Combined self-reported and observed chocolate consumption	7-day	The odds of abstinence from eating chocolate (combined self-report and observation) was 3.26 times higher for Cognitive Defusion, than for Cognitive restructuring (Wald=4.67, 95% CI [1.12-9.53]), and 4.61 times higher for Cognitive Defusion than for controls (Wald=7.55, 95% CI[1.55-13.71]). The odds of abstinence did not differ between cognitive restructuring and controls.	No sample size calculation Small sample*
Forman et al. (2013b)	2-arm RCT	-Acceptance-based coping (22) -Control-based coping (26)	48	Observed & Self-reported sweet consumption	Treatment period, Post-treatment	No significant differences were found between groups on self-reported consumption, or observed (taste-test) consumption and returned sweets.	No sample size calculation Very small sample*
Forman et al. (2007)	3-arm RCT	-Acceptance-based coping (30) –Control-based coping (36) -Control (32)	98	Observed chocolate consumption (box of marked chocolates)	Post-treatment	No significant difference between groups (group x time interaction) on chocolate abstinence.	Student sample No sample size calculation Small sample*
2.1.3 Effects of Mindfulness-based strategies on craving							
Forman et al. (2013b)	2-arm RCT	-Acceptance-based coping (22) -Control-based coping (26)	48	Self-reported Craving (FCQ-S)	Treatment period, Post-treatment	No significant differences were found at either time point between groups on state-based cravings.	No sample size calculation Self-report measures Very small sample*

Reference	Study design	Comparisons (n)	Sample size	Outcome	Follow-up	Results	Potential Biases
Moffitt et al. (2012)	3-arm RCT	-Cognitive Defusion (38) -Cognitive restructuring (36) -Waitlist Control (36)	110	Self-reported craving (FCQ-S and FCQ-T)	7-day	Changes in craving state: Temptation, intensity, and difficulty resisting did not differ significantly between the groups.	No sample size calculation Self-report measures Small sample*
Alberts et al. (2013)	3-arm RCT	-Acceptance (20) -Thought suppression (20) -Control (21)	61	Self-reported craving levels (G-FCQ-S)	Post-treatment, 20 – minutes	At post-treatment, there were increased craving levels in the acceptance (M Diff=.91; SMD= 1.32, $p<.001$), and thought suppression groups (M Diff= .7, SMD=.90, $p<.01$) compared with controls. No difference between acceptance and thought suppression. At 20 minutes, there were increased craving levels in the acceptance group (M Diff=1.06, SMD=1.18, $p<.001$), and thought suppression groups (M Diff=.74, SMD= .79, $p<.01$) compared with controls**.** No significant difference between acceptance and thought suppression.	Student Sample No sample size calculation Self-report measures Very small sample*
Alberts et al. (2010)	2-arm RCT	- Acceptance-based treatment (10) -Standard treatment (9)	19	Food Cravings (G-FCQ-T)	Post-treatment	There was a decline in cravings from baseline to post-treatment for the intervention group compared with controls (M Diff $_{\text{Change score}}$ =.58, group x time interaction $F(1,17)=8.02$, $p= .012$, $\eta^2=.32$).	No sample size calculation Self-report measures Very small sample*
Alberts et al. (2012)	2-arm RCT	- Acceptance based mindfulness (12) -Waitlist control (14)	26	Food Cravings	Post-treatment	Significant craving scores reduction (group x time interaction) after mindfulness compared to controls ($F(1,24)=7.09$, $p=.01$, $\eta^2= .29$)	No sample size calculation Self-report measures Very small sample*

Reference	Study design	Comparisons (n)	Sample size	Outcome	Follow-up	Results	Potential Biases
Hamilton et al. (2013)	3-arm RCT	-Body Scan (34) -Guided Imagery (29) -Control (31)	94	Self-reported craving (CEQ-S, CEQ-F)	Experimental period Post-treatment	There was a significant group x time interaction for craving $F(18,189)=1.90$, $p=.013$, $\eta^2=.04$. Craving levels remained constant during mindfulness-based strategies, compared to increases in controls.	Student sample No sample size calculation Self-report measures Small sample*
Forman et al. (2007)	3-arm RCT	-Acceptance-based coping (30) –Control-based coping (36) -Control (32)	98	Self-reported craving (FCQ-S)	Post-treatment	No significant difference between groups (group x time interaction) for cravings. There was a significant susceptibility to food x group interaction ($F(12,176)=2.35$, $p = .01$, partial $\eta^2=.14$) for craving scores. The acceptance-based coping group showed significantly lower craving scores relative to the control-based coping and control groups at the higher PFS levels, but not for the lower PFS levels (no data provided).	Student sample No sample size calculation Self-report measures Small sample*
Hooper et al. (2012)	3-arm non randomised controlled trial	-Defusion (16) -Thought suppression (17) -Control (14)	47	Self-reported chocolate craving	Post-treatment	No significant difference between the groups for chocolate craving	Student sample No sample size calculation No randomisation Self-report measures Very small sample*
May et al. (2010) Study 1	4-arm non randomised controlled trial	-Breath-focus (12) -Thought suppression (12) -Imagery Diversion (13) -Control (11)	48	Self-reported craving intensity (100mm VAS scale)	Experimental period Post-treatment period	There was a significant group x time interaction $F(2,88)= 2.57$, $p=0.24$, $\eta^2=.15$ Breath focus elevated post-task cravings compared to controls.	Student sample No sample size calculation No randomisation Self-report measures Very small sample*

Reference	Study design	Comparisons (n)	Sample size	Outcome	Follow-up	Results	Potential Biases
May et al. (2010) Study 2	3-arm non randomised controlled trial	-Body Scan (17) -Guided Imagery (16) -Control (16)	49	Craving intensity (100mm VAS) & Intrusive thoughts	Experimental period Post-treatment period	Taking into account baseline levels of food thoughts there was a significant interaction effect of group x time $F(1,45)= 9.13$, $p=.004$. There was a significant effect of condition during experimental period $F(2,25)=3.25$, $p=.048$, $\eta2=.13$ with Body scan significantly reducing intrusive thoughts as compared to controls ($p=.015$) but no difference between Guided Imagery and controls. There was no significant difference in intrusive thoughts between the groups at post-treatment. No significant between group (or group x time) differences for craving intensity.	Student sample No sample size calculation No randomisation Self-report measures Differences in baseline characteristics Very small sample*
2.1.4 Effects of Mindfulness-based strategies on other outcomes							
Hendrickson & Rasmussen (2013) Study 2	2-arm RCT	-Mindful eating (47) -Control (education video)(48)	95	Discounting patterns	Post-treatment	There was a significant time x group interaction for delay discounting for food $F(1,93)=5.71$,$p=.02$, partial $\eta^2=.06$, and for probability discounting for food $F(1,93)=5.10$, $p<.05$, $\eta^2=.05$. The mindful eating group showed more self-controlled (less impulsive) ($p=.003$) and less risk-averse discounting patterns ($p<.001$) for food compared to baseline, whereas controls did not differ in discounting from baseline to post-treatment.	Student sample No sample size calculation Self-report measures Small sample*

Reference	Study design	Comparisons (n)	Sample size	Outcome	Follow-up	Results	Potential Biases
Papies et al. (2012) Study 1	Mixed factorial design	2 (Control vs Mindful attention) x 2 (attractive vs neutral) x 2 (approach vs avoidance)	40	Approach bias (difference in response latencies)	Post-treatment	Significant interaction of condition, food type, and response $F(1,38)=13.12$, $p=.001$, partial $\eta^2= .26$. Although control participants show an approach bias towards attractive foods (approach responses were faster than avoidance responses with regard to attractive foods $F(1,19)= 14.99$, $p =.001$, partial $\eta^2= .44$, but not with regard to neutral food, $p=.75$). Participants in the mindful attention group did not show this approach bias. These effects of mindful attention occurred independent of dieting goals.	Student sample No sample size calculation Very small sample*
Papies et al. (2012) Study 2a	Mixed factorial design	2 (condition-between: Control vs Mindful attention) x 2 (food type-within: attractive vs neutral) x 2 (response-within: approach vs avoidance)	55	Approach bias (difference in response latencies)	5-mins	As in study 1, significant interaction between condition, food type, and response $F(1,53)=3.91$, $p=0.05$, partial $\eta^2= 0.07$. Mindful attention group showed no approach bias toward attractive food after the 5 minute distraction task, in contrast to controls who showed faster approach responses than avoidance responses with regard to attractive foods $F(1,24)= 7.05$, $p =.01$, partial $\eta^2= .23$, but not with regard to neutral food, $p=.97$.	Student sample No sample size calculation Very small sample*
Papies et al. (2012) Study 2b	Mixed factorial design	2 (condition-between: Control vs Mindful attention) x 2 (food type-within: attractive vs neutral) x 2 (response-within: approach vs avoidance)	55	Approach bias (difference in response latencies)	Post-treatment	Using novel stimuli, no significant interaction was found. Approach and avoidance reactions to attractive and neutral food were equally fast in both conditions. Combining Study 2a and b suggests that participants develop an approach bias toward attractive food during exposure to the food items.	No sample size calculation Very small sample*

Reference	Study design	Comparisons (n)	Sample size	Outcome	Follow-up	Results	Potential Biases
Papies et al. (2012) Study 3	Mixed factorial design	2 (food type: attractive vs neutral) x 2(condition: mindful attention vs control) x 2(set of pictures: trained vs novel) x 2(Response: approach vs avoidance)	50	Approach bias (difference in response latencies)	Post-treatment	Significant interaction of Condition x food type x response $F(1,48)= 6.22$, $p= 0.02$, partial $\eta^2= 0.12$ Controls showed an approach bias toward pictures of attractive food $F(1,23)= 5.49$, $p =.03$, partial $\eta^2= .19$, which seemed to be less pronounced for novel pictures (trend only $p=.09$). Mindful attention participants did not show an approach bias for either the trained attractive food images or the novel attractive food images (all $p >.53$).	Student sample No sample size calculation No randomisation Very small sample*
2.2 Visuospatial Loading							
2.2.1 Effects of visuospatial loading on consumption							
Kemps & Tiggemann (2013a)	2-arm RCT	-Dynamic visual noise (24) -Control (24)	48	Self-reported craving related consumption (for 2 week pre-baseline; 2 week post-intervention)	Post-treatment 2 weeks post baseline	There was a significant group x time interaction for craving related consumption $F(1,46)=4.47$, $p=.04$, partial $\eta^2= .08$. The dynamic visual noise group were 39% less likely to eat following a craving compared to their baseline measures, $t(23)=3.15$, $d= .50$, $p=.005$. No difference from baseline for controls. This resulted in a reduction of 31% in calorie-intake in the dynamic visual noise condition, $t(23)=3.25$, $SMD=.49$, $p=.004$, but not for controls (no difference between the groups at baseline).	Student Sample No sample size calculation Self-report measures Very small sample*

Reference	Study design	Comparisons (n)	Sample size	Outcome	Follow-up	Results	Potential Biases
Knauper et al. (2011)	4-arm RCT	-II plus activity imagery(25) -Goal intention (27) -II (18) -II plus cognitive task (21).	91	Self-reported amount consumed	Post-treatment	No significant differences in craved food consumption between the groups.	Student Sample. No sample size calculation. Self-report measures Very small sample*
2.2.2 Effects of visuospatial loading on craving							
Rodriguez-Martin et al. (2013)	2-arm RCT	-Self-help manual of imagery and non imagery tasks targeting craving components in working memory (40) -Intention to control food cravings (40)	80	Food cravings trait & Emotional and behavioural impact of food-related thoughts	1-month 3-month	Significant reduction at follow-up in scores for food cravings trait, $F(1,78)=13.175$, $p<.001$, partial $\eta^2>.310$, feelings of hunger $F(1,78)=32.98$, $p<.001$, partial $\eta^2>.297$, intentions to eat, $F(1,78)=21.185$, $p<.001$, partial $\eta^2>.214$, cue-dependent eating $F(1,78)=11.083$, $p<.01$, partial $\eta^2>.124$, and lack of control $F(1,78)=5.519$, $p<.05$, partial $\eta^2>.066$, in the self-help manual group compared to the control group.	No sample size calculation Self-report measures Small sample*

Reference	Study design	Comparisons (n)	Sample size	Outcome	Follow-up	Results	Potential Biases
Andrade et al. (2012) Study 2	2-arm RCT	-Clay-modelling (45) -Control (42)	87	Self-reported craving (CEQ-Snow) & Food-thought frequency	Experimental period Post-treatment	Mean craving scores post intervention were reduced during clay-modelling compared to controls t(85)=2.68, p=.009, 95% CI[.41-2.75] and less frequent t(85)=2.62, p=.01, 95% CI[.34-2.50] Both craving strength and imagery CEQ sub-scales showed an interaction between time and condition, F(1,85)= 4.24, p =.043, partial η^2= .05 and F(1,85)=5.13, p=.026, η^2= .06, respectively, reflecting a greater reduction in strength and imagery over time in the clay modelling condition compared to controls. During the experimental period there were fewer chocolate thoughts in the clay modelling condition, compared to the control group (M Diff=1.91, SMD= -.47, 95% CI[.16-3.66]	Student sample No sample size calculation Self-report measures Small sample*
Kemps & Tiggemann (2007) Study 2	3-arm RCT	-Visual imagery (30) -Olfactory imagery (30) -Auditory imagery (30)	90	Self-reported craving (VAS)	Post-treatment	Significantly greater decrease in craving ratings following the visual and olfactory imagery tasks than the auditory task (Time by Task interaction F(2,87)=5.38, p< .01, Cohen's f^2=.35, with medium to large effect size for visual vs auditory, f^2=.41, and olfactory vs auditory tasks, f^2=.29, but not for visual vs olfactory tasks, f^2=.07)	Student Sample No sample size calculation Self-report measures Small sample*
Kemps & Tiggemann (2007) Study 3	3-arm RCT	-Visual imagery (32) -Olfactory imagery (32) -Auditory imagery (32)	96	Self-reported craving (VAS)	Post-treatment	Significantly greater decrease in craving following the visual and olfactory imagery tasks, compared to the auditory task. (Time by Task interaction, F(2,93)=4.79, p< .01, f^2=.32, with moderate effect size for visual vs auditory, f^2=.31, and olfactory vs auditory tasks, f^2=.36, but not for visual vs olfactory tasks, f^2=.11).	Student Sample No sample size calculation Self-report measures Small sample*

Reference	Study design	Comparisons (n)	Sample size	Outcome	Follow-up	Results	Potential Biases
Kemps & Tiggemann (2013a)	2-arm RCT	-Dynamic visual noise (24) -Control (24)	48	Self-reported craving (VAS) & Self-reported craving related consumption (for 2 week pre-baseline; 2 week post-intervention)	Post-treatment 2 weeks post baseline	Craving intensity was significantly reduced from baseline to post-treatment by 23%, M Diff=13.56, SMD=1.09, p<.001in the dynamic visual noise condition. Initial craving intensity scores (Before using Dynamic visual noise) did not differ from the control scores p=.07. There was a significant group x time interaction for craving related consumption F(1,46)=4.47, p=.04, partial η^2= .08. The dynamic visual noise group were 39% less likely to eat following a craving compared to their baseline measures, t(23)=3.15, d= .50, p=.005. No difference from baseline for controls. This resulted in a reduction of 31% in calorie-intake in the dynamic visual noise condition, t(23)=3.25, SMD=.49, p=.004, but not for controls (no difference between the groups at baseline).	Student Sample No sample size calculation Self-report measures Very small sample* Possible analysis bias (between group comparison not reported for craving intensity)
Knauper et al. (2011)	4-arm RCT	-II plus activity imagery(25) -Goal intention (27) -II (18) -II plus cognitive task (21).	91	Self-reported craving & self-reported craving induced eating episodes	Post-treatment	There was a significant interaction of time x group (F(3,87)=2.77, p<.046, partial η^2= .09) such that the Implementation intentions + activity imagery group showed a significant reduction in craving intensity ratings from baseline to post-treatment, F(1,87)=9.90, p<.002, partial η^2= .10 and the other groups showed no differences.	Student Sample No sample size calculation Very small sample* Self-report measures

Reference	Study design	Comparisons (n)	Sample size	Outcome	Follow-up	Results	Potential Biases
Harvey et al. (2005)	Factorial experiment	2(induction scenario: food, holiday) x 2(imagery task:visual, auditory)	120	Self-reported craving intensity (VAS)	Post-treatment	Mean craving ratings decreased more following the visual imagery task than the auditory imagery task, (significant time by task interaction $F(1,112)=10.08$, $p < .01$. Cravings were significantly lower after both the imagery tasks than before (M Diff=8.81, SMD= -.31)	Student sample No sample size calculation Self-report measures
Kemps & Tiggemann (2013b) Study 1	Non randomised crossover trial	-Olfactory interference -Auditory interference -Control	56	Self-reported craving	Post-treatment	There was a significant difference in averaged craving scores between the tasks $F(2,110)=14.41$, $p < .001$, $f^2=.51$, with significantly lower craving ratings after olfactory than after auditory interference, (M Diff=7.88, SMD= -.36 $p<.01$, and control, (M Diff= 12.67, SMD= - .61, $p <.001$, but no difference between the auditory and control tasks. Separate analyses for sweet and savoury food categories showed the same pattern of differences between tasks $F(2,110)=8.73$, $p<.001$, $f=.40$ (sweet) and $F(2,110)=17.40$, $p<.001$, $f=.56$ (savoury), with again lower cravings after olfactory interference as compared to the auditory interference ($p<.01$) and control ($p<.01$).	Student sample No sample size calculation No randomisation Self-report measures Small sample*
Kemps & Tiggeman (2013b) Study 2	Non randomised crossover trial	-Olfactory interference -Auditory interference -Control	57	Self-reported chocolate craving (VAS)	Post-treatment	Averaged chocolate craving ratings were significantly lower after olfactory interference than auditory interference (M Diff= 8.27, SMD= -.36, $p <.01$), and controls (M Diff= 14.31, SMD= -.64, $p< .001$). The auditory interference also lead to significantly lower chocolate craving intensity ratings than the control (M Diff= 6.04, SMD= -.26, $p<.05$).	Student sample No sample size calculation No randomisation Self-report measures Small sample*

Reference	Study design	Comparisons (n)	Sample size	Outcome	Follow-up	Results	Potential Biases
Kemps et al. (2004) Study 1	Non randomised crossover trial	-Dynamic visual noise -Eye movements -Spatial tapping -Control	48	Self-reported craving (VAS)	Post-treatment	There was a significant main effect of condition, $F(3,44)=3.09$, $p<.05$, and interaction between task and stimulus type $F(3,44)=4.93$, $p<.01$, where visuospatial task condition had an effect on craving intensity ratings when presented with food-related images $F(3,45)=5.56$, $p<.01$, but not when presented with neutral images. Lower craving intensity ratings in the dynamic visual noise (M Diff= 3.97, SMD= -.15, $p<.01$) and eye movement conditions (M Diff= 5.4, SMD= -.21, $p<.001$) as compared to the control condition. No significant difference between the spatial tapping and control condition.	Student sample No sample size calculation No randomisation Self-report measures Small sample*
Kemps et al. (2004) Study 2	Non randomised crossover trial	-Dynamic visual noise -Eye movements -Spatial tapping -Control	56	Self-reported craving (VAS)	Post-treatment	There was a significant group x stimulus type interaction $F(3,52)= 3.25$, $p<.05$. For food-related verbal cues, craving intensity ratings were significantly lower for dynamic visual noise (M Diff=4.47, SMD=-.19, $p<.01$), eye movements (M Diff=2.4, SMD=-.13, $p<.025$), and spatial tapping (M Diff= 5.26, SMD= -.22, $p<.01$) compared to the control condition. No other significant differences found.	Student sample No sample size calculation No randomisation Self-report measures Small sample*
Kemps et al. (2005)	Non randomised crossover trial	-Dynamic visual noise -Auditory interference -Control	48	Self-reported chocolate craving (VAS)	Post-treatment	Craving ratings were lowest in the dynamic visual noise compared to controls (M Diff=12.12, SMD=-.49, $p<.001$) and to the auditory interference condition (M Diff= 5.72, SMD= -.22, $p<.05$). The ratings were also lower in the auditory interference condition compared to control (M Diff= 6.4, SMD= -.23, $p<.001$) There was no significant interaction between craving status (craver vs non craver) and task condition.	Student sample No sample size calculation No randomisation Self-report measures Small sample*,

Reference	Study design	Comparisons (n)	Sample size	Outcome	Follow-up	Results	Potential Biases
Kemps et al. (2008)	Non randomised crossover trial	-Dynamic visual noise -Thought suppression -No task	40	Self-reported craving (VAS)	Post-treatment	Craving intensity scores were lower in the dynamic visual noise (M Diff=17.06, SMD= -.79, p <.001), and thought suppression conditions (M Diff=13.77, SMD=-.62, p <.001) compared to controls. Dieting status and task interaction was significant F(2,76)=2.85, p<.05, d=.55, with dynamic visual noise resulting in less intense cravings for weight watchers (p<.01), but not for non dieters.	Student sample No sample size calculation No randomisation Self-report measures Small sample*
Kemps et al. (2012)	Non randomised crossover trial	-Food-odour -Non food odour -Neutral (non) odour	67	Self-reported chocolate craving (VAS)	Post-treatment	There was a significant effect of odour on craving ratings F(2,130)=3.35, p<.05, d=.45. Ratings were lower after the jasmine (non food) odour as compared to the green apple (food) odour (M Diff=4.03, SMD= -.16, p<.01) and the neutral (water) condition (M Diff=6.31, SMD= -.26, p<.05). There was no difference between the green apple and neutral conditions.	Student sample No sample size calculation No randomisation Self-report measures
Steel et al. (2006)	Non randomised crossover trial	-Dynamic visual noise -Control	42	Self-reported craving (VAS)	Post-treatment	Craving intensity ratings were lower for the dynamic visual noise condition (estimated SMD =0.88, p<.001). No interaction between hunger status and task.	Student sample No sample size calculation No randomisation Self-report measures Small sample*

Reference	Study design	Comparisons (n)	Sample size	Outcome	Follow-up	Results	Potential Biases
Andrade et al. (2012) Study 1a	Non randomised controlled trial	-Clay modelling -Counting backwards by threes -Control	63	Self-reported chocolate craving (3xVAS)	Post-treatment	There was a significant group x time interaction F(2,60)=3.19, p=.048, partial η^2= .096. There was a greater reduction in craving scores in the clay modelling than the control condition (M Diff=7.7, t(40)=2.14, p=.04) and a greater reduction in craving when counting backwards compared to controls (M Diff=6.9, t(40)=2.44, p=.02), but no difference in change scores between the clay modelling task and counting backwards conditions.	Student sample No sample size calculation No randomisation Self-report measures Very small sample*
2.3 Cognitive Loading							
2.3.1 Effects of cognitive loading on craving							
Van Dillen et al. (2013) Study 1	Non randomised controlled trial with 2 (food type: attractive vs. neutral; within participants) x_ 2 (cognitive load tasks)	-High cognitive load (digit span of number retained) -Low cognitive load	94	Self-reported craving (4-item 9-point Likert-type scale) & Attentional Bias (response latencies)	AB During experiment al period Cravings post-treatment	Participants reported less intense cravings post treatment in the high load compared to the low load condition (SMD=-.41, p=.052). There was a significant interaction group x food type interaction for response latencies F(1,92)=4.68, p=.033, η^2= .05 Under low load participants showed attentional bias towards attractive food stimuli (slower responses towards attractive food than to neutral food pictures M Diff=57msec, SMD=0.24, p=.033). Under high cognitive load, no such attentional bias was found, participants were equally fast in responding to both types of stimuli.	No sample size calculation No randomisation Self-report measures (craving only) Small sample*
2.3.2 Effects of cognitive loading on other outcomes							

Reference	Study design	Comparisons (n)	Sample size	Outcome	Follow-up	Results	Potential Biases
Van Dillen et al. (2013) Study 2	3-arm RCT	-High cognitive load -Moderate cognitive load -Control (no load)	107	Activation of hedonic responses to food stimuli	Post-treatment	Significant effect of cognitive load, F(1, 64) = 64. 53, p < .001, η^2=.506. There was also a significant prime x target x load interaction F(2,104)=3.33, p=.04, η^2= .06. Participants were faster to recognize hedonic target words when they were preceded by attractive food pictures compared to neutral food pictures under no load (M Diff= 37ms, SMD= -.32, p=.008), or moderate load (M Diff= 72ms, SMD=-0.35, p=.001). Under high cognitive load this priming effect of attractive food pictures on the accessibility of hedonic words was eliminated.	No sample size calculation Small sample*

Reference	Study design	Comparisons (n)	Sample size	Outcome	Follow-up	Results	Potential Biases
Van Dillen et al. (2013) Study 3	2-arm non randomised controlled trial with 2 (food type: attractive vs. neutral; within participants) x_ 2 (cognitive load tasks)	-High cognitive load -No cognitive load	46	Observed Snack Choice & Response times on food categorization task.	Post-treatment	High load significantly increased response time compared to controls. (M Diff=308ms, SMD=2.29, p<.002) There was a significant group x food type interaction on response times F(1,45)=10.68, p=.002, η^2=.20. In the absence of cognitive load participants were faster to categorise attractive food items than neutral food items (M Diff= 23ms, SMD=-0.18, p=.003), no such difference in response latencies was found for under high cognitive load. This pattern is particularly seen in participants who are susceptible to food, categorizing attractive food faster than neutral food under no load F(1,45)=28.55, p < .001 , η^2=.405, but not under high cognitive load. (Interaction F(1,45)=6.71, p=.01, η^2=.14. There was no significant difference in snack choice between groups. There was a significant group x PFS interaction for snack choice B=2.68, SE=0.97, Wald(1)=7.63, p=.006. There was no effect of cognitive load on snack choice (healthy vs unhealthy) for participants who are less susceptible to food. Those who score high on the PFS, suggesting more susceptible to food, were more likely to select an unhealthy snack after performing the categorization task without cognitive load, rather than with high cognitive load B = 4.08, SE=1.39, Wald(1)=8.65, p=.003.	No sample size calculation No randomisation Very small sample*
2.5 Implementation Intentions (if-then planning)							

Reference	Study design	Comparisons (n)	Sample size	Outcome	Follow-up	Results	Potential Biases
2.5.1 Effects on food consumption							
Achtziger et al. (2008) Study 1	2-arm RCT	-II to ignore thoughts about food -Control	92	Self-reported specified study food consumption	1-week	Significant group x time interaction effect , treatment ($F(1,90)= 3..86$, $p=0.05$, $\eta^2= .04$). Greater reduction in snack food consumption among implementation intention participants as compared to control participants (estimated SMD= .41, $p< .001$).	Student sample No sample size calculation Self-report measures Small sample*
van Konings-bruggen et al. (2014) Study 1	2x2 factorial experiment	-Only No-go (24) –Only II (20) -II and No-go (23) -Control (22)	87	Ad libitum food-serving behaviour	Post-treatment	No main effects of the go/no-go or II tasks. However, the interaction effect between the two tasks was significant, $F(1, 85) = 4.32$, $p = .041$, $\eta_p^2 = .05$. The go-no go training only decreased food serving in those who received the control implementation intentions $F(1,85)= 8.12$, $p = .005$, $\eta_p^2= .09$. Implementation intentions only decreased food-serving for those receiving the control go/nogo $F(1,85)= 5.06$, $p=.027$, $\eta_p^2= .06$. Post-hoc pairwise comparisons showed that food-serving 279ehaviour in the control group was significantly higher than the other conditions ($p = .031$ to $.005$).	Student Sample Small sample*

Reference	Study design	Comparisons (n)	Sample size	Outcome	Follow-up	Results	Potential Biases
van Konings-bruggen et al. (2014) Study 2	2x2 factorial experiment	-Only No-go (24) -Only II (23) -II and No-go (19) -Control (22)	88	Task performance (button holding) to receive chocolate	Post-treatment	No main effects of the go/no-go or II tasks. However, the interaction effect between the two tasks was significant (F(1, 84) = 5.72, p = .019, η_p^2=.06). The go-nogo task decreased button holding 280ehaviour compared to controls when control implementation intentions were used, as compared to the control condition, but not when diet implementation intentions were used. (Interaction F(1, 84) = 8.20, p = .005, η_p^2=.09). Implementation intention significantly decreased button-holding 280ehaviour vs controls, when control no-go was used (Interaction F(1, 84) = 7.84, p = .006, η_p^2=.09). Pairwise comparisons showed that controls held the button down significantly longer than either the no-go training, implementation intentions, or combined treatment groups (p=.039- to 005).	Student Sample Small sample*

Reference	Study design	Comparisons (n)	Sample size	Outcome	Follow-up	Results	Potential Biases
van Konings-bruggen et al. (2011) Study 2	3-arm RCT with dieting and dietary success as additional between-subject factors	-"Think of dieting" II -Won't eat implementation -Control	236	Self-reported food consumption frequency and amount analysed as a single measure of consumption	2-week	Significant condition x dieting x success interaction, $F(2,224)=4.37$, $p<.05$, partial $\eta^2= .05$. For dieters there was a condition x success interaction $F(2,224)=3.55$, $p<.05$, partial $\eta^2= .05$. Condition only affected consumption for unsuccessful dieters $F(2,224)= 5.60$, $p <.01$, $\eta^2= .05$. Unsuccessful dieters who formed the think-of-dieting implementation intentions consumed less than those in the no treatment control ($B=-.71$, $t=-3.14$, $p<.01$), and the won't eat control ($B=-.64$, $t=-2.64$, $p<.01$). For successful dieters, no differences were found. Consumption did not differ between the 'won't eat' and control conditions.	Student sample No sample size calculation (but relatively large sample) Self-report measures Possible analysis bias (between group comparison not reported, only interactions)

2.2 Effects of if-then planning on other outcomes

Reference	Study design	Comparisons (n)	Sample size	Outcome	Follow-up	Results	Potential Biases
Hofmann et al. (2010) Study 2	4-arm RCT	-Consummatory transformation (110) -Non consummatory (128) -II (128) -Control (140)	506	Automatic evaluations (Implicit Association Task) & Explicit Attitudes (7-point semantic differentials)	Post-treatment	There was a significant main effect of condition on automatic evaluations F(3,476)=13,38, p<.001. All groups differed significantly from each other (p<.05). Automatic evaluations were highest in the consummatory transformation condition which was higher than the control condition (M Diff=.13s, p<.05). Automatic evaluations in both the Non consummatory (M Diff=-.14, p<.05) and Implementation Intentions (M Diff=-.16, p<.01) were lower than the control condition. A significant main effect of condition for explicit attitudes was also found (F(3,476)=3.34, p=.02. Controls (M Diff= .67, SMD= .38) and the non consummatory transformation group (M Diff=.51, SMD=.29) had significantly more positive attitudes towards chocolate, than the Implementation Intentions group.	No sample size calculation (but relatively large sample)

Reference	Study design	Comparisons (n)	Sample size	Outcome	Follow-up	Results	Potential Biases
van Koningsbruggen et al. (2011) Study 1	2-arm RCT with dieting (or not) and dieting success (or not) as additional between-subject factors	-"Think of dieting" II -Control	119	Goal-activation (diet-related word completions)	Post-treatment (after filler questions)	No main effects of condition on goal-activation reported. Significant condition x dieting x success interaction $F(1,111)=4.96$, $p<.05$, partial $\eta^2= .04$. For dieters there was a condition x success interaction $F(1,111)=5.38$, $p<.05$, partial $\eta2=.05$. The unsuccessful dieters who formed the think-of-dieting implementation intentions completed more word fragments as diet-related than those in the no-treatment control condition, $F(1,111)=7.67$, $p< .01$, partial $\eta^2=.07$. No differences between conditions were found for successful dieters or normal eaters.	No sample size calculation Possible analysis bias (between group comparison not reported, only interactions)

2.5.3 Effects of other planning on food choice

Reference	Study design	Comparisons (n)	Sample size	Outcome	Follow-up	Results	Potential Biases
Townsend & Liu (2012) Study 2	3-arm RCT with analysis of sub-groups of perceived weight	-Planning daily food intake -Irrelevant planning -Control	309	Observed unhealthy snack choice vs healthy snack choice (healthy option, or not having any snacks at all	Post-treatment (after filler tasks)	No significant between group differences on unhealthy snack choice were found. There was a significant interaction between planning and weight perception β=.24, Wald=2.76, p <.001. In participants of average perceived weight, planning food intake had a significant positive impact on the likelihood of selecting the unhealthy option (N=138) (no planning= 71%, planning daily intake= 61%, $\chi^2(1)=10.48$, p =.001. For those rating themselves as overweight (N=59) planning increased the likelihood of choosing an unhealthy snack (85% vs 41% in control) $\chi^2(1)=12.22$, p<.001. Amongst those who rated themselves very overweight (N=10), only 20% selected the unhealthy choice in the no-planning control condition, but all (100%) of the participants in the planning daily intake condition did so, $\chi^2(1)=6.67$, p=.01.	Student Sample No sample size calculation

Reference	Study design	Comparisons (n)	Sample size	Outcome	Follow-up	Results	Potential Biases
Townsend & Liu (2012) Study 3	3-arm RCT with additional analysis of body fat sub-groups	-Concrete planning -Abstract planning -Control	161	Observed choice between a decision making task vs a biscuit taste test	Post-treatment (after filler tasks)	No significant effect of concrete planning, or abstract planning, compared to control. There was a significant interaction of concrete planning and calculated body fat percentage (BFP) β=1.61, Wald=8.93, p=.003. For those with a higher BFP (1SD above the mean), concrete planning significantly increased the likelihood of selecting the unhealthy snack taste test(β= 1.85, Wald = 6.56, p =.01). In contrast, for those with a lower BFP (1SD below the mean), concrete planning significantly reduced the unhealthy snack taste test (β= -1.37, Wald=4.51, p=.03). No interaction between BFP and abstract planning was found.	Student sample No sample size calculation Small sample*
Townsend & Liu (2012) Study 5	Mixed factorial design	3 (Positive, negative, no self-weight perception manipulation) x 2 (Planning vs no planning)	378	Observed snack choice (Unhealthy snack choice vs healthy snack choice)	Post-treatment	No main effects of planning or manipulated self-weight perception were found. No significant planning x weight perception interaction (p=.08). However, in sub group analyses, those who were made to feel negative about their weight (N=126), planning increased the propensity to choose the unhealthy option (no planning= 16%; planning =40% $\chi^2(1)$=8.60, p=.003). In contrast, planning decreased the unhealthy choice among those made to feel positive about their weight (no planning= 44%, planning =22%; $\chi^2(1)$=7.05, N=131, p=.01) There was no difference between the planning and no planning conditions among the control participants.	Student sample No sample size calculation

Reference	Study design	Comparisons (n)	Sample size	Outcome	Follow-up	Results	Potential Biases
2.6 Thought suppression							
2.6.1 Effects of food consumption							
Johnston et al. (1999)	2-arm RCT with sub-groups of cravers (vs non-cravers)	-Thought suppression -Control	42	Task performance (apple picker task) to receive chocolate	Post-treatment	Participants in the suppression condition picked significantly more apples (to receive chocolates) than did participants in the control condition ($F(1,38)=4.43$, $p<.05$, SMD=0.67). No differences in effortful behaviour to receive chocolates was found between cravers and non cravers.	No sample size calculation Very small sample*
Erskine et al. (2008)	3-arm non randomised controlled trial. Gender was also analysed as a further between-subjects factor	-Suppression (43) -Expression (44) -Control (47)	134	Number of chocolates consumed (bogus taste test)	Post-treatment	There was a significant intervention effect $F(2,125)=8.49$, $p<.0001$, $\eta^2=.12$, and a group x gender interaction $F(2,125)=9.19$, $p<.001$, $\eta^2=.13$. Both males (M Diff= 2.64, SMD=.92, p=.03) and females (p=.01) ate a larger number of chocolates after suppression than controls with no differences between males and females. After expression, males ate more than females (p=.001).	Student sample No sample size calculation No randomisation Small sample*

Reference	Study design	Comparisons (n)	Sample size	Outcome	Follow-up	Results	Potential Biases
Erskine et al. (2010)	3-arm non randomised controlled trial with eating restraint as an additional between-subjects factor	-Suppression (41) -Expression (39) -Control (36)	116 (127 before exclusion for noncompliance or outliers)	Observed chocolate consumption (Bogus taste test)	Post-treatment	There was a main effect of condition $F(2,110)=4.86$, $p=0.01$, $\eta^2=.08$ and significant interaction of group and dietary restraint ($F(2,110)=3.04$, $p=.05$, $\eta^2=.05$ Restrained eaters in the suppression group consumed significantly more than the expression ($p=.0001$) and control groups ($p=.02$). However, non restrainers did not differ in consumption between the suppression, expression and control groups ($p>.44$ in all cases). Within the suppression group, the restrainers consumed significantly more than the non restrainers ($p=.007$) but there was no difference between restrainers and non restrainers in the control and expression groups.	Student sample No sample size calculation No randomisation Small sample*
2.7 Cognitive Restructuring							
2.7.1 Effects on craving							

Reference	Study design	Comparisons (n)	Sample size	Outcome	Follow-up	Results	Potential Biases
Giuliani et al. (2013)	Non randomised crossover trial	-Look and regulate (thinking about the food in a way that reduces their desire to eat the depicted food). -Look at the food stimuli and imagine consuming it	82	Self-reported food craving/ desirability ratings (1-to-5 Likert scale)	Post-treatment	Main effect of Instruction on self-reported desire to consume the food, reduced desire after restructuring as compared to imagining consumption (M Diff=1.01, SMD= -1.81, $p< .001$. The magnitude of regulation success (percent reduction in self-reported craving) differed between craved and non craved foods ($F(1,81)=81.12$, $p<.001$). Regulation successfully reduced self-reported desire to consume both the craved and not craved foods as compared to the Look cue (Craved M Diff= 1.35, SMD=-1.93, p-<.001; Not craved M Diff=.67, SMD=-1.07, $p<.001$). Overall, percent reduction in self-reported craving was higher for the craved foods than not craved foods (M Diff=.09%, SMD=.49, $p<.001$)	No sample size calculation. No randomisation. Self-report measures

2.7.2 Effects of cognitive restructuring on automatic evaluations

Reference	Study design	Comparisons (n)	Sample size	Outcome	Follow-up	Results	Potential Biases
Hofmann et al. (2010) Study 1	3-arm RCT	-Non consummatory transformation (23) -Consummatory transformation (26) -Control unrelated task (22)	71	Automatic evaluations (IAT) & Explicit attitudes (Two 5-point semantic differentials)	Post-treatment	Automatic evaluations were significantly less positive for those who were instructed to transform the food item in an odd or novel manner as compared to those instructed to think about the consumption of the food item (M Diff= 0.19, SMD= -0.71, p=.013) as well as those in controls (M Diff=.15 SMD=-0.52, p=.046). No difference was found between the consummatory and control group. Similarly, explicit attitudes were significantly lower for the nonconsummatory group as compared to the consummatory group (M Diff= .82, SMD=-1.23, p< .01) and the control condition (M Diff= .63, SMD= -.99, p=.02). No difference was found between the control and consummatory groups.	Student sample No sample size calculation Very small sample*

Reference	Study design	Comparisons (n)	Sample size	Outcome	Follow-up	Results	Potential Biases
Hofmann et al. (2010) Study 2	4-arm RCT	-Consummatory transformation (110) -Non consummatory (128) -II (128) -Control (140)	506	Automatic evaluations (Implicit Association Task) & Explicit Attitudes (7-point semantic differentials)	Post-treatment	There was a significant main effect of condition on automatic evaluations F(3,476)=13,38, p<.001. All groups differed significantly from each other (p<.05). Automatic evaluations were highest in the consummatory transformation condition which was higher than the control condition (M Diff=.13s, p<.05). Automatic evaluations in both the Non consummatory (M Diff=-.14, p<.05) and Implementation Intentions (M Diff=-.16, p<.01) were lower than the control condition. A significant main effect of condition for explicit attitudes was also found (F(3,476)=3.34, p=.02. Controls (M Diff= .67, SMD= .38) and the nonconsummatory transformation group (M Diff=.51, SMD=.29) had significantly more positive attitudes towards chocolate, than the Implementation Intentions group.	No sample size calculation
2.8 Emotional Freedom Technique							
2.8.1 Effects on weight, craving, and susceptibility to food							

Reference	Study design	Comparisons (n)	Sample size	Outcome	Follow-up	Results	Potential Biases
Stapleton et al. (2011)	2-arm RCT	-Emotional Freedom Technique(49) -Wait list control (47)	96	Weight & Self-reported craving (FCI) & Perceived power of food	Post-treatment 6-month	There were no significant differences in weight loss between groups. There were significant group x time interactions for craving $F(1,84)=17.13$, $p<.001$, and PFS $F(1,83)=9.67$, $p=.003$ With greater reductions at post-treatment in craving and (M $\text{Diff}_{\text{change scores}}=11.15$; SMD= 0.90, $p<.001$) and PFS scores (M $\text{Diff}_{\text{change scores}} = 11.24$, SMD=0.68, $p=.003$) in EFT than in control. At 6-month follow-up these reductions were maintained (from baseline for craving $p< .05$ and PFS $p<.001$) but no further reductions. However this 6-month analysis was performed on collapsed data including both the EFT and WL groups.	No sample size calculation 52% lost to 6-month follow-up Small sample* Self-report measures (craving and PFS only) Possible analysis bias (collapsing of groups at 6 months)
2.9 "I don't" Refusal Framing							
2.9.1 Effects on food consumption							

Reference	Study design	Comparisons (n)	Sample size	Outcome	Follow-up	Results	Potential Biases
Patrick and Hagtvedt (2012) Study 1	2-arm Non randomised controlled trial	-I don't -I can't	111	Actual snack choice (healthy vs unhealthy)	Post-treatment	Significant main effect of refusal frame F(1,117)=11.34, p<.01. Participants in the "don't" refusal framing were more likely to choose the healthy snack as compared to "can't" refusal, $\chi^2(1) = 6.59$, p<.05. There was a refusal frame x goal relevance interaction β= -.71, $\chi^2(1) = 5.60$, p<.05. People using "don't" were more likely to choose healthy snacks when goal relevance was high rather than low β=-2.04, $\chi^2(1) = 11.35$, p<.01.	Student sample No sample size calculation No randomisation Small sample*
2.10 Autonomous learning conditions							
2.10.1 Effects on food consumption and subsequent self-control							
Magaraggia et al. (2013)	3-arm RCT	-Autonomous choice learning -Controlled choice learning with food provided -Controlled choice learning without food	60	Observed snack consumption & subsequent self-regulation task ('e'-hunt task).	Post-treatment	Participants in the autonomous choice group consumed significantly fewer jellybeans than those in a controlled-choice-and-food group (M Diff=7.76, SMD=-.68, p=.041). When controlling for food consumption, the autonomous choice group out-performed the controlled-choice-and-food group on the self-control task (F1,38= 5.34, p = .027, partial η^2= .13) with no difference between the two controlled-choice groups.	Student sample No sample size calculation Very small sample*

Abbreviations: RCT = Randomised Controlled Trial. SMD= Standardized Mean Difference. BMI= Body Mass Index (kg/m^2). SD= Standard Deviation. PA= Physical Activity. FCQ-S= Food Craving Questionnaire-State. FCQ-T= Food Craving Questionnaire Trait. PFS= Power of Food Scale. IAB= Initial Attentional Bias. MAB= Maintained Attentional Bias. AFT = Actionable Food Temptation. NAFT = Non Actionable Food Temptation. VAS= Visual Analogue Scale. * A small sample is defined here as less than 64 people per group (the number needed to have an 80% chance of detecting a SMD of 0.5, i.e. a medium effect size, with p<0.05). A very small sample is defined here as less than 30 per group. For factorial designs the smallest factor-group size was used (e.g., in a 2x3 factor design, the total sample size was divided by 3).

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Extracted data of studies evaluating techniques with unclear mechanisms of action

Reference	Study design	Comparisons (n)	Sample Size	Outcome	Follow-up	Results	Potential Biases
3.2 Manipulating Regulatory Fit							
3.2.2 Effects on food consumption							
Hong and Lee (2008) Study 2	3-arm RCT	-Regulatory fit -Regulatory non fit -Control filler task	63	Actual Snack choice (healthy vs unhealthy	Post-treatment	Individuals in the regulatory fit condition were more likely to choose the apple over the chocolate bar (83.3%) as compared to those in the control condition (52.6%; $\chi^2(1)=4.43$, $p<.05$), who were in turn more likely to choose the apple as compared to those in the regulatory unfit condition (20.0%; $\chi^2(1)=4.25$, $p<.05$).	Student sample No sample size calculation No manipulation check Very small sample*
Hong and Lee (2008) Study 3	4-arm RCT	-Feelings-based advertisement evaluation -Reasons-based advertisement evaluation -Choice between feelings and reasons -Control task	182	Actual Snack choice (healthy vs unhealthy)	Post-treatment	Participants who experienced regulatory fit (i.e. promotion-focused participants who wrote a feeling-based review and prevention-focused participants who wrote a reason based review) were more likely to choose the apple (65.2%) over the chocolate bar, relative to those in the control condition (45.5%; $\chi^2(1)= 4.66$, $p <.05$, who in turn were more likely to choose the apple than those in the non fit condition (27.9%; $\chi^2(1)=3.81$, $p = .05$	Student sample No sample size calculation
3.1 Episodic Future Thinking							
3.1.1 Effects on food consumption and delay discounting							

Reference	Study design	Comparisons (n)	Sample Size	Outcome	Follow-up	Results	Potential Biases
Daniel et al. (2013)	2-arm RCT	-Episodic future thinking (14) -Control episodic thinking (12)	26	Observed snack consumption & monetary delay discounting	Post-treatment	Controlling for baseline differences in degree of imagery, episodic future thinking led overweight and obese women tempted with the immediate gratification of unhealthy foods to reduce their calorie intake (M Diff=305, d=1.09, p=.011) and (monetary) delay-discounting as compared to the control condition (F(1,23)=6.57, p=.017, (10 dollars, d=1.44; 100 dollars, d=1.51).	No sample size calculation Baseline differences (controlled for in analyses) Very small sample* Self-report measures (delay discounting only)

Abbreviations: RCT = Randomised Controlled Trial. SMD= Standardized Mean Difference. BMI= Body Mass Index (kg/m^2). SD= Standard Deviation. PA= Physical Activity. FCQ-S= Food Craving Questionnaire-State. FCQ-T= Food Craving Questionnaire Trait. PFS= Power of Food Scale. IAB= Initial Attentional Bias. MAB= Maintained Attentional Bias. AFT = Actionable Food Temptation. NAFT = Non Actionable Food Temptation. VAS= Visual Analogue Scale.

* A small sample is defined here as less than 60 people per group (the number needed to have an 80% chance of detecting a SMD of 0.5, i.e. a medium effect size, with p<0.05). A very small sample is defined here as less than 30 per group. For factorial designs the smallest factor-group size was used (e.g., in a 2x3 factor design, the total sample size was divided by 3).

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Appendix 4 Service user consultation session

Service User Consultation 6 Nov 2014	
18:00 – 18:10	Welcome and registration
18:10 – 18:20	Overview of weight loss maintenance
18:20 – 18:30	Impulse Control
18:30 – 18:50	Helps and hindrances for the targets for change • 4 groups of 3 • Groups A and B work on Objective 1 and 2 • Groups C and D work on Objective 3 and 4 Everyone will be split up in 4 groups and each will be asked to work on two targets for change. They will be presented with the targets for change and will be asked how people might achieve that target. They will also be asked whether they could think of any barriers to achieving that target, and whether there are any strategies that could help the individual overcome that barrier.
18:50 – 19:00	Feedback for first 4 objectives. Going back to the whole group each subgroup will be asked about what they thought of. Groups A+B will be asked first, and C+D will then be asked whether they have anything to add as these were not their objectives. Then C+D will give their feedback on their two objectives and A+B will be asked whether they have anything to add.
19:00 – 19:10	Work on the two main objectives • Group A and D to work on Objective 5 • Group B and C to work on Objective 6

		After the feedback session the groups will be informed that the final two objectives are overlapping the other objectives they had worked on. However, they will be asked if they could think of anything that would affect the final two objectives. That haven't already been covered in the other objectives.
19:10 – 19:15	Feedback	
		The whole group will then feedback on the last two objectives and will be asked to add anything the other groups may not have already mentioned.
19:15 – 19:20	Prioritisation • Use of 3 sticky notes numbered 1, 2 and 3 • On a board have all 6 objectives. • People to vote for their top 3 importance of need to change with their best strategy written on the note.	
		Finally, each person will be given 3 sticky notes and will be asked to note down 1, 2, and 3 on the separate notes. On the board all 6 objectives will be written down and each person will be asked to rate out of those 6 their top 3 most important targets for change (1 being top). On the corresponding sticky note they will be asked to write down what they think was the best strategy to achieve that target for change and stick the 3 sticky notes on the board underneath the correct objective.

Developing an intervention to manage "impulsive eating"

Target for change 1: Resist the urge to select unhealthy food when a choice of foods is on offer.

- When facing a choice of foods, people who wish to manage their weight need to be able to resist the unhealthy options...

For example: If you go somewhere where there is an "all you can eat buffet". OR, if you are walking down the aisle at a supermarket, where the biscuits, chocolate and crisps are.

When we say "unhealthy" we mean food items that are high in fat, sugar, or salt. They often combine fat and sugar(for example, mars bars, chocolate digestives, crisps).

What will help people to achieve this target?

What will stop people achieving this target? What will get in the way?

How could we help people to overcome any barriers and achieve this target?

Target for change 2: Remove temptation. Reduce the amount of unhealthy food that is available.

People who wish to manage their weight need to control what food is available in their immediate environment such as at home, work, or in the car. “If it is not there, it can’t be eaten.”

For example: You might replace unhealthy snacks in the cupboards at home with healthier options. OR you might remove unhealthy snacks from the car.

What will help people to achieve this target?

What will stop people achieving this target? What will get in the way?

How could we help people to overcome any barriers and achieve this target?

Target for change 3: <u>Resist social pressure</u>

People who wish to manage their weight need to resist pressure from other people to eat more or to have unhealthy foods.

People often eat more in social situations

For example: - You may be tempted to eat more when eating out with friends at a birthday meal, having a Sunday roast with the family, or having lunch with someone at work. OR, you might be offered a piece of cake or a plate of biscuits when you go to someone's house. Everyone else is doing it …!

What will help people to achieve this target?

What will stop people achieving this target? What will get in the way?

How could we help people to overcome any barriers and achieve this target?

Target for change 4: Avoid eating to reduce stress or boredom

- Certain moods can trigger overeating. Stress, boredom, and feeling down are the most common influences. Not only do they trigger overeating, but the choice of food at these eating episodes tends to be the unhealthy items. People who want to manage their weight should resist this kind of “comfort eating”.

For example: you are bored at home and you know that there is a packet of digestives in the kitchen cupboard.

When we say “unhealthy” we mean food items that are high in fat, sugar, or salt. They often combine fat and sugar(for example, mars bars, chocolate digestives, crisps).

What will help people to achieve this target?

What will stop people achieving this target? What will get in the way?

How could we help people to overcome any barriers and achieve this target?

Target for change 5: Resist eating unhealthy snacks (unless this is a planned treat as part of an overall healthy eating plan)

- People who wish to manage their weight should try to resist eating unhealthy snacks that are not part of their healthy eating plans. It is ok to snack, but unplanned snacking (outside of planned meal and snack times) can add a lot of unwanted calories.

For example: You are buying some lunch and the shop is offering a "Meal Deal" where you can get a free can of drink and a bag of crisps. OR You are at work and you know there are cakes in the staff kitchen. You suddenly have this urge to eat a piece of cake but feel conflicted as you are trying to manage your weight.

What will help people to achieve this target?

What will stop people achieving this target? What will get in the way?

How could we help people to overcome any barriers and achieve this target?

Target for change 6: Stop eating when full/ stop overeating

- People who wish to manage their weight should be able to reduce their calorie intake by reducing the number of times they overeat at a meal. Overeating involves eating a lot more than a person really needs.

For example: when eating in a restaurant you are given a plate full of food. By the end of it you feel like you are about to explode and know you have eaten way more than you actually needed. What will help you to stop eating before you get to that point?

What will help people to achieve this target?

What will stop people achieving this target? What will get in the way?

How could we help people to overcome any barriers and achieve this target?

Developing an Eating Behaviour Change Intervention: Managing Impulsive Eating

Objective 1: Resist unplanned eating of unhealthy snacks

- People who wish to reduce their calorie intake through snacking less should aim to resist eating anything that wasn't planned. It is ok to snack, but unplanned, sometimes unconscious snacking, occurs and adds unnecessary calories.

What will help people to achieve this target?

What will stop people from achieving this target? What will get in the way?

How could we help people to overcome any barriers and help them achieve this target?

Objective 2: Stop eating when full/ stop overeating

- People who wish to lose weight are able to reduce their calorie intake through stopping eating on time, when they are full, and therefore need to be careful not to overeat. Obviously we all need to eat food, but too make sure the energy balance doesn't tip towards too much energy taken in, it is important to STOP eating when no longer hungry.

What will help people to achieve this target?

What will stop people achieving this target? What will get in the way?

How could we help people to overcome any barriers and achieve this target?

Objective 3: Manage impulsive choices when a range of unhealthy foods are available

- People who wish to lose weight need to be able to resist making unhealthy choices and grabbing large portions of food when faced with large varieties such as at a buffet with lots of different types of food. Again it is all about limiting the calories taken in. When faced with so much choice, how will people be able to resist eating the unhealthy foods and only eating reasonable portion sizes.

What will help people to achieve this target?

What will stop people achieving this target? What will get in the way?

How could we help people to overcome any barriers and achieve this target?

Objective 4: Resists social facilitation of eating

- People eat more when eating in social environments such as eating out with friends at a birthday meal, Sunday roast with the family, lunchtime at work etc. If a person wishes to lose weight they need to say no to offered foods, as well as ensuring they do not overeat at social meals.

What will help people to achieve this target?

What will stop people achieving this target? What will get in the way?

How could we help people to overcome any barriers and achieve this target?

Objective 5: Deal with emotions, stress, and boredom through engaging in alternative actions

- Certain moods initiate eating and trigger overeating. Stress, boredom, anger and anxiety are the most common triggers of overeating. Not only do they trigger overeating, but the choice of food at these eating episodes tends to be the unhealthy highly palatable foods. Eating in such situations is seen to elevate mood due to the positive affect attached to foods. People should resist eating in such situations and engage in alternative actions.

What type of actions would be most beneficial?

What will stop people achieving this target? What will get in their way?

How could we help people to overcome any barriers and help them achieve this target?

Appendix 7 Service user consultation summary report

This is a summary of views expressed in a consultation with service users who have tried to lose weight and maintain their weight loss through various methods. The consultation took place on the 6th of November 2014. It involved 10 people (all had attended the prior meeting at the start of the larger weight loss maintenance project SKIM).

After a brief overview of the development of SKIM so far, the individuals were introduced to the smaller intervention delivered through a smartphone app, that aims to help people manage their impulses towards food. Everyone understood the concept of impulsive processes in eating behaviour, as a sudden strong motivation, drive, or temptation to eat as well as the unconscious habitual patterns of eating. There seemed to be a general agreement that help with managing such processes is needed.

In 4 groups of twos and threes, everyone worked on the following performance objectives, trying to come up with what would help people achieve these targets, what factors would get in their way, and how to overcome those barriers.

A. Performance objectives
   - Resist the urge to select unhealthy foods when a choice of foods is available
   - Remove temptation, reduce amount of unhealthy food that is available
   - Resist social pressure
   - Avoid eating to reduce stress or boredom
   - Resist eating unhealthy snacks
   - Stop eating when full, stop overeating

B. Determinants and strategies

   1. Resist the urge to select unhealthy food when a choice of foods is on offer.

Determinants

Personal

- Hunger levels
- Understanding calories and fat content
- Confidence in asking for healthy/ fat free options when eating from a buffet, in restaurants, or ordering food or drinks in the presence of family and/or friends.
- Lack of motivation
- Cognitive capacity
- Relying on habit
- Perceived subjective norms /peer pressure: people don't agree with or question why you are choosing healthy options.
- Internal, justification dialogue; "you are worth it" (Attitudes to healthy/ unhealthy foods)
- Lack of self-control

Environmental

- Aggressive food marketing

- Availability of unhealthy/healthy food cues/items in the environment

Strategies

- Opt for the healthy options, or try to minimize the opportunity to choose from many items.
- Don't shop when hungry
- Use incentives/rewards to boost motivation
- Pause and pay attention when making food choices, bring the decision under conscious control
- Avoid shopping impulses by using online shopping (this incorporates the future episodic thinking, we make healthier choices when making choices for the future, immediate gratification is not an option)
- Plan what you are going to buy and stick to a shopping list (this somewhat takes away the in the moment decision making process).
- Increase confidence to stick to your intentions
- Restructure a reward association from unhealthy foods to 'deserving' the healthy food, not the unhealthy one (cognitive restructuring)

2. Remove temptation, reduce amount of unhealthy food that is available

Determinants

Personal

- Motivation (Perceived importance and confidence)
- Attitudes to healthy/unhealthy foods
- Cooking skills and knowledge of healthy vs unhealthy meals and ways of cooking
- Perceived time pressures
- Habit ("sometimes it just ends up in your shopping basket")

Social

- Social pressures, other members of the household want certain foods.

Environmental

- Other members of household want certain foods; social pressures
- Context-specific associations (eg. Celebratory occasions are associated with unhealthy foods)

Strategies

- Using a shopping list/ planning, only buy what is needed
- Alternative ways of cooking (ie. steaming)
- Asking others for ideas, getting motivation from others
- Restructuring healthy eating as a treat, a 'special cupboard of healthy treats' (cognitive restructuring)
- Help with planning eating schedules; Provide meal suggestions /recipes
- Increase self-control

3. Resist social pressure to eat unhealthily

Determinants

Personal

- Confidence to resist peer pressure
- Motivation/ Remembering your goals
- Self-esteem
- Avoidance tendencies/ Denial (" Ignorance is bliss", avoid thinking about the consequences)
- Habits
- Awareness of calories in food

Social

- Social support: Understanding from the people around you to not add temptation pressures

Strategies

- Reminding yourself of what you used to look like to remember your motivation; why you are sticking to your goals
- Mobilising social support
- Increase motivation
- Classical conditioning ("App needs an added (electric) zapper, or embarrassing noise to ward you off temptation; public commitment")
- Check food labelling to understand the calorie content
- Control and plan treats as part of a healthy eating schedule, to stave off wanting
- Pre-plan social occasions, by checking the menu beforehand and deciding on a meal before going to the restaurant; take control of the food served by hosting a diner party; incorporate non-eating activities in the social occasions
- Build self-esteem

4. <u>Avoid eating to reduce stress or boredom, or low mood</u>

Determinants

Personal

- Severity of low-mood, or stress
- Lack of self-control
- Perceived importance (feeling it is pointless to eat healthily)
- Perceived enjoyment
- Attitudes to healthy vs unhealthy foods

Environmental

- Food cue availability (around the house, watching food programmes)
- Lack of other activities

Strategies

- Exercise, or find alternative activities to keep busy
- Find diversion
- Medication for depression
- Talking therapy

- Removing unhealthy food items from the home environment, and swapping them with enjoyable healthy options; Swap unhealthy for healthy snacking

5. <u>Resist eating unhealthy snacks</u>

Determinants

Personal

- Attitude to hunger/ cravings (Hunger and cravings are not bad thing, people are eating to 'PREVENT' feeling hungry not in response to appetitive signals 'Oh I will just have this mars bar to tide me over until dinner'). This stops people from listening to their appetitive signals as they are eating to prevent their body from signalling hunger.
- Awareness and understanding of why unhealthy snacks are so desirable (marketing, ingredient combinations etc); Snack education ().
- Being more aware of one's bodily signals and eating in response to those.
- Boredom
- Emotions
- Attitudes towards unhealthy snacks (ie unhealthy snacks are considered a treat)
- Awareness/knowledge of healthy snacks
- Perceived subjective norm and habit (Cultural norms of tea breaks, coffee breaks with biscuits)

Environmental

- Availability of healthy/unhealthy foods

Strategies

- Restructure your way of thinking about 'snacks' and 'treats'
- Provide Healthy snack ideas/options.
- Build confidence to break habits

6. <u>Stop eating when full, stop overeating</u>

Determinants

Personal

- Self-control
- Perceived social norm
- Perceived cost
- Enjoyment of indulging
- Confidence (fear of being questioned why you are leaving food)
- Habit (ie. to finish whatever is on the plate, to order a desert at the restaurant)

Social

- Social pressures

Environmental

- Food cues (food on the plate, table, portion size)

Strategies

- Smaller portion sizes (using smaller cutlery, plates), removing a portion of food from original plate onto a side plate to leave it.
- Order a starter as a main
- Ordering something that is not your first choice
- Take time and care when choosing a restaurant
- Accept consequences of actions to indulge and move on again.
- Restructuring the way we see our actions, ‘leaving food is not considered the right thing to do in other’s people’s eyes’ for becoming a role model and showing others’ that ‘it is ok to leave food on plate when full.

C. Prioritisation of Performance Objectives

At the end of the session everyone was asked to as an individual, rate their top 3 most important (and perceived) achievable performance objectives and ranking them to indicate which was most important and achievab;e (1st), followed by the second and third most important. We were interested in the performance objectives that were considered most important to achieve. To aid prioritisation, ranks were given a number a points: Three points for 1st, two points for 2nd, and one point for third. With their selected top three, attendees were also asked whether they could suggest their best strategy of achieving those targets.

This rating session showed that 1) resisting the urge to choosing unhealthy foods when a choice of foods is available, 2) removing (unhealthy) temptation availability (where possible), and 3) stop eating when full were the most important changes that need to be considered. With the most popular strategies to achieving these targets being 1) being aware of the nutritional value and being mindful in your choice, 2) don’t buy the stuff and incorporating a ‘treat’ cupboard with healthy enjoyable snacks 3) smaller portion sizes/ portion control, respectively. Interestingly, although social influences came up a number of times as barriers to achieving some of the objectives, only one person voted for the importance, as third choice, of achieving the target of resisting social pressure.

Rank	Resist choosing unhealthy	Remove temptation availability	Social influence	Avoid boredom /stress eating	Resist eating unhealthy snacks	Reduce overeating
1st	5	2	-	-	-	3
2nd	1	4	-	2	1	2
3rd	1	-	1	3	2	3
Points	**20**	**14**	**1**	**7**	**4**	**16**

Appendix 8 Expert consultation summary report

This is a summary of views expressed in a consultation with people with experience in behaviour change and intervention development and assessment. The consultation took place on the 29th of September 2014. It involved 10 people (all had attended the PAtH workshop). The group included interventionists experienced in development of weight management interventions, health psychologists, and behaviour change PhD students.

A. What would the app need to help people with in order to facilitate impulse management

- Stop overeating
- Unplanned High fat/sugar/salt snacking
- Resist social facilitation
- Reduce unhealthy food choices when a range of foods are available
- Deal with emotions, stress and boredom, through engaging in alternative actions

B. Facilitators and barriers in impulse management

1. Overeating

Facilitators

- People need to eat more slowly - pay attention to appetite. It is important to sit down when eating, to be more aware of eating as an activity in itself./ eat mindfully.
- Drink more water, often dehydration is mistaken for hunger.
- Goal setting, recognise risks,
- Understand what a normal portion size should be
- Wait before taking seconds,
- self-monitoring.
- Avoiding buffets
- Social support
- Use smaller portion sizes – smaller plates

Barriers

- Promotions and multi-pack buying
- Pre-portioned meal sizes – ie. restaurants, take away
- Habits – ie. Finishing off the children's meals, cleaning the plate
- Stress
- Time
- Additives/ MSG

2. Unplanned unhealthy snacking

Facilitators

- Making aware of calorific cost/ what is needed to burn it off.
- Keeping healthy snack alternatives available at home/work and preparation help to resist unplanned eating.
- Smaller snack portions.
- Planned meals to avoid hunger
- Not buying unhealthy snacks/ removing access to unhealthy snacks
- Avoid high risk situations, make eating a conscious activity (mindfulness).

Barriers

- Lack of motivation
- Social situations
- Comfort
- Emotional triggers
- Craving & hunger
- Habit reward-seeking
- Obesogenic environment cues everywhere
- Modern living-easy access to low-cost unhealthy snacks
- Marketing: buy one get one free.

Overcoming barriers

- Government restrictions/marketing rules
- Implementation intentions
- Increasing people's awareness
- Increase self-confidence/assertiveness
- teaching coping strategies
- Acknowledging triggers
- Accountability
- Social support
- Removal of cues

3. Reduce unhealthy food choices when a range of foods are available

Facilitators

- Delay unhealthy eating. Eat the healthy food first.
- Incorporate a good balance or ratio of healthy and unhealthy foods on your plate.
- Being regularly active helps manage such impulses.
- Imagine the fat in the foods (reappraisal/ cognitive restructuring).
- When eating out, don't carry as much money, so it can't be bought.
- When eating out, plan where you are going? Is it a healthy restaurant? Or plan your meal choice in advance if you know where you are going and online menu's are available.
- Positive self-talk when feeling tempted.
- Could increase self-efficacy through role-play simulation.

Barriers

- Lack of will power
- Cost
- Convenience
- Overiding cues everywhere
- Busy, unconscious decisions, habit, reflex.

4. Resist social facilitation

Facilitators

- Avoid situations where social eating often takes place.
- People need to refuse any offered foods.
- Instead of having food at gatherings, have Physical Activity.
- Eat beforehand to reduce hunger.

Barriers

- Personality/ social desirability
- Cultural influences
- Social norms
- Lack of long term goals.
- If eating in social situations is unavoidable, consider healthy options and really take your time to look at those healthy options.
- Take notice of what you are eating and record it for self-monitoring.
- Be mindful. Plan, or bring own meals.

5. Reduce emotion, stress, boredom triggered eating episodes

Facilitators

- Engage in physical activity or relaxation to enhance mood, and reduce the need for other comfort eating.
- Introduce stress management.
- Talk to friends and identify other enjoyable activities that could be used as alternatives.
- Alternative actions need to be enjoyable and sustainable, as well as easy to initiate.
- Attentive thinking, being mindful of one's feeling and situations can help deal with them accordingly. Using a thought diary, can help raise awareness of your internal state.
- Reduce boredom by mixing up your routine every once in a while and planning out activities for time management.
- This also helps protect against bad habitual behaviour, as you are no longer on auto-pilot.
- You could plan out activities, to avoid boredom.

Barriers

- Habit,
- Not enjoying the alternative action.
- Ongoing stress.
- Feeling isolated.

Overcoming barriers

- Social support can really help in these situations, to help find ways of dealing with these issues.
- Monitoring of our feelings and eating behaviour can help identify our reasons for eating, which in turn helps identify strategies to use.
- In case of eating in these situations, try choosing healthy options.

Appendix 9 Needs assessment synthesis table

Targets for Change	**Potential service users (Interviews and Consultation)**	**Experts and Health professionals**	**Evidence-based practice guidance**	**Research and theoretical literature**
1. Unhealthy snack consumption including fast food. High energy food items (high in sugar/salt/fat)	-Used to sneak out of the house and secretly buy pasties, snickers, and sugary drinks and finish it all before going home and then having dinner with the family. But to lose weight I really have to stop doing that. -When out shopping really need to be careful with what is being put in shopping trolley, the meal plans really helped with as it kind of creates a shopping list to stick to. [van Beurden et al., 2017] Managing hunger levels so there is no added urge to having the unhealthy foods (don't shop when hungry). -need confidence to ask for the healthy option and change the perception that it is frowned upon to eat healthily to it being a positive message.	First need to recognise impulses when they occur and "put up a mental STOP sign". Then can use of Self-talk, Distraction techniques, Substitution, and Prevention of cravings. An accumulation of multiple small changes in calorie intake can have the desired effect of clinical weight loss. [CG, Health Psychologist] High fat/sugar/salt foods are highly palatable and therefore are considered rewarding. Eating such foods makes you want to eat them more and more often. [David Kessler, the end of overeating] Eating between mealtimes is where excess calories sneak in without always realising it and therefore get in the way of weight loss goals. [SS, General Practitioner]	- Eat as little as possible of: fried foods, drinks, and confectionery high in added sugars, other food and drinks high in fat and sugar such as some take-away and fast foods. -eat breakfast [NICE Guidelines CG43] Unduly restrictive and nutritionally unbalanced diets should not be used, because they are ineffective in the long term and can be harmful. The main requirement of a dietary approach to weight loss is that total energy intake should be less than energy expenditure. [NICE Guidelines CG 189] Intervention needs to motivate and support people to recognise how their social contexts and relationships	In people with an ad libitum diet, intake of free sugars, or sugar sweetened drinks is a determinant of body weight. [Morenga et al. (2013)] *Literature review* High energy density of many fast foods challenge human appetite control systems with conditions for which they were never designed. Among regular consumers they are likely to result in accidental consumption of excess energy and hence to promote weight gain and obesity. [Prentice & Jebb (2003)] Overweight people are more sensitive to external food cues than not-overweight people [Tetley et al. (2009)] Experimental findings on increasing self-control through the use of go/no-go task shows that the task may be a useful tool in inhibiting people's responses to palatable food cues.

Targets for Change	Potential service users (Interviews and Consultation)	Experts and Health professionals	Evidence-based practice guidance	Research and theoretical literature
	-Implement rewards and motivation boosts -Really stop and pay attention when making food choices, let the of understanding calorie and fat contents deter away from the temptation. -The internal justification dialogue can get in the way, as people try to justify that it is ok to have the unhealthy food as they 'deserve' it. Need to change the perception that unhealthy snacks are something to be deserved, to a more realistic view of them being damaging to your healthy and you deserving better than that. - Need more regulation of food-retailers and food-marketing - avoid shopping impulses by buying online, or sticking to a shopping list, this will also eliminate the tempting food availability in the house. [Service User consultation]	HP's consider environmental factors such as the availability of high calorific foods as considerable barriers to weight loss. [Greener et al. 2010] Adults make about 200 decisions about food each day but only a small proportion of these are under conscious control (14 on average). This means that interventions that encouragng change on a conscious level will be limited by the fact that so many of these choices are made on an unconscious level. [BNF- Behaviour Change conference] Keeping healthy snack alternatives available at home/work and preparation help to resist unplanned eating. Smaller snack portions. Planned meals to avoid hunger, not buying unhealthy snacks/ removing access to unhealthy snacks, avoid high risk situations, make eating a conscious activity (mindfulness). **Barriers:** -lack of motivation	may affect their behaviour, and identify and plan for situations that might undermine the changes they are trying to make -Make a personal commitment to adopt health-enhancing behaviours by setting (and recording) goals to undertake clearly defined behaviours, in particular contexts, over a specified time. -understand the short, medium, and long-term consequences of their health-related behaviours for themselves and others. [NICE 2014 Behaviour Change] Despite sophisticated mechanisms that exist to control energy intake, people often still eat when they feel full or refrain from eating when hungry. There are many other factors that influence eating behaviour as	[Veling et al. 2011] Engaging in tasks that compete for the same resources that are thought to underlie cravings reduces the urge to eat highly palatable foods. Elaborated Intrusion Theory. [ie. May et al. 2012] Impulsivity strongest predictor of weight gain and obesity [(Sutin, Ferrucci, Zonderman, & Terracciano, 2011)] Sensitization to food cues in the environment and their dysregulation in obese individuals may play a role in the development and/or maintenance of obesity. Evidence for altered reward system function. This attentional bias to food cues in the environment (regardless whether in a state of hunger or satiety) in obese participants was associated with their high scores on scales measuring susceptibility to disruptions in eating control as well as higher scores on the DEBQ which measures overeating including external eating.

Targets for Change	Potential service users (Interviews and Consultation)	Experts and Health professionals	Evidence-based practice guidance	Research and theoretical literature
	-Using a shopping list, or planning meals, and bringing food to work instead of buying food at work, will take away further food decisions. -Incorporate alternative ways of cooking (ie. steaming) -Restructure the way we think about healthy food, need to start considering it as a treat. Have a special cupboard in the house with 'healthy treats'. Cost of such food items might be a barrier. -Need a willingness to devote time to try and experiment with novel healthy options. -Lifestyle, habitual behaviour, and time pressures get in the way. -Other members of household may not be as helpful due to their food preferences. But need to start seeing oneself as promoting healthy diet,	-social situations -disorganised, no planning, time, stress -comfort -emotional triggers -craving & hunger -brain wiring (reward/habit) -obesogenic environment cues everywhere! -Modern living-easy access to low-cost unhealthy snacks -Marketing: buy one get one free. Strategies for barriers: -Government restrictions/marketing rules -Implementation intentions -Increasing people's awareness -Increase self-confidence/assertiveness -teaching coping strategies -acknowledging triggers -accountability -social support -removal of cues [Expert Consultation] Buffets need to be avoided as they trigger unhealthy impulses, where lots of various foods available, delay unhealthy eating. Eat the healthy	well as the body's satiety signals, such as portion size, the variety of food and drinks available, emotional states and the social situation around an eating occasion. [British Nutrition Foundation]	[(Castellanos et al., 2009)] Ego-depletion: using self-control resembles a muscle that may become tired over time. When depleted through a self-control task (thus self-regulation resources are low) human behaviour is determined by automatic attitudes that trigger a impulsive action tendency to approach or avoid a particular stimulus. In this sense, when depleted dietary restraint standards are undermined and eating behaviour is influenced by automatic attitudes towards the highly palatable foods available (even when highly motivated to restrain consumption). [(Hofmann, Rauch, & Gawronski, 2007b)] There appear to be at least three separable factors that underlie impulse control: attentional, inhibitory, and affect-regulatory mechanisms, respectively. Modifications in these areas can result in better control. [(Hofmann, Friese, & Roefs, 2009)]

Targets for Change	Potential service users (Interviews and Consultation)	Experts and Health professionals	Evidence-based practice guidance	Research and theoretical literature
	rather than being the odd one out. -Celebratory occasions are associated with unhealthy foods. -Slimming groups help with motivation [Service user consultation] *Social pressures* Need to be confident and motivated to stick to one's goals to resist social pressures. It is also important to actually remember one's goals in such situations. Reminding yourself of what you used to look like, and why it is you are trying to resist these pressures may give you that extra motivation. High self-esteem would facilitate this. -Need people to be supportive and understand what you are trying to do, and to therefore not add to the temptation.	food first. Make sure to have a good balance of ratio of healthy and unhealthy foods on your plate. Being regularly active helps manage such impulses. Imagine the fat in the foods (reappraisal/ cognitive restructuring). When eating out, don't carry as much money, so it can't be bought. When eating out, plan where you are going? Is it a healthy restaurant? Or plan your meal choice in advance if you know where you are going and online menus are available. Positive self-talk when feeling tempted. Could increase self-efficacy through role-play simulation. Stress management. **Barriers**: Lack of will power Cost Convenience Overriding cues everywhere Busy, unconscious decisions, habit, reflex. [Expert Consultation]		*Dual-systems accounts (e.g., hot-cold Metcalfe & Mischel, 1999; Strack & Deutsch, 2004)* In addition to deliberative intentional determinants (e.g., motivation) behaviour is influenced by unconscious, swift-acting, automatic, impulsive processes. Situational cues trigger the activation of neuronal clusters which link the cue with behavioural schemata such as consuming a tempting food (impulsive process). However, long term goals such as weight loss, may also activate conflicting schemata such as refraining from eating the tempting but fattening food (reflective process). Which behavioural schema results in overt behaviour depends on the strength of activation of the behavioural schemata. Moreover, situational factors such as the availability of the resources (which may be affected by ego-depletion, cognitive load, and alcohol intoxication) required for the reflective system to be able to process, influence the tug-of-war between the reflective and impulsive system. [Hofmann et al., 2008]

Targets for Change	Potential service users (Interviews and Consultation)	Experts and Health professionals	Evidence-based practice guidance	Research and theoretical literature
	-Bad habits again get in the way, often it is easier just not to think of the consequences. -Lack of diet-congruent options in social situations -Non-supportive social structure would wear down any resistance. -People could pre-plan their social eating occasions, taking care in investigating what restaurant to go to, or even host dinner parties so they have more control over the food available. [Service User Consultation]			Obesogenic Environment (Swinburn, Egger, and Razza (1999, p.564) *"the sum of influences that the surroundings, opportunities or conditions of life have on promoting obesity in individuals and populations".* Consists of one's microenvironment settings (workplace, transport, homes etc). that are dependent on the macroenvironmental sectors (industrial production, technology, social norms, policy context etc.) which directly influence the food eaten (or ways of living) in the microenvironments. These environments can enable or reinforce ways of living that promote (OR INHIBIT) the consumption of high calorific foods. [Swinburn et al. (1999)]
2. Overeating in a single sitting	-Portion sizes have gotten too big, these can be reduced by using smaller plates and smaller cutlery at home, but it can also be done in restaurant. Separate a	Telling patients that portion sizes have grown due to our bigger plate sizes really seems to work. At first they are shocked at how we all seem to be unaware of this, but then realize this is true and they do make	Watch the portion size of meals and snacks, and how often you are eating. [NICE Guidelines CG43 Obesity]	*Symposium.* Larger portion sizes (particularly of energy dense foods) can lead to excess energy intake. [Ledikwe et al. (2005)]

Targets for Change	Potential service users (Interviews and Consultation)	Experts and Health professionals	Evidence-based practice guidance	Research and theoretical literature
	portion of food you are not going to be eating and put it on a side plate. -perceived social norms also get in the way due to concerns about what family, friends, relatives thinks about food being left. Need to see ourselves as role-models and show others' it is perfectly acceptable to leave food. This will ultimately make it easier, for other's who are trying to eat more healthily to do the same. [Service User Consultation] *Interviews* People feel they know what food items are healthy and which aren't, but eat too much -Counting calories is a barrier as it takes too much time/effort to do accurately, and people end up turning back to normal behaviours /habits.	that swap to smaller portion sizes by either buying new smaller plates or not filling their plate up entirely when plating up. It isn't just eating of unhealthy foods that is the problem. It is the amount people eat. People are unaware of how much they eat. If you start off with a third of your usual portion, then once you're finished really think: "Am I still hungry", if you are go up and have a little bit more, and if not. Then that is your body telling you that you have had enough [SS, General Practitioner] People need to eat more slowly, use smaller portion sizes by using smaller plates. Drink more water, often dehydration is mistaken for hunger. It is important to sit down when eating, to be more aware of eating as an activity in itself/ eat mindfully. Goal setting, recognise risks, Understand what a normal portion size should be. Wait before taking seconds, self-monitoring. Barriers:	External eating: eating in response to food cues regardless of internal states of hunger and satiety. The variety of foods we are offered has an effect on how much we eat. We tend to eat more when presented with a wide variety of foods. Maybe resisting the dessert menu could make all the difference! [British Nutrition Foundation] How much sleep we get may also affect our satiety mechanisms. Lack of sleep is linked to an increased risk of obesity and some initial research suggests that a lack of sleep may affect our appetite, making us more inclined to overeat. So getting a good night's sleep may also be important in helping us to control our weigh. -Distractions, such as watching television, tend to make us less responsive to	*Experimental* **Soup study**, we eat because there is food in front of us. This shows the importance of portion sizes as we aren't really aware of our appetite and satiety. The findings are consistent with the notion that the amount of food on a plate or bowl increases intake because it influences consumption norms and expectations and it lessens one's reliance on self-monitoring. It seems that people use their eyes to count calories and not their stomachs. [Wansink et al. (2005)] *Qualitative investigation* Barriers to healthy portion size control bypass reflective and deliberative control. (1) lack of clarity about what constitutes an appropriate portion size, (2) guiltless eating, (3) lack of self-control over food cues, (4) distracted eating, (5) social pressures, (6) emotional eating rewards, and (7) quantification of habits ingrained from childhood. [Spence et al (2013)]

Targets for Change	Potential service users (Interviews and Consultation)	Experts and Health professionals	Evidence-based practice guidance	Research and theoretical literature
	-Patients really liked the idea of changing plate sizes so it wouldn't fit as much food, (easier than counting calories) –Norms learned through childhood not to waste food and stay at the table until plate was clean. -**Facilitato**r: those who stuck with measuring foods for a while, realised that what they ate was habitual, usually same breakfast, similar lunches, and dinners on weekly basis. Thus, once used to what a healthy portion size looks like they used that visual cue to keep going, rather than weighing and measuring all the ingredients all over again. [van Beurden et al. 2017; not reported] *Social pressures* Need to be confident and motivated to stick to one's goals to resist social	-Promotions and multi-pack buying -portion sizes -Finishing off the children's meals -huge portion sizes, takeaways -Restaurants -stress -time -additives/MSG Social support may help overcome these barriers. No buffets! Encouraging avoidance of MSG. [Expert Consultation]	our body's satiety signals and this can mean that we are more likely to eat more. Watching television has been linked to an increased risk of obesity (although this is complicated by the fact that TV viewing is a sedentary behaviour in itself). Nevertheless, avoiding distractions such as television while eating may help us to respond better to satiety signals and avoid overeating. -Feed Yourself Fuller to keep from overeating. 1) high protein, 2) low energy density 3) refrain from drinking alcohol, 4) high fibre, 5) low fat. [British Nutrition Foundation] Intervention needs to motivate and support people to recognise how their social contexts and relationships may affect their behaviour, and identify and plan for situations that might	Despite reportedly self-restricting portion size in the company of certain people (e.g. friends), most participants admitted that they also regularly consumed larger portion sizes in order to impress or ingratiate themselves to hosts/fellow diners. Overall, participants collectively agreed that there was a uniform requirement to be a "good guest" when visiting someone's home. This often involved consuming unappealing food (principally due to taste) to beyond the point of fullness; in order to be polite and not offend the host. In some instances, males in particular viewed eating as a "test of manhood", and, described these instances where they were teased by their male peers because of their reluctance to consume more Females also reported increasing their habitual portion sizes in the company of male diners to avoid appearing "mean about food" or feeling "like a spoil sport". For instance, one participant reported that she did not want to give the impression that she was "constantly counting calories".

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	pressures. It is also important to actually remember one's goals in such situations. Reminding yourself of what you used to look like, and why it is you are trying to resist these pressures may give you that extra motivation. High self-esteem would facilitate this. -Need people to be supportive and understand what you are trying to do, and to therefore not add to the temptation. -Bad habits again get in the way, often it is easier just not to think of the consequences. -Lack of diet-congruent options in social situations -Non-supportive social structure would wear down any resistance. -People could pre-plan their social eating occasions, taking care in investigating what restaurant to go to, or even host dinner parties so they		undermine the changes they are trying to make -Make a personal commitment to adopt health-enhancing behaviours by setting (and recording) goals to undertake clearly defined behaviours, in particular contexts, over a specified time. -understand the short, medium, and long-term consequences of their health-related behaviours for themselves and others. [NICE 2014 Behaviour Change] Portion size can have a strong influence on how much we eat. Most people tend to consume more when offered larger portions of food, without necessarily feeling any more satisfied. So a good tip for controlling how much you eat is to keep portion sizes moderate. When offered a range of snacks and	[(Spence et al., 2013)] *Qualitative investigation* Participants identified portion control as a key strategy to weight loss success. Many used plate size and visualizations of a 'palm-sized serving' as methods to simply determine healthy portion sizes. Straight forward strategies such as reducing plate size were not only effective for portion control and time management, but also gave participants control over dietary intake. [Gallagher et al. (2012)] Our current food environment offers a large variety of cheap and easily available highly palatable, sweet and fatty foods. Impulsive people are generally less successful at inhibiting prepotent responses and they are reward sensitive. Reward sensitivity could be a causal mechanism for overeating in an obesogenic environment whereas impulsivity may be a maintaining factor of the problem of overeating. When presented with a large variety of foods, school children

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	have more control over the food available. [Service User Consultation]		nibbles at a party, just serve yourself a sensible portion on a side plate, rather than constantly reaching for the large bowl. [British Nutrition Foundation]	that were reward-sensitive ate a lot more of the foods than the less reward-sensitive children. [(Guerrieri et al., 2007b)] *Narrative review* The presence of others affects how much people eat throuch (a) social facilitation which increases intake, (b) modelling, which can increase but also reduce the amount normally eaten depending on how much the other person is known to eat, (c) impression management, reduces intake when individuals feel judged or observed. [Herman et al., 2003] *Meta-analysis* Modelling has a large effect on people's food intake where people eat more than normal if the social model eats more and less than normal, if the social model eats less. Modelling has a greater inhibitory effect than augmenting effect. [Vartanian et al., 2015] However, the extent to which people inhibit or match their food intake to

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				others depends on the characteristics of the other person. If the other person is a stranger/ or a desirable partner, food intake tends to be inhibited as limited intake is considered more positive (self-presentational statement). Social facilitation of eating may be stronger among friends and relatives than among strangers and stronger among men than among women. De Castro's work on the influence of others on eating behaviour has shown that when other people are present (and are eating as well) during our meals, we eat a lot faster and our energy intake is a lot higher even though we consider our satiety levels to be lower. The larger the group of people, the larger the meal. [de Castro & de Castro, 1989; de Castro, 1990; de Castro & Brewer, 1992] *[For a more recent overview of social facilitation literature see Herman, 2015]* External eating (eating triggered by food cues) often leads to overeating, attentional bias and impulsivity

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				towards food cues therefore underlie our reactivity to such cues. [(Hou et al., 2011)]
3. Sugary/fizzy drink consumption	-Used to sneak out of the house and secretly buy pasties, snickers, and sugary drinks and finish it all before going home and then having dinner with the family. But to lose weight I really have to stop doing that. -When out shopping really need to be careful with what is being put in shopping trolley, the meal plans really helped with that as it kind of creates a shopping list to stick to. -If it is not in the cupboards it can't be eaten. [van Beurden et al., 2017; not reported]	Although people are more aware now of healthy vs unhealthy food or which foods have a higher calorie content. The problem is the hidden calories, in particular hidden sugars. "Hidden" sugars are in sauces, fizzy/soft drinks or juices, ready meals, etc. It's these types of added sugars that people are not aware of and therefore tend to overlook when considering their daily intake. For an overall healthy diet, it is important that people are aware of these hidden sugars and that they reduce the amount of these they consume. [RK, dietician and advanced public health practitioner]	An increased risk of obesity due to high intake of sugar-sweetened soft drinks and fruit juice is probably. Strategies to help people achieve and maintain a healthy weight include consuming as little as possible of drinks high in fat and sugar. [NICE guidelines CG43]	In people with an ad libitum diet, intake of free sugars, or sugar sweetened drinks is a determinant of body weight. [Morenga et al. (2013)] *Systematic review* The weight of epidemiologic and experimental evidence indicates that a greater consumption of sugar-sweetened beverages is associated with weight gain and obesity. [Malik et al. 2006] *Meta-analysis* Associations of sugary drink consumption with energy intake and body weight. [Vartanian et al. 2007] *Meta-analysis* Prospective cohort studies and RCTs provide evidence that sugary drink consumption

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				promotes weight gain in both children and adults. [Malik et al 2013]
4. Alcoholic drink consumption		Alcoholic drinks contain a lot of calories that are often forgotten about. On top of that, they affect our functioning as well. Inhibitory control may be reduced, which could lead to consuming more food-related calories. [CA, health psychologist]	Alcohol (7kcal/g) accounts for nearly 10% of the calorie intake amongst adults who drink. Daily energy intake may rise considerably when alcohol is consumed. Many people are unaware how many calories are consumed in the form of alcoholic drinks and they often fail to take these into account in their assessment of daily calorie consumption. Alcohol consumption can also lead to an increase in food intake. [Public Health England (2012)] Strategies to help people achieve and maintain a healthy weight include, for adults, minimising the	Energy consumed in the form of alcoholic drinks is additive to that from other dietary sources. Which leads to (short-term) passive over-consumption of energy when alcohol is consumed. In addition, alcohol consumption increases food intake, potentially through enhancing the short-term rewarding effects of food. [Yeomans (2010)]

Targets for Change	Potential service users (Interviews and Consultation)	Experts and Health professionals	Evidence-based practice guidance	Research and theoretical literature
			calories taken in from alcohol. [NICE Guidelines CG43]	
5. Programme engagement	-Needs to be appealing, novel, often updated to maintain interest, and be perceived as relevant to the person. It may also need to require the ability of personal tailoring, and should not require too much effort to navigate and use. -continued use requires ongoing motivation to change and to use the intervention. -Should offer choice, but not be overwhelming. -May take a while to get used to the workings of the intervention, although	-It is to be expected that effectiveness of an internet-based programme relies on people actually engaging with it. -Increase engagement through reminders, gamification, and appealing design. Really need to capture the user's interest and maintain that interest, potentially through personal tailoring. [UBHave, digital health conference]. To make sure the users engage with the app, some form of motivation to use the app needs to exist, it should also be as easy to use, enjoyable, and self-explanatory so people understand		*Systematic review of reviews* One of the most substantial problems in internet-based interventions is the low use of the interventions, which is seen across all behaviour domains (e.g., dietary behaviours, weight management, alcohol use, smoking, condom use, etc). [Kohl et al., 2013] *Meta-ethnography* Experiences of weight management in a behavioural weight management intervention context. Provide structure and support for people who are trying to manage their weight while fostering autonomous decision making in

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	computer literate, each new software/system has its' own learning curve. [van Beurden et al. 2017] Needs to be easily accessible at any time as support may needed on-the-go. We just need an electric zapper at the point of purchase to make us aware what we are doing and to use strategies. [Service user consultation]	how to use it easily. Removing as much need for cognitive effort as possible in trying to understand how the app works is important. Reminders will help prompt users to revisit specific parts that require frequent visits. Gamification like the use of a point system, levels, and rewards can increase enjoyment and motivation to use the app. [CP, App developer]		and outside the context of the weight management programme. [Garip & Yardley, 2012] Engagement with internet-based interventions has been associated with effectiveness [e.g., Donkin et al., 2011; Kelders et al., 2011; van Gemert-Pijnen et al., 2014; Hwang et al., 2013] *Literature review: defining engagement with technologies.* Engagement as a process of four stages: (1) point of engagement, (2) period of sustained engagement, (3) disengagement, and (4) reengagement). Engagement defined as: "a quality of user experience characterized by attributes of challenge, positive

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				affect, endurability, aesthetic and sensory appeal, attention, feedback, variety/novelty, interactivity, and perceived user control. [O'Brien & Toms, 2008] The internet intervention model, proposes that users approach an internet-based intervention with a set of user characteristics that are influenced by environmental factors. These user characteristics influence the use of the intervention, which is also influenced by the characteristics of the intervention itself such as appeal, behavioural prescriptions, burdens, content, delivery, message, participation, assessment.

Targets for Change	Potential service users (Interviews and Consultation)	Experts and Health professionals	Evidence-based practice guidance	Research and theoretical literature
				[Ritterband et al., 2009] “Gamification is the use of game design elements in none game contexts” which can make non-game applications more enjoyable, motivating, and/or engaging to use. [Deterding et al., 2011] *Delphi study* Among 62 experts in internet intervention research and practice, e-marketing, web design, and technical web development, personal factors such as motivation and perceived personal relevance were considered to be important in relation to an initial visit to /uptake of the internet-based intervention. To promote an extended visit (long enough to be able to meaningfully

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				process some of the intervention content) intervention factors such as tailored feedback, relevant and reliable information, and clarity and ease of use are considered important. Factors such as the initial experience with the intervention, the intention to change the target behaviour, the provision of new content, and reminders are considered important for revisits to the intervention. [Brouwer et al., 2008] HP's consider motivation to be crucial, and that there are sizable challenges that people face in sustaining their original motivation to lose weight over longer periods of time. A common view among the HP group was that people become

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				de-motivated when the rate of weight loss slowed down after initial quick success, and this coupled with unrealistic expectations about the total weight loss sought, prevented long-term success. [Greener et al. (2010)] *Systematic review* Potential exposure improving methods and strategies used in internet-based interventions: Interactive Behaviour change strategy (i.e., *feedback, goal setting, action/activity planning, self-monitoring, feedback on progress*), Interactive elements (e.g., *quizzes, searchable databases, calculators, and website links*), Peer support, Counselor

Targets for Change	Potential service users (Interviews and Consultation)	Experts and Health professionals	Evidence-based practice guidance	Research and theoretical literature
				support, email/phone contact, updates, intervention incenctive. Peer support, counselor support, email and/or phone contact, and updates of the intervention website may be (qualitative patterns in the evidence) positively related with more exposure to the intervention. [Brouwer et al., 2011] *Systematic review* Persuasive system design (dialogue) features such as reminders positively influence adherence. [Kelders et al., 2012] Using an interface that incorporates relational behaviours such as empathy and social dialogue significantly increases the users

Targets for Change	Potential service users (Interviews and Consultation)	Experts and Health professionals	Evidence-based practice guidance	Research and theoretical literature
				working alliance and ongoing engagement with the programme [Bickmore et al. 2005] Personalisation of the intervention and of feedback and encouragement has been suggested to improve engagement. [Gorton et al, 2011; Dennison et al. 2014, Ni Mhurchu, 2014; Tang et al., 2015; *review* Schubart, 2011] *Self-determination theory* Enhancing motivation to engage in a behaviour (use of the intervention and its strategies) through facilitating the integration of extrinsic motivation by promoting the following determinants, competence (sense of mastery or skill development), autonomy

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				(feeling like behaviour can be self-determined and make a difference to the outcome), and relatedness (feeling that the behaviour is accepted and approved of/supported by others). [Ryan & Deci, 2000] 61% of UK adults own a smartphone in 2014 [Ofcom, 2014] Android has 61.1% of market share in UK in 2014 [Kantar Worldpanel]

Bickmore, T., Gruber, A., & Picard, R. (2005). Establishing the computer-patient working alliance in automated health behaviour change interventions. *Patient Education and Counseling*, *59*(1), 21–30. https://doi.org/10.1016/j.pec.2004.09.008

British Nutrition Foundation. (2012). *Behaviour Change Conference - 10 Key Facts*. British Nutrition Foundation. Retrieved from http://www.nutrition.org.uk/nutritionscience/behaviour/behaviour-10-key-facts

Brouwer, W., Kroeze, W., Crutzen, R., Nooijer, J. de, Vries, N. K. de, Brug, J., & Oenema, A. (2011). Which Intervention Characteristics are Related to More Exposure to Internet-Delivered Healthy Lifestyle Promotion Interventions? A Systematic Review. *Journal of Medical Internet Research*, *13*(1), e2. https://doi.org/10.2196/jmir.1639

Brouwer, W., Oenema, A., Crutzen, R., Nooijer, J. D., Vries, N. D., & Brug, J. (2008). An Exploration of Factors Related to Dissemination of and Exposure to Internet-Delivered Behaviour Change Interventions Aimed at Adults: A Delphi Study Approach. *Journal of Medical Internet Research*, *10*(2), e10. https://doi.org/10.2196/jmir.956

Castellanos, E. H., Charboneau, E., Dietrich, M. S., Park, S., Bradley, B. P., Mogg, K., & Cowan, R. L. (2009). Obese adults have visual attention bias for food cue images: evidence for altered reward system function. *International Journal of Obesity*, *33*(9), 1063–1073. doi:10.1038/ijo.2009.138

De Castro, J. M. (1990). Social facilitation of duration and size but not rate of the spontaneous meal intake of humans. *Physiology and Behaviour*, *47*(6), 1129–1135.

De Castro, J. M., & Brewer, E. M. (1992). The amount eaten in meals by humans is a power function of the number of people present. *Physiology and Behaviour*, *51*(1), 121–125. doi:10.1016/0031-9384(92)90212-K

De Castro, J. M., & De Castro, E. S. (1989). Spontaneous meal patterns of humans: Influence of the presence of other people. *American Journal of Clinical Nutrition*, *50*(2), 237–247.

Dennison, L., Morrison, L., Lloyd, S., Phillips, D., Stuart, B., Williams, S., … Yardley, L. (2014). Does Brief Telephone Support Improve Engagement With a Web-Based Weight Management Intervention? Randomised Controlled Trial. *Journal of Medical Internet Research*, *16*(3), e95. https://doi.org/10.2196/jmir.3199

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness: Defining “gamification” (pp. 9–15). Presented at the Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments, MindTrek 2011. https://doi.org/10.1145/2181037.2181040

Donkin, L., Christensen, H., Naismith, S. L., Neal, B., Hickie, I. B., & Glozier, N. (2011). A Systematic Review of the Impact of Adherence on the Effectiveness of e-Therapies. *Journal of Medical Internet Research*, *13*(3), e52. https://doi.org/10.2196/jmir.1772

Gallagher, R., Kirkness, A., Armari, E., & Davidson, P. M. (2012). Weight management issues and strategies for people with high cardiovascular risk undertaking an Australian weight loss program: A focus group study. *Nursing & Health Sciences*, *14*(1), 18–24. doi:10.1111/j.1442-2018.2011.00651.x

Garip, G., & Yardley, L. (2011). A synthesis of qualitative research on overweight and obese people's views and experiences of weight management. *Clinical Obesity*, *1*(2–3), 110–126. https://doi.org/10.1111/j.1758-8111.2011.00021.x

Greener, J., Douglas, F., & van Teijlingen, E. (2010). More of the same? Conflicting perspectives of obesity causation and intervention amongst overweight people, health professionals and policy makers. *Social Science & Medicine*, *70*(7), 1042–1049. https://doi.org/10.1016/j.socscimed.2009.11.017

Gorton, D., Dixon, R., Maddison, R., Mhurchu, C. N., & Jull, A. (2011). Consumer views on the potential use of mobile phones for the delivery of weight-loss interventions. *Journal of Human Nutrition and Dietetics*, *24*(6), 616–619. https://doi.org/10.1111/j.1365-277X.2011.01163.x

Guerrieri, R., Nederkoorn, C., & Jansen, A. (2007). The interaction between impulsivity and a varied food environment: its influence on food intake and overweight. *International Journal of Obesity*, *32*(4), 708–714. doi:10.1038/sj.ijo.0803770

Hwang, K. O., Ning, J., Trickey, A. W., & Sciamanna, C. N. (2013). Website usage and weight loss in a free commercial online weight loss program: retrospective cohort study. *Journal of Medical Internet Research*, *15*(1), e11. https://doi.org/10.2196/jmir.2195

Herman, C. P. (2015). The social facilitation of eating. A review. *Appetite*, *86*, 61–73. https://doi.org/10.1016/j.appet.2014.09.016

Hofmann, W., Friese, M., & Wiers, R. W. (2008). Impulsive versus reflective influences on health behaviour: a theoretical framework and empirical review. *Health Psychology Review*, *2*(2), 111–137. https://doi.org/10.1080/17437190802617668

Hofmann, W., Friese, M., & Roefs, A. (2009). Three ways to resist temptation: The independent contributions of executive attention, inhibitory control, and affect regulation to the impulse control of eating behaviour. *Journal of Experimental Social Psychology*, *45*(2), 431–435. doi:10.1016/j.jesp.2008.09.013

Hofmann, W., Rauch, W., & Gawronski, B. (2007). And deplete us not into temptation: Automatic attitudes, dietary restraint, and self-regulatory resources as determinants of eating behaviour. *Journal of Experimental Social Psychology*, *43*(3), 497–504. doi:10.1016/j.jesp.2006.05.004

Hou, R., Mogg, K., Bradley, B. P., Moss-Morris, R., Peveler, R., & Roefs, A. (2011). External eating, impulsivity and attentional bias to food cues. *Appetite*, *56*(2), 424–427. doi:10.1016/j.appet.2011.01.019

Kantar Worldpanel (n.d) *Smartphone OS Sales Market Share Evolution*. Retrieved May 2014 from http://www.kantarworldpanel.com/global/smartphone-os-market-share/

Kelders, S. M., Van Gemert-Pijnen, J. E. W. C., Werkman, A., Nijland, N., & Seydel, E. R. (2011). Effectiveness of a Web-based intervention aimed at healthy dietary and physical activity behaviour: a randomised controlled trial about users and usage. *Journal of Medical Internet Research*, *13*(2), e32. https://doi.org/10.2196/jmir.1624

Kelders, S. M., Kok, R. N., Ossebaard, H. C., & Van Gemert-Pijnen, J. E. (2012). Persuasive System Design Does Matter: a Systematic Review of Adherence to Web-based Interventions. *Journal of Medical Internet Research*, *14*(6), e152. https://doi.org/10.2196/jmir.2104

Kohl, L. F., Crutzen, R., & Vries, N. K. de. (2013). Online Prevention Aimed at Lifestyle Behaviours: A Systematic Review of Reviews. *Journal of Medical Internet Research*, *15*(7), e146. https://doi.org/10.2196/jmir.2665

Ledikwe, J. H., Ello-Martin, J. A., & Rolls, B. J. (2005). Portion Sizes and the Obesity Epidemic. *The Journal of Nutrition*, *135*(4), 905–909.

Malik, V. S., Pan, A., Willett, W. C., & Hu, F. B. (2013). Sugar-sweetened beverages and weight gain in children and adults: a systematic review and meta-analysis. *The American Journal of Clinical Nutrition*, *98*(4), 1084–1102. https://doi.org/10.3945/ajcn.113.058362

Malik, V. S., Schulze, M. B., & Hu, F. B. (2006). Intake of sugar-sweetened beverages and weight gain: a systematic review. *The American Journal of Clinical Nutrition*, *84*(2), 274–288.

May, J., Andrade, J., Kavanagh, D. J., & Hetherington, M. (2012). Elaborated Intrusion Theory: A Cognitive-Emotional Theory of Food Craving. *Current Obesity Reports*, *1*(2), 114–121. https://doi.org/10.1007/s13679-012-0010-2

Metcalfe, J., & Mischel, W. (1999). A hot/cool-system analysis of delay of gratification: Dynamics of willpower. *Psychological Review*, *106*(1), 3–19. https://doi.org/10.1037/0033-295X.106.1.3

Morenga, L. T., Mallard, S., & Mann, J. (2013). Dietary sugars and body weight: systematic review and meta-analyses of randomised controlled trials and cohort studies. *BMJ*, *346*, e7492. https://doi.org/10.1136/bmj.e7492

National Institute for Health and Care Excellence. (2014). *Behaviour Change: Individual Approaches.* NICE guideline (PH49). NICE: London

National Institute for Health and Care Excellence. (2014). *Obesity: Identification, Assessment and Management*. NICE guideline (CG187).

National Institute for Health and Clinical Excellence. (2006). *Obesity.* NICE guideline (CG43). NICE: London

National Institute for Health and Clinical Excellence. (2007). *Behaviour change: general approaches.* NICE guideline (PH6). NICE: London

Ni Mhurchu, C., Whittaker, R., McRobbie, H., Ball, K., Crawford, D., Michie, J., … Myers, K. (2014). Feasibility, acceptability and potential effectiveness of a mobile health (mHealth) weight management programme for New Zealand adults. *BMC Obesity*, *1*, 10. https://doi.org/10.1186/2052-9538-1-10

O'Brien, H. L., & Toms, E. G. (2008). What is user engagement? A conceptual framework for defining user engagement with technology. *Journal of the American Society for Information Science and Technology*, *59*(6), 938–955. https://doi.org/10.1002/asi.20801

Ofcom (2014) *The Communications Market Report*. Ofcom. Retrieved from https://www.ofcom.org.uk/__data/assets/pdf_file/0031/19498/2014_uk_cmr.pdf

Prentice, A. M., & Jebb, S. A. (2003). Fast foods, energy density and obesity: a possible mechanistic link. *Obesity Reviews*, *4*(4), 187–194. https://doi.org/10.1046/j.1467-789X.2003.00117.x

Ritterband, L. M., Thorndike, F. P., Cox, D. J., Kovatchev, B. P., & Gonder-Frederick, L. A. (2009). A Behaviour Change Model for Internet Interventions. *Annals of Behavioural Medicine*, *38*(1), 18–27. https://doi.org/10.1007/s12160-009-9133-4

Deci, E. L., Eghrari, H., Patrick, B. C., & Leone, D. R. (1994). Facilitating internalization: the self-determination theory perspective. *Journal of Personality*, *62*(1), 119–142.

Schubart, J. R., Stuckey, H. L., Ganeshamoorthy, A., & Sciamanna, C. N. (2011). Chronic Health Conditions and Internet Behavioural Interventions: A Review of Factors to Enhance User Engagement. *CIN: Computers, Informatics, Nursing*, *29*(2), 81. https://doi.org/10.1097/NCN.0b013e3182065eed

Spence, M., Livingstone, M. B. E., Hollywood, L. E., Gibney, E. R., O'Brien, S. A., Pourshahidi, L. K., & Dean, M. (2013). A qualitative study of psychological, social and behavioural barriers to appropriate food portion size control. *The International Journal of Behavioural Nutrition and Physical Activity*, *10*, 92. doi:10.1186/1479-5868-10-92

Strack, F., & Deutsch, R. (2004). Reflective and impulsive determinants of social behaviour. *Personality and Social Psychology Review: An Official Journal of the Society for Personality and Social Psychology, Inc*, *8*(3), 220–247. https://doi.org/10.1207/s15327957pspr0803_1

Sutin, A. R., Ferrucci, L., Zonderman, A. B., & Terracciano, A. (2011). Personality and obesity across the adult life span. *Journal of Personality and Social Psychology*, *101*(3), 579–592. doi:10.1037/a0024286

Swinburn, B., Egger, G., & Raza, F. (1999). Dissecting obesogenic environments: the development and application of a framework for identifying and prioritizing environmental interventions for obesity. *Preventive Medicine*, *29*(6 Pt 1), 563–570. doi:10.1006/pmed.1999.0585

Tetley, A., Brunstrom, J., & Griffiths, P. (2009). Individual differences in food-cue reactivity. The role of BMI and everyday portion-size selections. *Appetite*, *52*(3), 614–620. doi:10.1016/j.appet.2009.02.005

UBhave. (2013). Health-related Behaviour Change through Technology. *2nd UBhave project conference*. 25th Sept, London, UK

van Gemert-Pijnen, J. E. V., Kelders, S. M., & Bohlmeijer, E. T. (2014). Understanding the Usage of Content in a Mental Health Intervention for Depression: An Analysis of Log Data. *Journal of Medical Internet Research*, *16*(1), e27. https://doi.org/10.2196/jmir.2991

Vartanian, L. R., Schwartz, M. B., & Brownell, K. D. (2007). Effects of Soft Drink Consumption on Nutrition and Health: A Systematic Review and Meta-Analysis. *American Journal of Public Health*, *97*(4), 667–675. https://doi.org/10.2105/AJPH.2005.083782

Vartanian, L. R., Spanos, S., Herman, C. P., & Polivy, J. (2015). Modeling of food intake: a meta-analytic review. *Social Influence*, *10*(3), 119–136. https://doi.org/10.1080/15534510.2015.1008037

Veling, H., Aarts, H., & Papies, E. K. (2011). Using stop signals to inhibit chronic dieters' responses toward palatable foods. *Behaviour Research and Therapy*, *49*(11), 771–780. doi:10.1016/j.brat.2011.08.005

Wansink, B., Painter, J. E., & North, J. (2005). Bottomless bowls: why visual cues of portion size may influence intake. *Obesity Research*, *13*(1), 93–100. doi:10.1038/oby.2005.12

Yeomans, M. R. (2010). Alcohol, appetite and energy balance: Is alcohol intake a risk factor for obesity? *Physiology & Behaviour*, *100*(1), 82–89. https://doi.org/10.1016/j.physbeh.2010.01.012

Appendix 10 Triangulation

Performance objective	Potential service users (Interviews and Consultation)	Experts and Health professionals	Evidence-based practice guidance	Research and theoretical literature
PO1. Individual reduces weekly frequency of unhealthy snack/food consumption	Agree	Agree	Agree	Agree
PO2. Individual reduces frequency of overeating episodes (over a 28-day period).	Agree	Agree	Agree	Agree
PO3. Individual reduces weekly fizzy/sugary drink consumption.	Agree	Agree	Agree	Agree
PO4. Individual reduces weekly alcoholic drink consumption.	Silence	Agree	Agree	Agree
PO5. Individual effectively engages with the intervention.	Agree	Agree	Silence	Agree

Appendix 11 ImpulsePal intervention map

Performance objective	Modifiable Determinants	Change objective	Change techniques	Practical application
PO1. Individual reduces weekly frequency of unhealthy snack/food consumption (foods high in fat/sugar/salt)	Initiation of impulse	I.I. 1. Prevent initiation of impulse to eat unhealthy snack /food. I.I. 2. Initiate impulse to engage in alternative /healthier action. I.I. 3. Identify personal cues /triggers that initiate impulses to eat unhealthy snacks and food.	Remove access to the reward, Avoidance/reducing exposure to cues for the behaviour, Change physical environment. Implementation Intentions. Habit reversal. Provide information about antecedents that reliably predict performance of the behaviour. *(Boundary Conditions: e.g., Habitualness, Context, Cognitive Load, Acute Alcohol, Emotion, Mood, Motivational State).*	Promote removal of unhealthy foods from the home/work environment in the if-then plan section. Promote selecting existing or creating own if-then plans for personal high-risk situations. Provide information about when and where impulses to eat may be triggered: "*Struggle with temptations? You are not alone! Everyone has to deal with the tug-of-war between impulses and intentions. This struggle is often experienced as cravings, urges, temptations, or desire*" "*Impulses drive our food choices – without thinking – in response to situational triggers. The triggered impulses make it difficult to resist unhealthy snacks, overeating, or mindless eating*." Advise to identify own triggers of impulsive eating: "*You can find out what your triggers are by thinking about when and where you tend to feel food cravings, have to work hard, to resist the temptation to eat unhealthy*

Performance objective	Modifiable Determinants	Change objective	Change techniques	Practical application
				snacks, eat a lot, or end up eating without really thinking about it."
	Strength of impulse *This includes the strength of neuronal activation but also the cognitive elaboration of craving*	S.I. 1. Reduce strength of impulse/ craving to eat unhealthy snack /food. S.I. 2. Engage strategies to cope with strength of impulse to eat unhealthy food /snack without eating. S.I.3 Identify where strong impulses /cravings to eat unhealthy snack /food may occur.	Visuospatial Loading. Physical Activity (brisk walk) Mindfulness-based strategies, mental imagery. Deconditioning. Distraction Problem Solving Social support.	Encourage use of emergency button when craving occurs. Present **dynamic visual noise** when individual indicates (by pressing an "emergency button") that a craving/urge is in progress and that they need support. Promote use of physical activity (brisk walk) in Implementation Intentions section. Inform that repeated temptation resistance (reward removal) will eventually make it easier to resist temptations over time. Encourage the use of Urge-surfing to deal with cravings without acting upon them. Being aware of thoughts and sensations and objectively observing them. Encourage to think of cravings like a wave that may increase over time but will eventually subside. Promote use of Urge-surfing in the Emergency button. Promote use of Brain Training in emergency button.

Performance objective	Modifiable Determinants	Change objective	Change techniques	Practical application
				Prompt individual to look at own or other strategies in if-then plans to identify ways of dealing with the current situation. Encourage to engage friends/family for support or ideas, in specific high-risk situations in the if-then plans. See. I.I.3
	Inhibitory control	I.C.1. Engage inhibitory control to inhibit behavioural responses towards unhealthy snack /food.	Inhibition training, associative learning.	Encourage completion of the "Brain Training" game (Go/no-go task) 3 times per week. **Version 1:** Neutral images (not consumption related) vs images of unhealthy food items, sugary drinks, and alcoholic drinks. Go cue (consistently paired with neutral image) = Green Go sign, No-go cue (consistently paired with unhealthy images) = Red Stop sign. Go/no-go cues appear 100ms after image presentation. Images appear at random, on either the left or right side of the screen (phone to be placed in "landscape" view). Individual to touch the side of the screen where the image appears IF a Go cue appears but not if a No-go cue appears.

Performance objective	Modifiable Determinants	Change objective	Change techniques	Practical application
				Version 2: Neutral images (clothing) vs healthy food images vs unhealthy food and drink images. Go cue (consistently paired with healthy images and 50% of neutral images) = Green circle around image. No-go cue (consistently paired with unhealthy images and 50% of neutral images) = Red circle around image. Go/no-go cues appear 100ms after image presentation. Images appear at random. Individual to touch the screen when image appears with a Go cue but not if image appears with a No-go cue.
	Awareness /cognitive resources (presented separately from inhibitory control as the Go/NoGo training may result in automatically engaging inhibitory control on presentation of food cues - associative learning).	A. 1. Express awareness of personal in-the-moment food choices and eating behaviour. A. 2. Engage cognitive resources to inhibit /override impulses to eat unhealthy snack /food items. A. 3. Identify personal situational cues and triggers	Provide information about antecedents. Implementation Intentions Visuospatial loading Mindfulness-based strategies Priming/cues	See antecedents above. Advise engagement in alternative tasks or thinking about diet goals in if-then plans. See dynamic visual noise above. See Urge-surfing above. Encourage use of GPS function to create time&location specific goal primes /diet reminders (Danger Zones).

Performance objective	Modifiable Determinants	Change objective	Change techniques	Practical application
		that influence own unhealthy eating behaviour.		
	Intention	I. 1. Intend to reduce unhealthy snack /food consumption. I. 2. Intend to initiate impulse to engage in alternative /healthier action.	Implementations	Encourage selecting and creating own if-then plans by identifying own high-risk situations where impulses affect eating behaviour and finding alternative /healthier actions that would provide a solution for that situation. Advise to review and amend if-then plans over time.
	Self-efficacy	S.E.1 Express confidence in reducing unhealthy snack /food consumption.	Behavioural practice.	Inform that repeated temptation resistance (reward removal) will eventually make it easier to resist temptations over time.
	Food /drink availability	F.A. 1. Resist eating in response to food availability. F.A. 2. Remove access /exposure to unhealthy snack /food items. F.A. 3. Use strategies to reduce strength of impulse to eat unhealthy snack	Impulse management. Implementation Intentions. Distraction. Remove access to the reward, Avoidance/reducing exposure to cues for the behaviour, Change physical environment.	See strategies for dealing with the initiation of an impulse, strength of an impulse, and use of inhibitory control or cognitive resources to inhibit or override an impulse. See change physical environment above.

Performance objective	**Modifiable Determinants**	**Change objective**	**Change techniques**	**Practical application**
		/food triggered by food availability. F.A. 4. Damage limitation	Relapse prevention	Promote alternative /healthier actions in situations where food is available in if-then plans. Promote reducing food cues in the environment in the if-then plans. Promote reduced portion size to minimise calorific intake in the if-then plans.
	Situational /habit cues	S.C. 1. Resist eating in response to situational cues (other than *food/drink availability* or *social pressures* such as tiredness, mood, stress, time of day). S.C. 2 Identify personal situational cues (other than F*ood/ drink availability* such as tiredness, mood, stress, time of day) that influence unhealthy snack /food consumption. S.C. 3. Identify strategies to cope with situational cues.	Impulse Management Implementation Intentions Problem solving. Diet reminders /goal primes	See strategies for dealing with the initiation of an impulse, strength of an impulse, and use of inhibitory control or cognitive resources to override an impulse. See change physical environment above. Promote alternative /healthier actions in situations which tend to lead to snack /food consumption in if-then plans. (e.g., boredom, low mood, celebration, habitual contexts etc). Encourage creating own if-then plans. Encourage use of Danger Zones, to create situational specific diet reminders/ goal primes.

Performance objective	**Modifiable Determinants**	**Change objective**	**Change techniques**	**Practical application**
	Social influences	S.F.1 Resist eating unhealthy snack /food items in response to social pressures. S.F. 2 Identify social situations that influence unhealthy snack /food consumption. S.F. 3. Identify strategies to cope with social situations.	Impulse Management Implementation Intentions Problem solving Social support.	See strategies for dealing with the initiation of an impulse, strength of an impulse, and use of inhibitory control or cognitive resources to override an impulse. Promote alternative /healthier actions in situations which tend to lead to snack /food consumption in if-then plans. (e.g., boredom, low mood, celebration, habitual contexts etc). Encourage creating own if-then plans. Encourage to engage friends/family for support or ideas, in specific high-risk situations in the Implementation Intentions.
PO2. Individual reduces frequency of overeating (eating unusually large amount of food in one sitting) over a	Strength of impulse *This includes the strength of neuronal activation but also the cognitive elaboration of craving*	S.I. 4. Reduce strength of impulse /desire to continue to eat. S.I. 3. Engage strategies to cope with strength of impulse /desire to continue eating.	Mindfulness-based strategies. Implementation Intentions.	See urge-surfing above. Encourage mindful-eating in if-then plans.

Performance objective	Modifiable Determinants	Change objective	Change techniques	Practical application
period of 28 days.				
	Inhibitory control	I.C. 2. Engage inhibitory control to inhibit behavioural responses towards the food that is being consumed.	Inhibition training	See Brain training.
	Awareness /cognitive resources	A. 3. Bring eating behaviour into awareness. A. 4 Identify personal situational cues and triggers that influence the amount that is eaten in one sitting.	Implementation Intentions. Appetite regulation Priming.	Promote mindful eating in if-then plans. Promote the use of urge-surfing during a meal time in if-then plan. Promote thinking of diet goal in if-then plans. Promote using breaks during meal to assess appetite to make a conscious decision whether or not to continue to eat. See danger zones above.
	Intention	I. 3. Intend to reduce amount eaten in one sitting. I. 2. See PO1. I. 3. See PO1.	Implementation Intentions. Problem solving.	Promote alternative /healthier actions in situations where overeating tends to occur in if-then plan. Encourage creating own if-then plans for situations where overeating occurs (e.g., at a buffet, in a restaurant, in front of the television).
	Self-efficacy	S.E. 2 Express confidence in limiting the amount eaten in one sitting.	Behavioural practice.	See repeated temptation resistance.

Performance objective	**Modifiable Determinants**	**Change objective**	**Change techniques**	**Practical application**
	Food /drink availability	F.A. 1. See PO1. F.A. 6. Remove access /exposure to large portions of food.	Implementation Intentions Change physical environment.	Promote strategies to reduce portion sizes in if-then plans. (e.g., using smaller plates, moving food onto side plate, asking to take leftovers home).
	Situational cues	S.C. 4. Resist eating large amounts of food in one sitting in response to situational cues. S.C. 5. Identify personal situational cues (other than F*ood/ drink availability*) that influence the amount that is eaten in one sitting. S.C. 2. See PO1. S.C. 3 See PO1.	Implementation Intentions Change physical environment. Mobilising social support Mindfulness-based strategies. Diet reminders /goal primes	Promote strategies to reduce portion sizes in if-then plans. (e.g., using smaller plates, moving food onto side plate, asking to take leftovers home). Promote asking significant other people for support in if-then plans. See Urge surfing above. See Danger Zones above.
	Social influences	S.F. 4. Resist eating large amounts of food in one sitting in response to social pressures.	Impulse Management Implementation Intentions	See strategies for dealing with the initiation of an impulse, strength of an impulse, and use of inhibitory control or cognitive resources to override an impulse.

Performance objective	Modifiable Determinants	Change objective	Change techniques	Practical application
		S.F. 5 Identify social situations that influence the amount that is eaten in one sitting. S.F. 3. See PO1.	Problem solving Social support	Promote alternative responses in the if-then plans (e.g., moving a portion of food onto a side plate) Promote considering self as rolemodel in the if-then plans (i.e., it is ok to not eat everything on the plate). Promote mobilising social support in the if-then plans.
PO3. Individual reduces weekly sugary /fizzy drink consumption.	Initiation of impulse	I.I. 4. Prevent initiation of impulse to drink sugary /fizzy drinks. I.I. 2. See PO1. I.I. 3. Identify personal cues /triggers that initiate impulses to drink sugary /fizzy drinks.	See PO1.	See PO1.
	Strength of impulse *This includes the strength of neuronal activation but also the cognitive*	S.I. 6. Reduce strength of impulse drink sugary /fizzy drinks. S.I. 7. Engage strategies to cope with strength of	See PO1.	See PO1.

Performance objective	Modifiable Determinants	Change objective	Change techniques	Practical application
	elaboration of craving	impulse /desire to to drink sugary /fizzy drinks. S.I.5 Identify where strong impulses /craving to drink sugary /fizzy drinks may occur.		
	Inhibitory control	I.C. 3. Engage inhibitory control to inhibit behavioural responses towards sugary /fizzy drinks.	See PO1.	Go/No go task includes images of sugary drinks.
	Awareness /cognitive resources	A.5. Be aware of in-the-moment drink choices and drinking behaviour. A.6. Identify personal situations when and where sugary /fizzy drinks are consumed.	See PO1.	See PO1.
	Intention	I. 4. Intend to reduce sugary /fizzy drink consumption. I. 2. See PO1. I. 3. See PO1.	See PO1.	See PO1.

Performance objective	Modifiable Determinants	Change objective	Change techniques	Practical application
	Self-efficacy	S.E. 3 Express confidence in ability to reduce sugary /fizzy drink consumption.	See PO1.	See PO1.
	Food /drink availability	F.A. 7. Resist drinking sugary /fizzy drinks in response to drink availability. F.A. 8. Remove access /exposure to sugary /fizzy drinks.	See PO1.	See PO1.
	Situational cues	S.C. 6. Resist drinking sugary /fizzy drinks in response to situational cues. S.C. 7. Identify personal situational cues (other than F*ood/ drink availability*) that influence sugary /fizzy drink consumption. S.C. 2. See PO1. S.C.3 See PO1.	See PO1.	See PO1.

Performance objective	Modifiable Determinants	Change objective	Change techniques	Practical application
PO4. Individual reduces weekly alcoholic drink consumption.	Initiation of impulse	I.I. 5. Prevent initiation of impulse to drink alcoholic drinks. I.I. 2. See PO1. I.I. 3. Identify personal cues /triggers that initiate impulses to drink alcoholic drinks.	See PO1.	See PO1.
	Strength of impulse *This includes the strength of neuronal activation but also the cognitive elaboration of craving*	S.I. 8. Reduce strength of impulse drink alcoholic drinks. S.I. 9. Engage strategies to cope with strength of impulse /desire to drink alcoholic drinks. S.I.10. Identify where strong impulses /craving to drink alcoholic drinks may occur.	See PO1.	See PO1.
	Inhibitory control	I.C. 3. Engage inhibitory control to inhibit behavioural responses towards alcoholic drinks.	See PO1.	See PO1.

Performance objective	Modifiable Determinants	Change objective	Change techniques	Practical application
	Awareness /cognitive resources	A.5. See PO3. A.7. Identify personal situations when and where alcoholic drinks are consumed.	See PO1.	See PO1.
	Intention	I. 1. Intend to reduce alcoholic drink consumption. I. 2. See PO1. I. 3. See PO1.	See PO1.	See PO1.
	Self-efficacy	S.E. 4 Express confidence in ability to reduce alcoholic drink consumption.	See PO1.	See PO1.
	Food /drink availability	F.A. 9. Resist drinking aloholic drinks in response to drink availability. F.A. 10. Remove access /exposure to alcoholic drinks.		
	Situational cues	S.C. 8 Resist consuming alcoholic drinks in response	See PO1.	See PO1.

Performance objective	Modifiable Determinants	Change objective	Change techniques	Practical application
		to situational cues (other than Food/ *drink availability).* S.C. 9. Identify personal situational cues (other than Food/ *drink availability*) that influence alcoholic drink consumption. S.C. 2. See PO1. S.C. 3 See PO1.		
	Social facilitation	S.F. 6. Resist consuming alcoholic drinks in response to social pressures. S.F. 7 Identify social situations that influence alcoholic drink consumption. S.F. 3. See PO1.	See PO1.	See PO1.

Performance objective	Modifiable determinant	Change objective	Strategy or change technique	Practical application.

PO5 Individual engages with the intervention. -Accesses all components to learn about the strategies available. -Uses Brain Training at least three times during the first week. -May or may not use the digital device to effectively engage with: If-then planning,	*Motivation* Autonomy	M.A.1 Feel empowered to be able to make choices in the intervention.	Offer a choice of strategies. Warm and inviting language rather than directive (avoid condescending tone). V2. Tunneling	Offer 5 distinct components from which the user can choose in any given situation. Offer choice within each component, Promote *choosing* from a bank of "if"-situations followed by *choosing* from the corresponding bank of "then"-responses populated with strategies identified in the service user group, expert consultation, and interviews. Promote *creating* new "if"-situations and "then"-responses. Inform the user that they *can* do something (e.g., You can find out what your triggers are by keeping track of when and where you feel food cravings and have to work hard to resist the temptation to eat; You can either pick your if-then's from a list or create your own), rather than that they must/have to. V2. Guide user through the 5 components, using "locked content" which opens when specific criteria have been met to avoid overwhelming the user with choice of information and strategies. V2. Offer audio-guided urge-surfing to provide choice on how to implement this strategy.
	Motivation Competence	M.C.1 Know how to use the intervention and its strategies.	Instruction on how to perform a behaviour.	Provide detailed instructions on how to use the app:

		M.C.2 Feel confident and able to use the intervention and its strategies when required.	Small achievable changes. Behavioural practice Feedback on behaviour Self-monitoring of behaviour Demonstration of behaviour	- Provide detailed instructions on how to create if-then plans and how to use them. - Provide detailed Urge-surfing instructions using the STOP acronym. Stop, Take a breath, Observe and Imagine, Practice and proceed. - Provide detailed instructions on how to play the brain training game. - Provide detailed instructions on identifying which locations (Danger Zones) to select, how to select them and how to identify specific time boundaries to ensure the prompt is context specific. - Provide detailed instructions on when and how to use the emergency button, where it can be found, and what information it stores. Use familiar smartphone app functionality and navigation (e.g., main menu, googlemaps, notification). Encourage practicing the Urge-surfing technique (e.g., *It also helps to practice mindfulness with a breath focus when you don't feel a craving.)* Provide performance feedback during Brain Training game play to encourage better performance.

				Provide tailored feedback on "temptation resistance" (i.e., congratulate when user has successfully, or partially, resisted the temptation. Provide a remedial/normalising message when user has not succeeded, encourage to learn from the event, and try again next time.) Provide feedback on strategy use as self-reported by the user highlighting which strategies they used and which seem to work for them. Provide links signposting to online instructional videos.
	Motivation Relatedness	M.R.1 Feel treated like a normal person and are respected	Using an interface that incorporates relational behaviours such as empathy and social dialogue	Introduce the premise of ImpulsePal by normalising the problem "*Struggle with temptations? You are not alone! Everyone has to deal with the tug-of-war between impulses and intentions. This struggle is often experienced as cravings, urges, temptations or desire.* *That is why I am here. I am ImpulsePal….*" Use non-judgmental language, indicate empathy, and encourage learning from lapses. *"You didn't manage to resist your impulse this time. Don't worry, that's perfectly normal! Impulses are hard to overcome and change takes practice. Think about what you can learn from this experience. The more you practice, the more*

				you will learn about what works best for you and the easier it will become." "Well done! Keep this up. The more impulses you manage to resist the easier it will get. Eventually, the impulse will get so weak there will be no need to struggle with temptations. V2. Present lengthy instructions as a dialogue between user and ImpulsePal app.
	Memory	M.1. Remember to play Brain Training game three times per week.	Prompts	Send notification to prompt game play when user has not completed a Brain training session on two consecutive days. V2. Allow user to create reminders for if-then plans.
	Accessibility	A.1 Able to access the intervention anywhere and at any time. A.2 Able to access and comprehend the content.	Digital device with access to internet. Strategies that do not require intervention access. Use of plain English language.	Use smartphone app as the platform of delivery. Incorporate strategies which do not rely on device use (e.g., if-then planning, urge-surfing) Add emergency button to the home screen for enhanced accessibility for in-the-moment need. Keep sentences short, use active verbs, use "you" and "we", use words appropriate for the reader (i.e., temptation, craving or "without thinking" vs impulsive processes), give instructions, use lists where appropriate.

				V2. Present lengthy instructions as a dialogue between user and ImpulsePal app, distributing text in manageable chunks over a number of screens.
	Appeal and Usability	A/U.1 Think the intervention is easy to use and navigate. A/U.1 Think the interface is appealing.		Use clear fonts for text-based instructions and identifiable thumbnails for clear signposting. Use clean colour palette. V2. Offer Urge-surfing as audio-guided option.
	Enjoyability	E.1 Think the intervention is fun and engaging to use.	Game design elements Interactivity/Participation Feedback	Provide scoring system in the Brain Training task as part of feedback. For a correct response points are provided based on reaction time. For an incorrect response 2 points are deducted. At the start and end of the session provide the users “Best score”, “Latest score”, and Minutes played this week. Incorporate elements that require user actions. (e.g., enter motivation, create if-then plans, play brain-training). Provide feedback on user actions/behaviour (e.g., “log in successful”, “saved”, See M.C.2).
	Updates/novelty/variety	U/N/V.1 Think the intervention is novel and offers a variety of strategies to use.		Use of novel techniques that users may not have come across, offer a variety of strategies that work in different ways.

	Personalisation	P. Be able to adapt intervention to personal, goals, influences, and preferences.		Enable selection of personal risk situations or option to create own. See If-then planning, Danger Zones. Provide personalised feedback based on user actions and user-entered data. V2. Enable training to personally relevant food items. Provide various categories of unhealthy foods and allow selection of up to three categories.

Appendix 12 ImpulsePal (v1) additional screenshots and costs

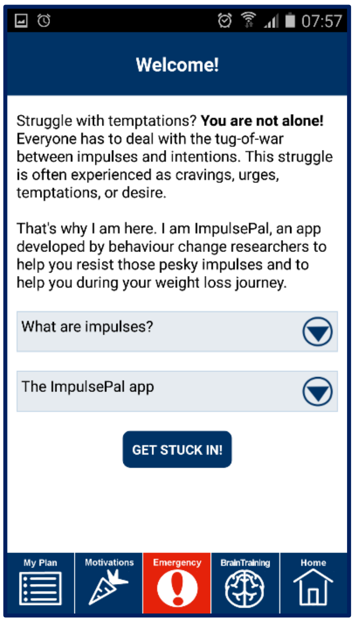
The following images illustrate some of the programme materials and the way the user navigates through the intervention

1

1

Once ImpulsePal is installed the user is presented with a log-in screen and able to **log in** using the details provided by the researcher after randomisation during the baseline visit.

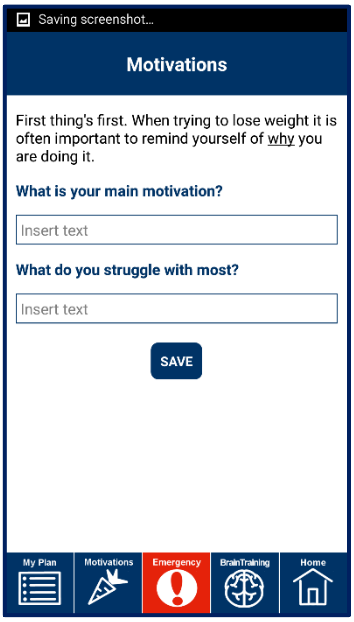
2



2

After successfully logging in to the app (*on first use*) the user is taken to the welcome screen which explains what ImpulsePal is and how it may help. The bottom navigational bar is shown throughout the app except for on the main menu screen (4), the dynamic visual noise screen, the Danger Zone's map screen, and during the brain training session.

3

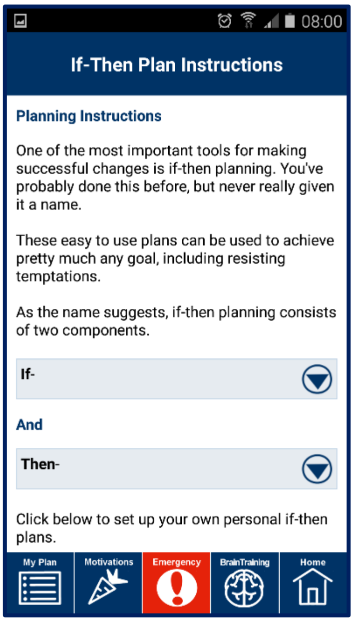


3
Before moving to the main menu, the user is asked about their motivations and their main barrier to losing weight.

4

4
The main menu is the navigational screen linking to the various techniques and their instructions. The user is able navigate to their motivations and Stats via the ImpulsePal button. The instructions pages for each of the components is shown on first use of that component, following which they can be found via the “i”-information button next to the respective components.

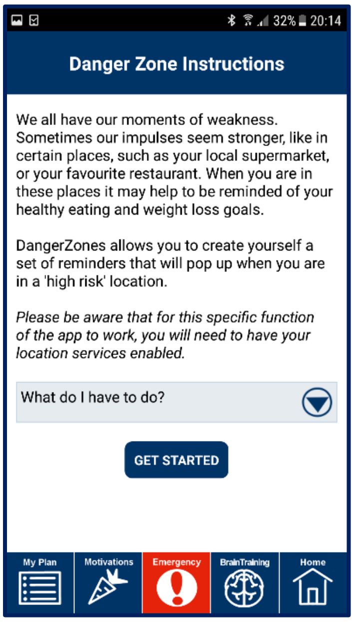
5

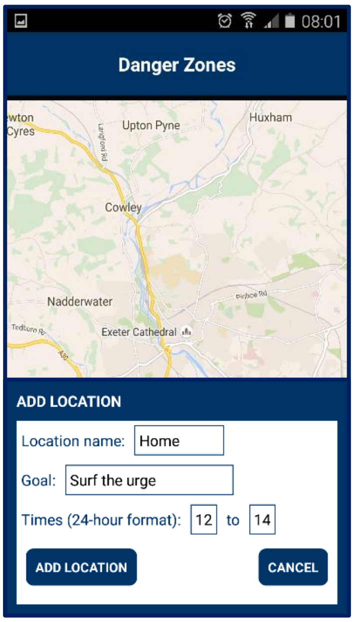


5

The My Plan navigation button in the Main menu leads to the if-then planning strategy. On first use of each of the key components in ImpulsePal, the user is presented with the instructions screen for the corresponding strategy. Any subsequent use of the My Plan navigational button in the main menu will lead to screen 7 and the instructions can be found under the “I” – information button next the My Plan button.

6

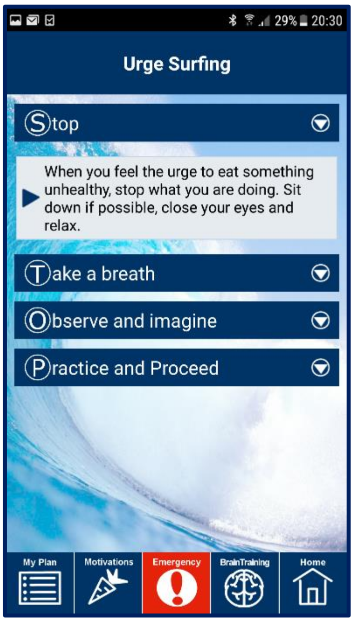




6

The Danger Zones navigational button directs the user to the Danger Zones instructions on first use and directly to the Danger Zones map on subsequent uses. The user is encouraged to think about specific locations where they might struggle with temptations and when particularly these struggles might occur in the identified locations. The user is then encouraged to highlight these locations on the map along with a specific goal for that situation, and a time boundary to make sure the reminders are as situationally specific as possible. Once saved, the app sends notifications to the user with the user’s goal if the smartphone enters the location within the specified times.

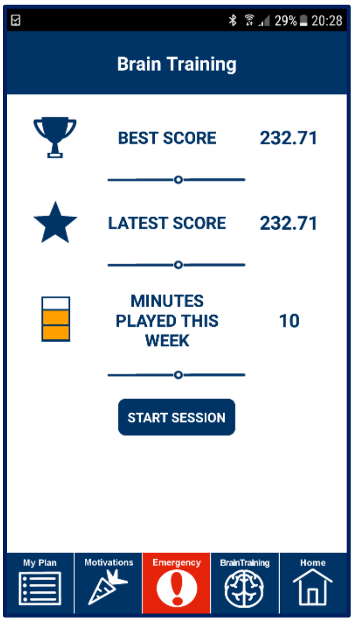
7



11

Urge surging in ImpulsePal is text-guided and uses easy steps to help the user perform this technique. The acronym STOP is used for the steps to help the user remember and implement this technique without necessarily having to access the ImpulsePal app.

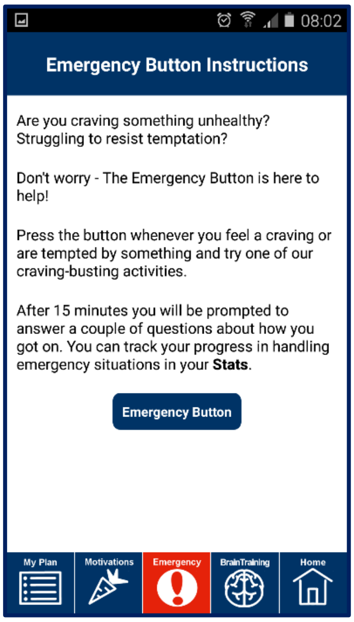
8



8

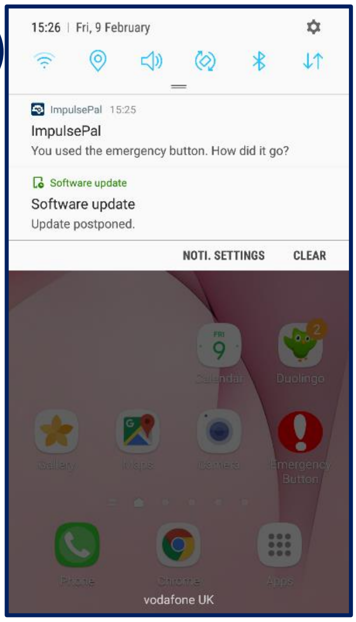
The Brain Training navigational button in the main menu directs the user to the instructions (12) for the Brain Training task on first use, and to the Score page (13) on any subsequent use from which the user can start their training session. During the task, unhealthy food images are consistently paired with a No-go cue (Red Stop sign) following which the user must withhold touching the screen, and Neutral images (e.g., socks, hats, pencils) are consistently paired with a Go-cue (Green Go sign) following which the user needs to touch the screen. The user is provided with feedback in the form of scores. +1 for correct No-go trial, and + (score calculated based on reaction speed) for correct Go trial, -2 for incorrect No-go trial, and -1 for incorrect Go trial.

9



9
On first the instructions page for the emergency button is presented. On any subsequent use, pressing the emergency button is immediately followed by the "In The Moment" screen which contains dynamic visual noise and a congratulatory message about pausing the impulse. The emergency button menu directs to some of the strategies in the app, as well as a "none of the above" option if simply stopping and pausing for a minute has been enough, or the user decides to use a different strategy.

10



10
15 minutes after the user has pressed the emergency button, ImpulsePal sends a notification to the user which prompts the user to answer questions about how they got on with trying to resist the temptation to give into the impulse. The user is asked to rate the urge to eat using a visual analogue scale ranging from very week to extreme. The user is also asked whether they "succeeded", "mostly/partly succeeded", or "did not succeed" this time. Their answer is followed up by a message tailored to the users answer. A congratulatory message is shown following a "succeeded" and "" response, whereas a remedial message is shown for a "did not succeed this time" response.

Cost of development and maintenance of the ImpulsePal app

<table>
<tr><td>ImpulsePal version 1
Android workable prototype
Database development
Deliverable Android app file and coding.</td><td>£4000</td></tr>
<tr><td>ImpulsePal version 2
Amendments to Android app code following Cycle 1 data collection and analysis
Amendments to database</td><td>£2300</td></tr>
<tr><td>Predicted annual maintenance fees (not including developmental work)
University of Exeter server use
Certificate (permission) updates</td><td>£600 p.a.
£100 p.a.</td></tr>
</table>

Appendix 13 Questionnaires

Information about yourself

Date of birth : Day ☐☐ Month ☐☐ Year ☐☐☐☐

For the following questions, please tick which best describes you. If you are not sure of the answer, leave it blank and the researcher will go through it with you later.

Gender
- ☐ Male
- ☐ Female
- ☐ Prefer not to disclose

Education level
(highest level completed)
- ☐ Primary school
- ☐ Some secondary school
- ☐ Secondary school up to 16 years
- ☐ Secondary school up to 18 years
- ☐ Professional training
- ☐ Undergraduate university
- ☐ Postgraduate
- ☐ Other (specify) ____________________

Ethnicity
- ☐ Afro-caribbean / Black Caribbean / Black African
- ☐ Chinese
- ☐ South Asian
- ☐ White
- ☐ Mixed origin
- ☐ Prefer not to disclose
- ☐ Other (specify) ____________________

Smartphone
- ☐ Samsung
- ☐ Sony
- ☐ HTC
- ☐ LG
- ☐ Acer
- ☐ ZTE
- ☐ Huawei
- ☐ OnePlus
- ☐ Nexus
- ☐ Other (specify) ____________________

Your health

Smoking

☐ Currently smoking
☐ Never smoked
☐ Given up smoking   dd / mm / yyyy

(please specify a date)

Do you have any medical conditions that affect what you can eat or drink?

☐ Yes
☐ No

If yes, please briefly name or describe these

Your weight management

Are you taking Orlistat or any other prescribed medication to help you with weight management?

☐ Yes
☐ No

If yes, please state the name of the medication and the dose you take:

Are you taking any other medication that might affect your weight?

☐ Yes
☐ No

If yes, please state the name of the medication and the dose you take:

Are you currently involved in another weight loss programme?

☐ Yes
☐ No

If yes, please state the name of the programme:

General Behaviour (BIS-15)

Please read the following statements and circle what best describes you. Do not spend too much time on any statement. Answer quickly and honestly.

	Rarely	**Occasionally**	**Often**	**Almost Always**
I act on impulse	1	2	3	4
I act on the spur of the moment	1	2	3	4
I do things without thinking	1	2	3	4
I say things without thinking	1	2	3	4
I buy things on impulse	1	2	3	4
I plan for job security	1	2	3	4
I plan for the future	1	2	3	4
I save regularly	1	2	3	4
I plan tasks carefully	1	2	3	4
I am a careful thinker	1	2	3	4
I am restless at lectures or talks	1	2	3	4
I squirm at plays or lectures	1	2	3	4
I concentrate easily	1	2	3	4
I don’t pay attention	1	2	3	4
I get easily bored solving thought problems.	1	2	3	4

Restraint (Cognitive restraint

Please read the following statements and circle what best describes you. Do not spend too much time on any statement. Answer quickly and honestly.

	Definitely false	Mostly false	Mostly true	Definitely true
I deliberately take small helpings as a means of controlling my weight.	1	2	3	4
I consciously hold back at meals in order not to weight gain.	1	2	3	4
I do not eat some foods because they make me fat.	1	2	3	4
	Almost Never	**Seldom**	**Usually**	**Almost Always**
How frequently do you avoid “stocking up” on tempting foods.	1	2	3	4

	Unlikely	Slightly likely	Moderately likely	Very likely
How likely are you to consciously eat less than you want?	1	2	3	4

On a scale of 1 to 8, where 1 means no restraint in eating (eating whatever you want, whenever you want it) and 8 means total restraint (constantly limiting food intake and never “giving in”), what number would you give yourself?	…………

The Power of Food (PFS)

The following questions help gauge how food affects you. Using the scale, indicate from 1-5 which of the following best describes you:

	Don't agree at all	Agree a little	Agree somewhat	Agree	Strongly agree
I find myself thinking about food even when I'm not physically hungry.	1	2	3	4	5
I get more pleasure from eating than I do from almost anything else.	1	2	3	4	5
If I see or smell a food I like, I get a powerful urge to have some.	1	2	3	4	5
When I'm around a fattening food I love, it's hard to stop myself from at least tasting it.	1	2	3	4	5
It's scary to think of the power that food has over me.	1	2	3	4	5
When I know a delicious food is available, I can't help myself from thinking about having some.	1	2	3	4	5
I love the taste of certain foods so much that I can't avoid eating them even if they're bad for me.	1	2	3	4	5
Just before I taste a favourite food, I feel intense anticipation.	1	2	3	4	5
When I eat delicious food I focus a lot on how good it tastes.	1	2	3	4	5

Sometimes, when I'm doing everyday activities, I get an urge to eat "out of the blue" (for no apparent reason).	1	2	3	4	5
I think I enjoy eating a lot more than most other people.	1	2	3	4	5
Hearing someone describe a great meal makes me really want to have something to eat.	1	2	3	4	5
It seems like I have food on my mind a lot.	1	2	3	4	5
It's very important to me that the foods I eat are as delicious as possible.	1	2	3	4	5
Before I eat a favourite food my mouth tends to flood with saliva.	1	2	3	4	5

Cravings (FCQ-T-r)

Using the scale, please indicate from 1-6 which of the following best describes you:

	Never	Very rarely	Rarely	Occasionally	Very Frequently	Always
When I crave something, I know I won't be able to stop eating once I start.	1	2	3	4	5	6
If I eat what I am craving, I often lose control and eat too much.	1	2	3	4	5	6
Food cravings invariably make me think of ways to get what I want to eat.	1	2	3	4	5	6
I feel like I have food on my mind all the time	1	2	3	4	5	6
I find myself preoccupied with food.	1	2	3	4	5	6
Whenever I have cravings, I find myself making plans to eat.	1	2	3	4	5	6
I crave foods when I feel bored, angry, or sad.	1	2	3	4	5	6
I have no will power to resist my food crave.	1	2	3	4	5	6
Once I start eating, I have trouble stopping.	1	2	3	4	5	6
I can't stop thinking about eating no matter how hard I try.	1	2	3	4	5	6
If I give in to a food craving, all control is lost.	1	2	3	4	5	6
Whenever I have a food craving, I keep on thinking about eating until I actually eat	1	2	3	4	5	6

If I am craving something, thoughts of eating it consume me.	1	2	3	4	5	6
My emotions often make me want to eat.	1	2	3	4	5	6
It is hard for me to resist the temptation to eat appetizing foods that are in my reach.	1	2	3	4	5	6

For the following questions, please fill in the appropriate number in the boxes on the right. Remember that the questions only refer to the past four weeks (28 days). **(Overeating)**

Over the past four weeks (28 days) ……

1.	Over the past 28 days, how many <u>times</u> have you eaten what other people would regard as an <u>unusually large amount of food</u> (given the circumstances)	
2.	.... On how many of these times did you have a sense of having lost control over your eating (at the time that you were eating)?	
3.	Over the past 28 days, on how many **<u>DAYS</u>** have such episodes of overeating occurred (i.e., you have eaten an unusually large amount of food <u>and</u> have had a sense of loss of control at the time)?	

Confidence to regulate eating habits (Self-efficacy)

A number of situations are described below that can make it hard to stick to a healthy eating plan. Please rate in each of the blanks on the column how certain you are that you can stick to a healthy diet on a regular basis.

Rate your degree of confidence by recording a number from 0 to 100 using the scale given below:

10	20	30	40	50	60	70	80	90	100

Cannot do at all **Moderately can do** **Highly certain can do**

	Confidence (0-100)
Eating at a restaurant	
When lots of high fat food is available in the house	
Feel a strong urge to eat foods high in fat that you like	
When you are bored	
When someone offers you high fat foods	
When faced with unhealthy foods in a supermarket	
When you are in the company of others	
When you are at work	
When you are at home	
How confident are you that you can eat healthily in the long term (at least the next 5 years)	

Food Frequency Questionnaire

	Never	Once or twice per week	3-4 times per week	5-6 times per week	Once a day	Twice a day	3 or more times pre day
Crisps	1	2	3	4	5	6	7
Chocolate	1	2	3	4	5	6	7
Ice-cream	1	2	3	4	5	6	7
Chips	1	2	3	4	5	6	7
Sweets	1	2	3	4	5	6	7
Cakes	1	2	3	4	5	6	7
Biscuits	1	2	3	4	5	6	7
Pastries/Sweet pies	1	2	3	4	5	6	7
Soft drinks	1	2	3	4	5	6	7
Low sugar/diet soft drinks	1	2	3	4	5	6	7
Alcoholic drinks	1	2	3	4	5	6	7

Appendix 14 Sampling framework for qualitative process evaluation

Cycle 1			
BMI **Age**	**25 – 30**	**30 – 35**	**35+**
<40	M	-	F
40 – 55	F	F x 3	F
55+	F x 2	F	F

Cycle 2			
BMI **Age**	**25 – 30**	**30 – 35**	**35+**
<40	M	F	F x 2
40 – 55	M x 2	F x 2	M
55+	F x 2	-	-

Appendix 15 Semi-structured interview topic guide

The following topic guide may be condensed if it takes more than 80 minutes to deliver and may be amended following feedback from the first few interviews.

PRE INTERVIEW

-Welcome interviewee
-Thank you for agreeing to take part in an interview
- Check understanding of study and purpose of interview
    - focus on the app and its strategies for impulse management
- Check understanding of data protection and how data will be used
- Check consent, can withdraw from interview at any time, consent for recording etc.

SECTION ONE

The aim of this section of the interview is to take a narrative approach to get interviewees' experiences of using the app (0-4 weeks), from their own perspective.
Intro: I'd like to start by asking you a few questions about your experiences with the ImpulsePal app and what made you try it out. [For this section researchers phone showing ImpulsePal can be used to aid discussion.]

Topic question	• **Prompts / Probes**
Why did you decide to take part in this piece of research?	• What prompted you to try it out? • What did you hope would happen? • What were you expecting from it?
If a friend asked you to describe the ImpulsePal programme, what would you say?	• What is involved in using the ImpulsePal app?
What did you think of the programme being delivered via a smartphone app?	•
How did you get on with using app in general?	• How long did it take you to get know how to use it? • How easy /difficult was it to use the app? • Was it easy to find what you were looking for? • What aspects were not easy to use? • What are your thoughts about the notifications? e.g. were they helpful /unhelpful? Were there too many? Were they noticeable?
How did you get on with the content of the ImpulsePal app?	• What did you find helpful • What did you find unhelpful • Were there any parts of the app that were especially positive e.g. where you felt things were really working for you?

	• Were there any parts of the app or it's strategies that were difficult, e.g. where you felt you were slipping? • Was it fun / enjoyable?
Was there anything outside of the programme (such as work, family or social circumstances) that affected how you got on?	
What effect did using this app have on you?	• Have you changed your snacking behaviour in any way? • Have you changed mentally/psychologically in any way? • Do you do anything differently now? • Have you learned anything from using the app?
Have there been any changes in your weight since using the app?	• Do you feel the app has helped? • What strategies do you feel have helped you most • What strategies do you feel have helped you the least, or even hindered your weight management.
Are you still using the app?	• If no: ○ When did you stop using the app? ○ Could you tell us a bit more about why your stopped using the app?
Will you consider continuing using this app?	•
If we were to make the app available to other people, would you change anything about it?	•

CONCLUSION

Thanks for sharing your thoughts in this interview. We will consider what you and other participants say and use it to improve the ImpulsePal app.

We may ask to interview you again in two months' time, to see how things have gone with your weight management.

Appendix 16 ImpulsePal's data driven refinements

ImpulsePal v2	ImpulsePal v3
Includes recognisable drop-down menu to facilitate navigation to personal statistics on impulse management, motivations, and ImpulsePal app instructions.	
Splitting of instruction text over separate screens to facilitate reading in manageable chunks.	Weight self-monitoring function
Minor changes to text to clarify ImpulsePal app and strategy instructions.	
Presenting instruction text in the form of a dialogue between user and the app.	Use on iOS, Windows, Android.
Sequential unlockable content.	
Offers reminder function for the if-then plans.	Enable registration of account and data to be accessed across devices.
Shorter Brain Training task. Split over 3 blocks. Scores are saved even when user only finishes 1 block.	Capturing of weight, motivations, and Danger Zone notification data (i.e., time sent)
Incorporation of healthy "Go" training.	
Offers personalisation of trainable food categories. (e.g., wine and cheese, chocolate and cakes, crisps)	
Offers audio-guided urge surfing.	
Danger Zone postcode look up to facilitate location searching.	

References

Abdullah, A., Peeters, A., de Courten, M., & Stoelwinder, J. (2010). The magnitude of association between overweight and obesity and the risk of diabetes: A meta-analysis of prospective cohort studies. *Diabetes Research and Clinical Practice*, *89*(3), 309–319. https://doi.org/10.1016/j.diabres.2010.04.012

Abraham, C., & Michie, S. (2008). A taxonomy of behavior change techniques used in interventions. *Health Psychology*, *27*(3), 379–387. https://doi.org/10.1037/0278-6133.27.3.379

Abraham, C., Wood, C. E., Johnston, M., Francis, J., Hardeman, W., Richardson, M., & Michie, S. (2015). Reliability of identification of behavior change techniques in intervention descriptions. *Annals of Behavioral Medicine*, *49*(6), 885–900. https://doi.org/10.1007/s12160-015-9727-y

Achtziger, A., Gollwitzer, P. M., & Sheeran, P. (2008). Implementation intentions and shielding goal striving from unwanted thoughts and feelings. *Personality and Social Psychology Bulletin*, *34*(3), 381–393. https://doi.org/10.1177/0146167207311201

Adams, T. D., Gress, R. E., Smith, S. C., Halverson, R. C., Simper, S. C., Rosamond, W. D., … Hunt, S. C. (2007). Long-term mortality after gastric bypass surgery. *New England Journal of Medicine*, *357*(8), 753–761. https://doi.org/10.1056/NEJMoa066603

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, *50*(2), 179–211. https://doi.org/10.1016/0749-5978(91)90020-T

Alberts, H. J. E. M., Mulkens, S., Smeets, M., & Thewissen, R. (2010). Coping with food cravings. Investigating the potential of a mindfulness-based intervention. *Appetite*, *55*(1), 160–163. https://doi.org/10.1016/j.appet.2010.05.044

Alberts, H. J. E. M., Thewissen, R., & Middelweerd, M. (2013). Accepting or suppressing the desire to eat: Investigating the short-term effects of acceptance-based craving regulation. *Eating Behaviors*, *14*(3), 405–409. https://doi.org/10.1016/j.eatbeh.2013.06.008

Alberts, H. J. E. M., Thewissen, R., & Raes, L. (2012). Dealing with problematic eating behaviour. The effects of a mindfulness-based intervention on eating behaviour, food cravings, dichotomous thinking and body image concern. *Appetite*, *58*(3), 847–851. https://doi.org/10.1016/j.appet.2012.01.009

Alexander, J. A., & Hearld, L. R. (2012). Methods and metrics challenges of delivery-system research. *Implementation Science*, *7*, 15. https://doi.org/10.1186/1748-5908-7-15

Allan, J. L., Johnston, M., & Campbell, N. (2010). Unintentional eating. What determines goal-incongruent chocolate consumption? *Appetite*, *54*(2), 422–425. https://doi.org/10.1016/j.appet.2010.01.009

Allom, V., Mullan, B., & Hagger, M. (2015). Does inhibitory control training improve health behaviour? A meta-analysis. *Health Psychology Review*, *0*(ja), 1–38. https://doi.org/10.1080/17437199.2015.1051078

Alshurafa, M., Briel, M., Akl, E. A., Haines, T., Moayyedi, P., Gentles, S. J., … Guyatt, G. H. (2012). Inconsistent definitions for intention-to-treat in relation to missing outcome data: systematic review of the methods literature. *PloS One*, *7*(11), e49163. https://doi.org/10.1371/journal.pone.0049163

Althubaiti, A. (2016). Information bias in health research: definition, pitfalls, and adjustment methods. *Journal of Multidisciplinary Healthcare*, *9*, 211–217. https://doi.org/10.2147/JMDH.S104807

Andrade, J., Pears, S., May, J., & Kavanagh, D. J. (2012). Use of a clay modeling task to reduce chocolate craving. *Appetite*, *58*(3), 955–963. https://doi.org/10.1016/j.appet.2012.02.044

Angrisani, L., Santonicola, A., Iovino, P., Formisano, G., Buchwald, H., & Scopinaro, N. (2015). Bariatric Surgery Worldwide 2013. *Obesity Surgery*, *25*(10), 1822–1832. https://doi.org/10.1007/s11695-015-1657-z

Atkinson, N. L., & Gold, R. S. (2002). The promise and challenge of eHealth interventions. *American Journal of Health Behavior*, *26*(6), 494–503.

Aune, D., Greenwood, D. C., Chan, D. S. M., Vieira, R., Vieira, A. R., Rosenblatt, D. A. N., … Norat, T. (2012). Body mass index, abdominal fatness and pancreatic cancer risk: a systematic review and non-linear dose–response meta-analysis of prospective studies. *Annals of Oncology*, *23*(4), 843–852. https://doi.org/10.1093/annonc/mdr398

Aune, Dagfinn, Sen, A., Prasad, M., Norat, T., Janszky, I., Tonstad, S., … Vatten, L. J. (2016). BMI and all cause mortality: systematic review and non-linear dose-response meta-analysis of 230 cohort studies with 3.74 million deaths among 30.3 million participants. *BMJ*, *353*, i2156. https://doi.org/10.1136/bmj.i2156

Bandura, A. (1998). Health promotion from the perspective of social cognitive theory. *Psychology & Health*, *13*(4), 623–649. https://doi.org/10.1080/08870449808407422

Bandura, A. (2006). Guide for constructing self-efficacy scales. In *Self-efficacy Beliefs of Adolescents* (pp. 307–323). Charlotte, NC: Information Age Publishing.

Bardus, M., Smith, J. R., Samaha, L., & Abraham, C. (2015). Mobile Phone and Web 2.0 technologies for weight management: A systematic scoping review. *Journal of Medical Internet Research*, *17*(11), e259. https://doi.org/10.2196/jmir.5129

Bardus, M., van Beurden, S. B., Smith, J. R., & Abraham, C. (2016). A review and content analysis of engagement, functionality, aesthetics, information quality, and change techniques in the most popular commercial apps for weight management. *International Journal of Behavioral Nutrition and Physical Activity*, *13*, 35. https://doi.org/10.1186/s12966-016-0359-9

Baron, R. M., & Kenny, D. A. (1986). The moderator-mediator variable disctinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, *51*, 1173–1182.

Bartholomew, L. K., Parcel, G. S., Kok, G., Gottlieb, N. H., & Fernandez, M. E. (2011). *Planning Health Promotion Programs. An Intervention Mapping Approach* (3rd ed.). San Francisco: John Wiley & Sons, Ltd.

Bates, B., Cox, L., Nicholson, S., Page, P., Prentice, A., Steer, T., & Swan, G. (2016). *National Diet and Nutrition Survey. Results from Years 5 and 6 (combined) of the Rolling Programms (2012/2013 - 2013-2014)*. London: Public Health England. Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/551352/NDNS_Y5_6_UK_Main_Text.pdf

Batra, P., Das, S. K., Salinardi, T., Robinson, L., Saltzman, E., Scott, T., … Roberts, S. B. (2013). Relationship of cravings with weight loss and hunger. Results from a 6month worksite weight loss intervention. *Appetite*, *69*(Supplement C), 1–7. https://doi.org/10.1016/j.appet.2013.05.002

Baumeister, R. F., & Heatherton, T. F. (1996). Self-regulation failure: An overview. *Psychological Inquiry*, *7*(1), 1–15. https://doi.org/10.1207/s15327965pli0701_1

Baumeister, R. F., Heatherton, T. F., & Tice, D. M. (1994). *Losing Control: How and why People Fail at Self-regulation*. Academic Press.

Baumeister, R. F., Vohs, K. D., & Tice, D. M. (2007). The strength model of self-control. *Current Directions in Psychological Science*, *16*(6), 351–355. https://doi.org/10.1111/j.1467-8721.2007.00534.x

Bennett, G. G., Steinberg, D. M., Stoute, C., Lanpher, M., Lane, I., Askew, S., … Baskin, M. L. (2014). Electronic health (eHealth) interventions for weight management among racial/ethnic minority adults: a systematic review. *Obesity Reviews: An Official Journal of the International Association for the Study of Obesity*, *15 Suppl 4*, 146–158. https://doi.org/10.1111/obr.12218

Boekhout, J. M., Peels, D. A., Berendsen, B. A., Bolman, C. A., & Lechner, L. (2017). An eHealth Intervention to Promote Physical Activity and Social Network of Single, Chronically Impaired Older Adults: Adaptation of an Existing Intervention Using Intervention Mapping. *JMIR Research Protocols*, *6*(11). https://doi.org/10.2196/resprot.8093

Bond, D. S., Phelan, S., Leahey, T. M., Hill, J. O., & Wing, R. R. (2009). Weight loss maintenance in successful weight losers: surgical versus non-surgical methods. *International Journal of Obesity (2005)*, *33*(1), 173–180. https://doi.org/10.1038/ijo.2008.256

Borrelli, B. (2011). The assessment, monitoring, and enhancement of treatment fidelity in public health clinical trials. *Journal of Public Health Dentistry*, *71*(s1), S52–S63. https://doi.org/10.1111/j.1752-7325.2011.00233.x

Borrelli, B., Sepinwall, D., Ernst, D., Bellg, A. J., Czajkowski, S., Breger, R., … Orwig, D. (2005). A new tool to assess treatment fidelity and evaluation of treatment fidelity across 10 years of health behavior research. *Journal* *of Consulting and Clinical Psychology*, *73*(5), 852–860. https://doi.org/10.1037/0022-006X.73.5.852

Boschen, M. J., & Casey, L. M. (2008). The use of mobile telephones as adjuncts to cognitive behavioral psychotherapy. *Professional Psychology: Research and Practice*, *39*(5), 546–552. https://doi.org/10.1037/0735-7028.39.5.546

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Brethauer, S. A., Aminian, A., Romero-Talamás, H., Batayyah, E., Mackey, J., Kennedy, L., … Schauer, P. R. (2013). Can diabetes be surgically cured? *Annals of Surgery*, *258*(4), 628–637. https://doi.org/10.1097/SLA.0b013e3182a5034b

Brown, J. D., Buscemi, J., Milsom, V., Malcolm, R., & O'Neil, P. M. (2016). Effects on cardiovascular risk factors of weight losses limited to 5–10 %. *Translational Behavioral Medicine*, *6*(3), 339–346. https://doi.org/10.1007/s13142-015-0353-9

Buchwald, H., Avidor, Y., Braunwald, E., Jensen, M. D., Pories, W., Fahrbach, K., & Schoelles, K. (2004). Bariatric surgery: A systematic review and meta-analysis. *JAMA*, *292*(14), 1724–1737. https://doi.org/10.1001/jama.292.14.1724

Buckland, N. J., Finlayson, G., & Hetherington, M. M. (2013). Pre-exposure to diet-congruent food reduces energy intake in restrained dieting women. *Eating Behaviors*, *14*(3), 249–254. https://doi.org/10.1016/j.eatbeh.2013.03.003

Butland, B., Jebb, S., Kopelman, P., McPherson, K., Thomas, S., Mardell, K., & Parry, B. (2007). *Foresight: Tackling Obesities: Future Choices - Project report.* (2nd ed.). London: Government Office for Science.

Cappelleri, J. C., Bushmakin, A. G., Gerber, R. A., Leidy, N. K., Sexton, C. C., Karlsson, J., & Lowe, M. R. (2009). Evaluating the Power of Food Scale in obese subjects and a general sample of individuals: development and measurement properties. *International Journal of Obesity*, *33*(8), 913. https://doi.org/10.1038/ijo.2009.107

Castellanos, E. H., Charboneau, E., Dietrich, M. S., Park, S., Bradley, B. P., Mogg, K., & Cowan, R. L. (2009). Obese adults have visual attention bias for food cue images: evidence for altered reward system function. *International Journal of Obesity*, *33*(9), 1063–1073. https://doi.org/10.1038/ijo.2009.138

Christensen, R., Kristensen, P. K., Bartels, E. M., Bliddal, H., & Astrup, A. (2007). Efficacy and safety of the weight-loss drug rimonabant: a meta-analysis of randomised trials. *Lancet*, *370*(9600), 1706–1713. https://doi.org/10.1016/S0140-6736(07)61721-8

Christou, N. V., Look, D., & MacLean, L. D. (2006). Weight gain after short- and long-limb gastric bypass in patients followed for longer than 10 Years. *Annals of Surgery*, *244*(5), 734–740. https://doi.org/10.1097/01.sla.0000217592.04061.d5

Churchill, S., & Jessop, D. C. (2011). Reflective and non-reflective antecedents of health-related behaviour: Exploring the relative contributions of impulsivity and implicit self-control to the prediction of dietary behaviour. *British Journal of Health Psychology*, *16*(2), 257–272. https://doi.org/10.1348/135910710X498688

Coelho, J. S., Jansen, A., Roefs, A., & Nederkoorn, C. (2009). Eating behavior in response to food-cue exposure: examining the cue-reactivity and counteractive-control models. *Psychology of Addictive Behaviors: Journal of the Society of Psychologists in Addictive Behaviors*, *23*(1), 131–139. https://doi.org/10.1037/a0013610

Colles, S. L., Dixon, J. B., & O'Brien, P. E. (2008). Grazing and loss of control related to eating: Two high-risk factors following bariatric surgery. *Obesity*, *16*(3), 615–622. https://doi.org/10.1038/oby.2007.101

Collins, L. M., Dziak, J. J., Kugler, K. C., & Trail, J. B. (2014). Factorial Experiments: Efficient Tools for Evaluation of Intervention Components. *American Journal of Preventive Medicine*, *47*(4), 498–504. https://doi.org/10.1016/j.amepre.2014.06.021

Colquitt, J. L., Picot, J., Loveman, E., & Clegg, A. J. (2009). Surgery for obesity - Colquitt - 2009 - The Cochrane Library - Wiley Online Library, (2), CD003641. https://doi.org/DOI: 10.1002/14651858.CD003641.pub3.

Craig, G. (2011). *The EFT manual*. CA: Psychology Press.

Craig, P., Dieppe, P., Macintyre, S., Michie, S., Nazareth, I., & Petticrew, M. (2008). Developing and evaluating complex interventions: the new

Medical Research Council guidance. *BMJ*, *337*(sep29 1), a1655–a1655. https://doi.org/10.1136/bmj.a1655

Craig, P., Dieppe, P., Macintyre, S., Michie, S., Nazareth, I., & Petticrew, M. (2013). Developing and evaluating complex interventions: The new Medical Research Council guidance. *International Journal of Nursing Studies*, *50*(5), 587–592. https://doi.org/10.1016/j.ijnurstu.2012.09.010

Cugelman, B. (2013). Gamification: What it is and why it matters to digital health behavior change developers. *JMIR Serious Games*, *1*(1). https://doi.org/10.2196/games.3139

Daniel, T. O., Stanton, C. M., & Epstein, L. H. (2013). The future is now: Reducing impulsivity and energy intake using Episodic Future Thinking. *Psychological Science*, *24*(11), 2339–2342. https://doi.org/10.1177/0956797613488780

Deci, E. L., & Ryan, R. M. (2000). The “What” and “Why” of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry*, *11*(4), 227–268. https://doi.org/10.1207/S15327965PLI1104_01

Deloitte. (2017). *The Deloitte Consumer Review: Digital Predictions 2017*. London: The Creative Studio at Deloitte.

Dennison, L., Morrison, L., Conway, G., & Yardley, L. (2013). Opportunities and challenges for smartphone applications in supporting health behavior change: Qualitative study. *Journal of Medical Internet Research*, *15*(4), e86. https://doi.org/10.2196/jmir.2583

Dent, M., Chrisopoulos, S., Mulhall, C., & Ridler, C. (2010). *Bariatric surgery for obesity*. Oxford: National Obesity Observatory. Retrieved from http://www.noo.org.uk/uploads/doc/vid_8774_NOO%20Bariatric%20Surgery%20for%20Obesity%20FINAL%20MG%20011210.pdf

Department for Communities and Local Government. (2016). *Local Authority Revenue Expenditure and Financing England: 2016-17 Budget*. National Statistics.

Department for Communities and Local Government. (2017). *Local Authority Revenue Expenditure and Financing England: 2017-2018 Budget*. National Statistics.

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness: Defining “gamification” (pp. 9–15). Presented at the Proceedings of the 15th International Academic MindTrek

Conference: Envisioning Future Media Environments, MindTrek 2011. https://doi.org/10.1145/2181037.2181040

Diliberti, N., Bordi, P. L., Conklin, M. T., Roe, L. S., & Rolls, B. J. (2004). Increased Portion Size Leads to Increased Energy Intake in a Restaurant Meal. *Obesity Research*, *12*(3), 562–568. https://doi.org/10.1038/oby.2004.64

Dombrowski, S. U., Knittle, K., Avenell, A., Araújo-Soares, V., & Sniehotta, F. F. (2014). Long term maintenance of weight loss with non-surgical interventions in obese adults: systematic review and meta-analyses of randomised controlled trials. *BMJ*, *348*, g2646. https://doi.org/10.1136/bmj.g2646

Dombrowski, Stephan U., Sniehotta, F. F., Avenell, A., Johnston, M., MacLennan, G., & Araújo-Soares, V. (2012). Identifying active ingredients in complex behavioural interventions for obese adults with obesity-related co-morbidities or additional risk factors for co-morbidities: a systematic review. *Health Psychology Review*, *6*(1), 7–32. https://doi.org/10.1080/17437199.2010.513298

Dombrowski, S.U., Sniehotta, F. F., Avenell, A., & Coyne, J. (2007). Current issues and future directions in Psychology and Health : Towards a cumulative science of behaviour change: Do current conduct and reporting of behavioural interventions fall short of best practice? *Psychology & Health*, *22*(8), 869–874. https://doi.org/10.1080/08870440701520973

Douglas Ian J., Bhaskaran Krishnan, Batterham Rachel L., & Smeeth Liam. (2015). The effectiveness of pharmaceutical interventions for obesity: weight loss with orlistat and sibutramine in a United Kingdom population-based cohort. *British Journal of Clinical Pharmacology*, *79*(6), 1020–1027. https://doi.org/10.1111/bcp.12578

Dumas, A.-A., Lemieux, S., Lapointe, A., Provencher, V., Robitaille, J., & Desroches, S. (2017). Development of an evidence-informed blog to promote healthy eating among mothers: Use of the Intervention Mapping Protocol. *JMIR Research Protocols*, *6*(5). https://doi.org/10.2196/resprot.7147

Eberl, C., Wiers, R. W., Pawelczack, S., Rinck, M., Becker, E. S., & Lindenmeyer, J. (2013). Approach bias modification in alcohol dependence: Do clinical effects replicate and for whom does it work best? *Developmental Cognitive Neuroscience*, *4*, 38–51. https://doi.org/10.1016/j.dcn.2012.11.002

Eldridge, S. M., Chan, C. L., Campbell, M. J., Bond, C. M., Hopewell, S., Thabane, L., & Lancaster, G. A. (2016). CONSORT 2010 statement: extension to randomised pilot and feasibility trials. *The BMJ*, *355*. https://doi.org/10.1136/bmj.i5239

Elfhag, K., & Rössner, S. (2005). Who succeeds in maintaining weight loss? A conceptual review of factors associated with weight loss maintenance and weight regain. *Obesity Reviews*, *6*(1), 67–85. https://doi.org/10.1111/j.1467-789X.2005.00170.x

Erskine, J. A. K. (2008). Resistance can be futile: investigating behavioural rebound. *Appetite*, *50*(2–3), 415–421. https://doi.org/10.1016/j.appet.2007.09.006

Erskine, J. A. K., & Georgiou, G. J. (2010). Effects of thought suppression on eating behaviour in restrained and non-restrained eaters. *Appetite*, *54*(3), 499–503. https://doi.org/10.1016/j.appet.2010.02.001

Erskine, J. A. K., Georgiou, G. J., & Kvavilashvili, L. (2010). I suppress, therefore I smoke effects of Thought Suppression on smoking behavior. *Psychological Science*, *21*(9), 1225–1230. https://doi.org/10.1177/0956797610378687

Fairburn, C. G., & Beglin, S. J. (1994). Assessment of eating disorders: Interview or self-report questionnaire? *International Journal of Eating Disorders*, *16*(4), 363–370. https://doi.org/10.1002/1098-108X(199412)16:4<363::AID-EAT2260160405>3.0.CO;2-#

Fedoroff, I., Polivy, J., & Herman, C. P. (2003). The specificity of restrained versus unrestrained eaters' responses to food cues: general desire to eat, or craving for the cued food? *Appetite*, *41*(1), 7–13.

Ferriter, C., & Ray, L. A. (2011). Binge eating and binge drinking: An integrative review. *Eating Behaviors*, *12*(2), 99–107. https://doi.org/10.1016/j.eatbeh.2011.01.001

Field, A. E., Coakley, E. H., Must, A., & et al. (2001). Impact of overweight on the risk of developing common chronic diseases during a 10-year period. *Archives of Internal Medicine*, *161*(13), 1581–1586. https://doi.org/10.1001/archinte.161.13.1581

Finkelstein, E. A., & Kruger, E. (2014). Meta- and cost-effectiveness analysis of commercial weight loss strategies. *Obesity*, *22*(9), 1942–1951. https://doi.org/10.1002/oby.20824

Fishbein, M., & Ajzen, I. (2010). *Predicting and Changing Behavior: The Reasoned Action Approach*. New York: Psychology Press.

Fontaine, Kevin R., Bartlett, S. J., & Barofsky, I. (2000). Health-related quality of life among obese persons seeking and not currently seeking treatment. *International Journal of Eating Disorders*, *27*(1), 101–105. https://doi.org/10.1002/(SICI)1098-108X(200001)27:1<101::AID-EAT12>3.0.CO;2-D

Fontaine, K.R., Redden, D., Wang, C., Westfall, A., & Allison, D. (2003). Years of life lost due to obesity. *JAMA*, *289*(2), 187–193. https://doi.org/10.1001/jama.289.2.187

Forman, E. M., Butryn, M. L., Hoffman, K. L., & Herbert, J. D. (2009). An open trial of an acceptance-based behavioral intervention for weight Loss. *Cognitive and Behavioral Practice*, *16*(2), 223–235. https://doi.org/10.1016/j.cbpra.2008.09.005

Forman, E. M., Butryn, M. l., Juarascio, A. s., Bradley, L. e., Lowe, M. r., Herbert, J. d., & Shaw, J. a. (2013). The mind your health project: A randomized controlled trial of an innovative behavioral treatment for obesity. *Obesity*, *21*(6), 1119–1126. https://doi.org/10.1002/oby.20169

Forman, E. M., Hoffman, K. L., Juarascio, A. S., Butryn, M. L., & Herbert, J. D. (2013). Comparison of acceptance-based and standard cognitive-based coping strategies for craving sweets in overweight and obese women. *Eating Behaviors*, *14*(1), 64–68. https://doi.org/10.1016/j.eatbeh.2012.10.016

Forman, E. M., Hoffman, K. L., McGrath, K. B., Herbert, J. D., Brandsma, L. L., & Lowe, M. R. (2007). A comparison of acceptance- and control-based strategies for coping with food cravings: an analog study. *Behaviour Research and Therapy*, *45*(10), 2372–2386. https://doi.org/10.1016/j.brat.2007.04.004

Franken, I. H. A. (2003). Drug craving and addiction: integrating psychological and neuropsychopharmacological approaches. *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, *27*(4), 563–579. https://doi.org/10.1016/S0278-5846(03)00081-2

French, S. A., Story, M., & Jeffery, and R. W. (2001). Environmental influences on eating and physical activity. *Annual Review of Public Health*, *22*(1), 309–335. https://doi.org/10.1146/annurev.publhealth.22.1.309

Friese, M., Hofmann, W., & Wiers, R. W. (2011). On taming horses and strengthening riders: Recent developments in research on interventions to improve self-control in health behaviors. *Self and Identity*, *10*(3), 336–351. https://doi.org/10.1080/15298868.2010.536417

Gerrard, M., Gibbons, F. X., Houlihan, A. E., Stock, M. L., & Pomery, E. A. (2008). A dual-process approach to health risk decision making: The prototype willingness model. *Developmental Review*, *28*(1), 29–61. https://doi.org/10.1016/j.dr.2007.10.001

Geyskens, K., Dewitte, S., Pandelaere, M., & Warlop, L. (2008). Tempt me just a little bit more: The effect of prior food temptation actionability on goal activation and consumption. *Journal of Consumer Research*, *35*(4), 600–610. https://doi.org/10.1086/591068

Geyskens, K., Soetens, B., & Roets, A. (2010). Exposure makes the heart grow less fond!: the effects of exposure to palatable foods on the subsequent attention processing of food cues. *Journal of Health Psychology*, *15*(2), 230–238. https://doi.org/10.1177/1359105309348807

Gillison, F., Greaves, C. J., Stathi, A., Ramsay, R., Bennett, P., Taylor, G., … Chandler, R. (2012). ‘Waste the waist’: The development of an intervention to promote changes in diet and physical activity for people with high cardiovascular risk. *British Journal of Health Psychology*, *17*(2), 327–345. https://doi.org/10.1111/j.2044-8287.2011.02040.x

Giuliani, N. R., Calcott, R. D., & Berkman, E. T. (2013). Piece of cake. Cognitive reappraisal of food craving. *Appetite*, *64*, 56–61. https://doi.org/10.1016/j.appet.2012.12.020

Glasgow, R. E., Nelson, C. C., Strycker, L. A., & King, D. K. (2006). Using RE-AIM metrics to evaluate diabetes self-management support interventions. *American Journal of Preventive Medicine*, *30*(1), 67–73. https://doi.org/10.1016/j.amepre.2005.08.037

Gloy, V. L., Briel, M., Bhatt, D. L., Kashyap, S. R., Schauer, P. R., Mingrone, G., … Nordmann, A. J. (2013). Bariatric surgery versus non-surgical treatment for obesity: a systematic review and meta-analysis of randomised controlled trials. *BMJ*, *347*, f5934. https://doi.org/10.1136/bmj.f5934

Gollwitzer, P. M., & Sheeran, P. (2006). Implementation intentions and goal achievement: A meta-analysis of effects and processes. *Advances in Experimental Social Psychology*, *38*, 69–119. https://doi.org/10.1016/S0065-2601(06)38002-1

Gomm, R., & Davies, C. (2000). *Using Evidence in Health and Social Care*. London: Sage.

Gorden, M. E. (2014). Benchmarking the Half-Life and Decay of Mobile Apps. Retrieved August 7, 2017, from http://flurrymobile.tumblr.com/post/115191376315/benchmarking-the-half-life-and-decay-of-mobile

Gracia, J. A., Martínez, M., Elia, M., Aguilella, V., Royo, P., Jiménez, A., … Arribas, D. (2009). Obesity surgery results depending on technique performed: Long-term outcome. *Obesity Surgery*, *19*(4), 432–438. https://doi.org/10.1007/s11695-008-9762-x

Gray-Burrows, K. A., Day, P. F., Marshman, Z., Aliakbari, E., Prady, S. L., & McEachan, R. R. C. (2016). Using intervention mapping to develop a home-based parental-supervised toothbrushing intervention for young children. *Implementation Science*, *11*, 61. https://doi.org/10.1186/s13012-016-0416-4

Greaves, C. J., & Campbell, J. L. (2007). Supporting self-care in general practice. *The British Journal of General Practice*, *57*(543), 814–821.

Greaves, C. J., Gillison, F., Stathi, A., Bennett, P., Reddy, P., Dunbar, J., … Taylor, G. (2015). Waste the waist: a pilot randomised controlled trial of a primary care based intervention to support lifestyle change in people with high cardiovascular risk. *International Journal of Behavioral Nutrition and Physical Activity*, *12*(1), 1. https://doi.org/10.1186/s12966-014-0159-z

Greaves, C. J., Sheppard, K. E., Abraham, C., Hardeman, W., Roden, M., Evans, P. H., … IMAGE Study Group. (2011). Systematic review of reviews of intervention components associated with increased effectiveness in dietary and physical activity interventions. *BMC Public Health*, *11*, 119. https://doi.org/10.1186/1471-2458-11-119

Greaves, C. J., Wingham, J., Deighan, C., Doherty, P., Elliott, J., Armitage, W., … Taylor, R. S. (2016). Optimising self-care support for people with heart failure and their caregivers: development of the Rehabilitation Enablement in Chronic Heart Failure (REACH-HF) intervention using intervention mapping. *Pilot and Feasibility Studies*, *2*, 37. https://doi.org/10.1186/s40814-016-0075-x

Greenwald, A. G., McGhee, D. E., & Schwartz, J. L. (1998). Measuring individual differences in implicit cognition: the implicit association test. *Journal of Personality and Social Psychology*, *74*(6), 1464–1480.

Griffiths, F., Lindenmeyer, A., Powell, J., Lowe, P., & Thorogood, M. (2006). Why are health care interventions delivered over the internet? A systematic review of the published literature. *Journal of Medical Internet Research*, *8*(2), e10. https://doi.org/10.2196/jmir.8.2.e10

Guerrieri, R., Nederkoorn, C., & Jansen, A. (2007a). How impulsiveness and variety influence food intake in a sample of healthy women. *Appetite*, *48*(1), 119–122. https://doi.org/10.1016/j.appet.2006.06.004

Guerrieri, R., Nederkoorn, C., & Jansen, A. (2007b). The interaction between impulsivity and a varied food environment: its influence on food intake and overweight. *International Journal of Obesity*, *32*(4), 708–714. https://doi.org/10.1038/sj.ijo.0803770

Guerrieri, R., Nederkoorn, C., & Jansen, A. (2012). Disinhibition is easier learned than inhibition. The effects of (dis)inhibition training on food intake. *Appetite*, *59*(1), 96–99. https://doi.org/10.1016/j.appet.2012.04.006

Hagger, M. S., Panetta, G., Leung, C.-M., Wong, G. G., Wang, J. C. K., Chan, D. K. C., … Chatzisarantis, N. L. D. (2013). Chronic inhibition, self-control and eating behavior: Test of a ‘Resource Depletion’ model. *PLOS ONE*, *8*(10), e76888. https://doi.org/10.1371/journal.pone.0076888

Hagger, M. S., Wood, C., Stiff, C., & Chatzisarantis, N. L. (2010). Ego depletion and the strength model of self-control: a meta-analysis. *Psychological Bulletin*, *136*(4), 495.

Hamilton, J., Fawson, S., May, J., Andrade, J., & Kavanagh, D. J. (2013). Brief guided imagery and body scanning interventions reduce food cravings. *Appetite*, *71*, 158–162. https://doi.org/10.1016/j.appet.2013.08.005

Hamman, R. F., Wing, R. R., Edelstein, S. L., Lachin, J. M., Bray, G. A., Delahanty, L., … Wylie-Rosett, J. (2006). Effect of weight loss with lifestyle intervention on risk of diabetes. *Diabetes Care*, *29*(9), 2102–2107. https://doi.org/10.2337/dc06-0560

Hardman, C. A., Rogers, P. J., Etchells, K. A., Houstoun, K. V. E., & Munafò, M. R. (2013). The effects of food-related attentional bias training on appetite and food intake. *Appetite*, *71*, 295–300. https://doi.org/10.1016/j.appet.2013.08.021

Hare, T. A., Malmaud, J., & Rangel, A. (2011). Focusing attention on the health aspects of foods changes value Signals in vmPFC and improves dietary choice. *Journal of Neuroscience*, *31*(30), 11077–11087. https://doi.org/10.1523/JNEUROSCI.6383-10.2011

Hartmann-Boyce, J., Johns, D. J., Jebb, S. A., Aveyard, P., & Behavioural Weight Management Review Group. (2014). Effect of behavioural techniques and delivery mode on effectiveness of weight management: systematic review, meta-analysis and meta-regression. *Obesity Reviews*, *15*(7), 598–609. https://doi.org/10.1111/obr.12165

Harvey, K., Kemps, E., & Tiggemann, M. (2005). The nature of imagery processes underlying food cravings. *British Journal of Health Psychology*, *10*(Pt 1), 49–56. https://doi.org/10.1348/135910704X14249

Hattar, A., Hagger, M. S., & Pal, S. (2015). Weight-loss intervention using implementation intentions and mental imagery: a randomised control trial study protocol. *BMC Public Health*, *15*, 196. https://doi.org/10.1186/s12889-015-1578-8

Hayes, A. F. (2012). PROCESS: A veratile computational tool for observed variable mediation, moderation, and conditional process modelling [White paper]. Retrieved from http://www.afhayes.com/ public/process2012.pdf

Health and Social Care Information Centre. (2013). *Health Survey for England 2013*. HSCIC. Retrieved from http://www.hscic.gov.uk/catalogue/PUB10364/obes-phys-acti-diet-eng-2013-rep.pdf

Hendrickson, K. L., & Rasmussen, E. B. (2013). Effects of mindful eating training on delay and probability discounting for food and money in obese and healthy-weight individuals. *Behaviour Research and Therapy*, *51*(7), 399–409. https://doi.org/10.1016/j.brat.2013.04.002

Higgins, J. P., Altman, D. G., & Sterne, J. A. C. (2011). Chapter 8: Assessing Risk of Bias in Included Studies. In J. P. Higgins & S. Green (Eds.), *Cochrane Handbook for Systematic Reviews of Interventions* (5.1.0). The Cochrane Collaboration. Retrieved from https://onlinelibrary.wiley.com/doi/10.1002/9780470712184.ch8

Hoddinott, P. (2015). A new era for intervention development studies. *Pilot and Feasibility Studies*, *1*(1), 1–4. https://doi.org/10.1186/s40814-015-0032-0

Hoefling, A., & Strack, F. (2008). The tempting effect of forbidden foods. High calorie content evokes conflicting implicit and explicit evaluations in restrained eaters. *Appetite*, *51*(3), 681–689. https://doi.org/10.1016/j.appet.2008.06.004

Hoffmann, T. C., Glasziou, P. P., Boutron, I., Milne, R., Perera, R., Moher, D., … Michie, S. (2014). Better reporting of interventions: template for intervention description and replication (TIDieR) checklist and guide. *BMJ*, *348*, g1687. https://doi.org/10.1136/bmj.g1687

Hofmann, W., Deutsch, R., Lancaster, K., & Banaji, M. R. (2010). Cooling the heat of temptation: Mental self-control and the automatic evaluation of tempting stimuli. *European Journal of Social Psychology*, *40*(1), 17–25. https://doi.org/10.1002/ejsp.708

Hofmann, W., Friese, M., & Roefs, A. (2009). Three ways to resist temptation: The independent contributions of executive attention, inhibitory control, and affect regulation to the impulse control of eating behavior. *Journal of Experimental Social Psychology*, *45*(2), 431–435. https://doi.org/10.1016/j.jesp.2008.09.013

Hofmann, W., Friese, M., & Strack, F. (2009). Impulse and self-control from a dual-systems perspective. *Perspectives on Psychological Science*, *4*(2), 162–176. https://doi.org/10.1111/j.1745-6924.2009.01116.x

Hofmann, W., Friese, M., & Wiers, R. W. (2008). Impulsive versus reflective influences on health behavior: a theoretical framework and empirical review. *Health Psychology Review*, *2*(2), 111–137. https://doi.org/10.1080/17437190802617668

Hofmann, W., Rauch, W., & Gawronski, B. (2007a). And deplete us not into temptation: Automatic attitudes, dietary restraint, and self-regulatory resources as determinants of eating behavior. *Journal of Experimental Social Psychology*, *43*(3), 497–504. https://doi.org/10.1016/j.jesp.2006.05.004

Hofmann, W., Rauch, W., & Gawronski, B. (2007b). And deplete us not into temptation: Automatic attitudes, dietary restraint, and self-regulatory resources as determinants of eating behavior. *Journal of Experimental Social Psychology*, *43*(3), 497–504. https://doi.org/10.1016/j.jesp.2006.05.004

Hong, J., & Lee, A. Y. (2008). Be fit and be strong: Mastering self-regulation through regulatory fit. *Journal of Consumer Research*, *34*(5), 682–695. https://doi.org/10.1086/521902

Hooper, N., Sandoz, E. K., Ashton, J., Clarke, A., & McHugh, L. (2012). Comparing thought suppression and acceptance as coping techniques for food cravings. *Eating Behaviors*, *13*(1), 62–64. https://doi.org/10.1016/j.eatbeh.2011.10.002

Hormes, J. M., & Meule, A. (2016). Psychometric properties of the English Food Cravings Questionnaire-Trait-reduced (FCQ-T-r). *Eating Behaviors*, *20*(Supplement C), 34–38. https://doi.org/10.1016/j.eatbeh.2015.11.011

Hou, R., Mogg, K., Bradley, B. P., Moss-Morris, R., Peveler, R., & Roefs, A. (2011). External eating, impulsivity and attentional bias to food cues. *Appetite*, *56*(2), 424–427. https://doi.org/10.1016/j.appet.2011.01.019

Houben, K. (2011). Overcoming the urge to splurge: Influencing eating behavior by manipulating inhibitory control. *Journal of Behavior Therapy and Experimental Psychiatry*, *42*(3), 384–388. https://doi.org/10.1016/j.jbtep.2011.02.008

Houben, K., & Jansen, A. (2011). Training inhibitory control. A recipe for resisting sweet temptations. *Appetite*, *56*(2), 345–349. https://doi.org/10.1016/j.appet.2010.12.017

Hsu, Y.-W., Chu, D.-C., Ku, P.-W., Liou, T.-H., & Chou, P. (2010). Pharmacotherapy for obesity: Past, present and future. *Journal of Experimental & Clinical Medicine*, *2*(3), 118–123. https://doi.org/10.1016/S1878-3317(10)60019-8

Hutchesson, M. J., Rollo, M. E., Krukowski, R., Ells, L., Harvey, J., Morgan, P. J., … Collins, C. E. (2015). eHealth interventions for the prevention and treatment of overweight and obesity in adults: a systematic review with meta-analysis. *Obesity Reviews*, *16*(5), 376–392. https://doi.org/10.1111/obr.12268

Hwang, K. O., Ning, J., Trickey, A. W., & Sciamanna, C. N. (2013). Website usage and weight loss in a free commercial online weight loss program: retrospective cohort study. *Journal of Medical Internet Research*, *15*(1), e11. https://doi.org/10.2196/jmir.2195

Internet Live Stats. (n.d.). U.K. Internet Users. Retrieved October 28, 2016, from http://www.internetlivestats.com/internet-users/uk/

Janse Van Rensburg, K., Taylor, A., Hodgson, T., & Benattayallah, A. (2009). Acute exercise modulates cigarette cravings and brain activation in response to smoking-related images: an fMRI study. *Psychopharmacology*, *203*(3), 589–598. https://doi.org/10.1007/s00213-008-1405-3

Jebb, S. A., Ahern, A. L., Olson, A. D., Aston, L. M., Holzapfel, C., Stoll, J., … Caterson, I. D. (2011). Primary care referral to a commercial provider for weight loss treatment versus standard care: a randomised controlled trial. *The Lancet*, *378*(9801), 1485–1492. https://doi.org/10.1016/S0140-6736(11)61344-5

Jeffery, R. W., Drewnowski, A., Epstein, L. H., Stunkard, A. J., Wilson, G. T., Wing, R. R., & Hill, D. R. (2000). Long-term maintenance of weight loss: current status. *Health Psychology: Official Journal of the Division of Health Psychology, American Psychological Association*, *19*(1 Suppl), 5–16.

Jenkins, K. T., & Tapper, K. (2014). Resisting chocolate temptation using a brief mindfulness strategy. *British Journal of Health Psychology*, *19*(3), 509–522. https://doi.org/10.1111/bjhp.12050

Johnson, P. O., & Fay, L. C. (1950). The Johnson-Neyman technique, its theory and application. *Psychometrika*, *15*(4), 349–367. https://doi.org/10.1007/BF02288864

Johnston, L., Bulik, C. M., & Anstiss, V. (1999). Suppressing thoughts about chocolate. *The International Journal of Eating Disorders*, *26*(1), 21–27.

Jolly, K., Lewis, A., Beach, J., Denley, J., Adab, P., Deeks, J. J., … Aveyard, P. (2011). Comparison of range of commercial or primary care led weight reduction programmes with minimal intervention control for weight loss in obesity: Lighten Up randomised controlled trial. *BMJ*, *343*(nov03 2), d6500–d6500. https://doi.org/10.1136/bmj.d6500

Jordan, C. H., Wang, W., Donatoni, L., & Meier, B. P. (2014). Mindful eating: Trait and state mindfulness predict healthier eating behavior. *Personality and Individual Differences*, *68*, 107–111. https://doi.org/10.1016/j.paid.2014.04.013

Jordan, H., Roderick, P., & Martin, D. (2004). The Index of Multiple Deprivation 2000 and accessibility effects on health. *Journal of Epidemiology & Community Health*, *58*(3), 250–257. https://doi.org/10.1136/jech.2003.013011

Julious, S. A. (2005). Sample size of 12 per group rule of thumb for a pilot study. *Pharmaceutical Statistics*, *4*(4), 287–291. https://doi.org/10.1002/pst.185

Jumbe, S., Bartlett, C., Jumbe, S. L., & Meyrick, J. (2016). The effectiveness of bariatric surgery on long term psychosocial quality of life – A systematic review. *Obesity Research & Clinical Practice*, *10*(3), 225–242. https://doi.org/10.1016/j.orcp.2015.11.009

Karl, J. P., Young, A. J., Rood, J. C., & Montain, S. J. (2013). Independent and combined effects of eating rate and energy density on energy intake, appetite, and gut hormones. *Obesity*, *21*(3), E244–E252. https://doi.org/10.1002/oby.20075

Karlsson, J., Persson, L.-O., Sjöström, L., & Sullivan, M. (2000). Psychometric properties and factor structure of the Three-Factor Eating Questionnaire (TFEQ) in obese men and women. Results from the Swedish Obese Subjects (SOS) study. *International Journal of Obesity*, *24*(12), 1715. https://doi.org/10.1038/sj.ijo.0801442

Karmali, S., Brar, B., Shi, X., Sharma, A. M., Gara, C. de, & Birch, D. W. (2013). Weight Recidivism Post-Bariatric Surgery: A Systematic Review. *Obesity Surgery*, *23*(11), 1922–1933. https://doi.org/10.1007/s11695-013-1070-4

Katan, M. B. (2009). Weight-loss diets for the prevention and treatment of obesity. *New England Journal of Medicine*, *360*(9), 923–925. https://doi.org/10.1056/NEJMe0810291

Kavanagh, D. J., Andrade, J., & May, J. (2005). Imaginary relish and exquisite torture: The Elaborated Intrusion Theory of desire. *Psychological Review*, *112*(2), 446–467. https://doi.org/10.1037/0033-295X.112.2.446

Kemps, E., & Tiggemann, M. (2007). Modality-specific imagery reduces cravings for food: an application of the elaborated intrusion theory of desire to food craving. *Journal of Experimental Psychology. Applied*, *13*(2), 95–104. https://doi.org/10.1037/1076-898X.13.2.95

Kemps, E., & Tiggemann, M. (2013a). Hand-held dynamic visual noise reduces naturally occurring food cravings and craving-related consumption. *Appetite*, *68*(Supplement C), 152–157. https://doi.org/10.1016/j.appet.2013.05.001

Kemps, E., & Tiggemann, M. (2013b). Olfactory stimulation curbs food cravings. *Addictive Behaviors*, *38*(2), 1550–1554. https://doi.org/10.1016/j.addbeh.2012.06.001

Kemps, E., Tiggemann, M., & Bettany, S. (2012). Non-food odorants reduce chocolate cravings. *Appetite*, *58*(3), 1087–1090. https://doi.org/10.1016/j.appet.2012.03.002

Kemps, E., Tiggemann, M., & Christianson, R. (2008). Concurrent visuo-spatial processing reduces food cravings in prescribed weight-loss dieters. *Journal of Behavior Therapy and Experimental Psychiatry*, *39*(2), 177–186. https://doi.org/10.1016/j.jbtep.2007.03.001

Kemps, E., Tiggemann, M., & Hart, G. (2005). Chocolate cravings are susceptible to visuo-spatial interference. *Eating Behaviors*, *6*(2), 101–107. https://doi.org/10.1016/j.eatbeh.2004.08.006

Kemps, E., Tiggemann, M., Martin, R., & Elliott, M. (2013). Implicit approach-avoidance associations for craved food cues. *Journal of Experimental Psychology. Applied*, *19*(1), 30–38. https://doi.org/10.1037/a0031626

Kemps, E., Tiggemann, M., Orr, J., & Grear, J. (2014). Attentional retraining can reduce chocolate consumption. *Journal of Experimental Psychology. Applied*, *20*(1), 94–102. https://doi.org/10.1037/xap0000005

Kemps, E., Tiggemann, M., Woods, D., & Soekov, B. (2004). Reduction of food cravings through concurrent visuospatial processing. *International Journal of Eating Disorders*, *36*(1), 31–40. https://doi.org/10.1002/eat.20005

Kent, S., Fusco, F., Gray, A., Jebb, S. A., Cairns, B. J., & Mihaylova, B. (2017). Body mass index and healthcare costs: a systematic literature review of individual participant data studies. *Obesity Reviews*, *18*(8), 869–879. https://doi.org/10.1111/obr.12560

Kessler, D. A. (2009). *The End of Overeating: Taking Control of the Insatiable American Appetite*. Rodale.

Knäuper, B., Pillay, R., Lacaille, J., McCollam, A., & Kelso, E. (2011). Replacing craving imagery with alternative pleasant imagery reduces craving intensity. *Appetite*, *57*(1), 173–178. https://doi.org/10.1016/j.appet.2011.04.021

Knowler, W. C., Barrett-Connor, E., Fowler, S. E., Hamman, R. F., Lachin, J. M., Walker, E. A., … Diabetes Prevention Program Research Group. (2002). Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *The New England Journal of Medicine*, *346*(6), 393–403. https://doi.org/10.1056/NEJMoa012512

Kodama, S., Saito, K., Tanaka, S., Horikawa, C., Fujiwara, K., Hirasawa, R., … Sone, H. (2012). Effect of web-based lifestyle modification on weight control: a meta-analysis. *International Journal of Obesity*, *36*(5), 675–685. https://doi.org/10.1038/ijo.2011.121

Kohl, L. F., Crutzen, R., & Vries, N. K. de. (2013). Online prevention aimed at lifestyle behaviors: A systematic review of reviews. *Journal of Medical Internet Research*, *15*(7), e146. https://doi.org/10.2196/jmir.2665

Kozak, A. T., Buscemi, J., Hawkins, M. A. W., Wang, M. L., Breland, J. Y., Ross, K. M., & Kommu, A. (2017). Technology-based interventions for weight management: current randomized controlled trial evidence and future directions. *Journal of Behavioral Medicine*, *40*(1), 99–111. https://doi.org/10.1007/s10865-016-9805-z

Kroese, F. M., Evers, C., & De Ridder, D. T. D. (2009). How chocolate keeps you slim. The effect of food temptations on weight watching goal importance, intentions, and eating behavior. *Appetite*, *53*(3), 430–433. https://doi.org/10.1016/j.appet.2009.08.002

Kroese, F. M., Evers, C., & de Ridder, D. T. D. (2013). If it’s good it must be bad: the indirect effect of temptation strength on self-control through perceived unhealthiness. *Eating Behaviors*, *14*(4), 522–524. https://doi.org/10.1016/j.eatbeh.2013.07.006

Lambert, J. D., Greaves, C. J., Farrand, P., Haase, A. M., & Taylor, A. H. (2017). Development of a web-based intervention (eMotion) based on behavioural activation to promote physical activity in people with depression. *Mental Health and Physical Activity*, *13*, 120–136. https://doi.org/10.1016/j.mhpa.2017.10.003

Laran, J. (2010). Choosing your future: Temporal distance and the balance between self-control and indulgence. *Journal of Consumer Research*, *36*(6), 1002–1015. https://doi.org/10.1086/648380

Larsen, J. K., Hermans, R. C. J., Sleddens, E. F. C., Vink, J. M., Kremers, S. P. J., Ruiter, E. L. M., & Fisher, J. O. (2018). How to bridge the intention-behavior gap in food parenting: Automatic constructs and underlying techniques. *Appetite*, *123*, 191–200. https://doi.org/10.1016/j.appet.2017.12.016

Laurin, K., Kay, A. C., & Fitzsimons, G. M. (2012). Divergent effects of activating thoughts of God on self-regulation. *Journal of Personality and Social Psychology*, *102*(1), 4–21. https://doi.org/10.1037/a0025971

Lawrence, N. S., O'Sullivan, J., Parslow, D., Javaid, M., Adams, R. C., Chambers, C. D., … Verbruggen, F. (2015). Training response inhibition to food is associated with weight loss and reduced energy intake. *Appetite*, *95*, 17–28. https://doi.org/10.1016/j.appet.2015.06.009

Lawrence, N. S., Verbruggen, F., Morrison, S., Adams, R. C., & Chambers, C. D. (2015). Stopping to food can reduce intake. Effects of stimulus-specificity and individual differences in dietary restraint. *Appetite*, *85*, 91–103. https://doi.org/10.1016/j.appet.2014.11.006

Ledikwe, J. H., Ello-Martin, J. A., & Rolls, B. J. (2005). Portion sizes and the obesity epidemic. *The Journal of Nutrition*, *135*(4), 905–909.

Lennon, M. R., Bouamrane, M.-M., Devlin, A. M., O'Connor, S., O'Donnell, C., Chetty, U., … Mair, F. S. (2017). Readiness for delivering digital health at dcale: Lessons from a longitudinal qualitative evaluation of a national digital health innovation program in the United Kingdom. *Journal of Medical Internet Research*, *19*(2), e42. https://doi.org/10.2196/jmir.6900

Levine, D. M., Savarimuthu, S., Squires, A., Nicholson, J., & Jay, M. (2015). Technology-Assisted Weight Loss Interventions in Primary Care: A Systematic Review. *Journal of General Internal Medicine*, *30*(1), 107–117. https://doi.org/10.1007/s11606-014-2987-6

Lin, H. X., Choong, Y.-Y., & Salvendy, G. (1997). A proposed index of usability: A method for comparing the relative usability of different software systems. *Behaviour & Information Technology*, *16*(4–5), 267–277. https://doi.org/10.1080/014492997119833

Little, P., Stuart, B., Hobbs, F. R., Kelly, J., Smith, E. R., Bradbury, K. J., … Yardley, L. (2016). An internet-based intervention with brief nurse support to manage obesity in primary care (POWeR+): a pragmatic, parallel-group, randomised controlled trial. *The Lancet Diabetes & Endocrinology*, *4*(10), 821–828. https://doi.org/10.1016/S2213-8587(16)30099-7

Lloyd, J. J., Logan, S., Greaves, C. J., & Wyatt, K. M. (2011). Evidence, theory and context - using intervention mapping to develop a school-based intervention to prevent obesity in children. *International Journal of Behavioral Nutrition and Physical Activity*, *8*(1), 73. https://doi.org/10.1186/1479-5868-8-73

Local Government Association. (2017). *LGA Budget Submission Autumn 2017*. London: Local Government Association. Retrieved from https://www.local.gov.uk/sites/default/files/documents/5.20%20budget%20submission_06.pdf

Look AHEAD Research Group, Pi-Sunyer, X., Blackburn, G., Brancati, F. L., Bray, G. A., Bright, R., … Yanovski, S. Z. (2007). Reduction in weight and cardiovascular disease risk factors in individuals with type 2 diabetes: one-year results of the look AHEAD trial. *Diabetes Care*, *30*(6), 1374–1383. https://doi.org/10.2337/dc07-0048

Looyestyn, J., Kernot, J., Boshoff, K., Ryan, J., Edney, S., & Maher, C. (2017). Does gamification increase engagement with online programs? A systematic review. *PLoS ONE*, *12*(3). https://doi.org/10.1371/journal.pone.0173403

Lowe, M. R., Butryn, M. L., Didie, E. R., Annunziato, R. A., Thomas, J. G., Crerand, C. E., … Halford, J. (2009). The Power of Food Scale. A new measure of the psychological influence of the food environment. *Appetite*, *53*(1), 114–118. https://doi.org/10.1016/j.appet.2009.05.016

Luszczynska, A., Scholz, U., & Sutton, S. (2007). Planning to change diet: a controlled trial of an implementation intentions training intervention to reduce saturated fat intake among patients after myocardial infarction. *Journal of Psychosomatic Research*, *63*(5), 491–497. https://doi.org/10.1016/j.jpsychores.2007.06.014

MacKinnon, D. P., Lockwood, C. M., Hoffman, J. M., West, S. G., & Sheets, V. (2002). A comparison of methods to test Mediation and other intervening variable effects. *Psychological Methods*, *7*(1), 83.

Magaraggia, C., Dimmock, J. A., & Jackson, B. (2013). The effect of learning climate on snack consumption and ego depletion among undergraduate students. *Appetite*, *69*, 174–179. https://doi.org/10.1016/j.appet.2013.06.003

Magro, D. O., Geloneze, B., Delfini, R., Pareja, B. C., Callejas, F., & Pareja, J. C. (2008). Long-term weight regain after gastric bypass: A 5-year prospective study. *Obesity Surgery*, *18*(6), 648–651. https://doi.org/10.1007/s11695-007-9265-1

Mann, T., Tomiyama, A. J., Westling, E., Lew, A.-M., Samuels, B., & Chatman, J. (2007). Medicare's search for effective obesity treatments: diets are not the answer. *The American Psychologist*, *62*(3), 220–233. https://doi.org/10.1037/0003-066X.62.3.220

Manzoni, G. M., Pagnini, F., Corti, S., Molinari, E., & Castelnuovo, G. (2011). Internet-based behavioral interventions for obesity: an updated systematic review. *Clinical Practice and Epidemiology in Mental Health: CP & EMH*, *7*, 19–28. https://doi.org/10.2174/1745017901107010019

Marteau, T. M., Hollands, G. J., & Fletcher, P. C. (2012). Changing human behavior to prevent disease: The importance of targeting automatic processes. *Science*, *337*(6101), 1492–1495. https://doi.org/10.1126/science.1226918

Mason, A. E., Jhaveri, K., Cohn, M., & Brewer, J. A. (2017). Testing a mobile mindful eating intervention targeting craving-related eating: feasibility and proof of concept. *Journal of Behavioral Medicine*, 1–14. https://doi.org/10.1007/s10865-017-9884-5

Mateo, G. F., Granado-Font, E., Ferré-Grau, C., & Montaña-Carreras, X. (2015). Mobile phone apps to promote weight loss and increase physical activity: A systematic review and meta-analysis. *Journal of Medical Internet Research*, *17*(11), e253. https://doi.org/10.2196/jmir.4836

May, J., Andrade, J., Batey, H., Berry, L.-M., & Kavanagh, D. J. (2010). Less food for thought. Impact of attentional instructions on intrusive thoughts about snack foods. *Appetite*, *55*(2), 279–287. https://doi.org/10.1016/j.appet.2010.06.014

May, J., Andrade, J., Kavanagh, D. J., & Hetherington, M. (2012). Elaborated Intrusion Theory: A cognitive-emotional theory of food craving. *Current Obesity Reports*, *1*(2), 114–121. https://doi.org/10.1007/s13679-012-0010-2

May, J., Andrade, J., Panabokke, N., & Kavanagh, D. (2010). Visuospatial tasks suppress craving for cigarettes. *Behaviour Research and Therapy*, *48*(6), 476–485. https://doi.org/10.1016/j.brat.2010.02.001

McEachan, R. R. C., Conner, M., Taylor, N. J., & Lawton, R. J. (2011). Prospective prediction of health-related behaviours with the Theory of Planned Behaviour: a meta-analysis. *Health Psychology Review*, *5*(2), 97–144. https://doi.org/10.1080/17437199.2010.521684

McKinsey Global Institute. (2014, November). Overcoming obesity: An initial economic analyses. Retrieved from www.mckinsey.com/mgi

Meule, A., Hermann, T., & Kübler, A. (2014). A short version of the Food Cravings Questionnaire—Trait: the FCQ-T-reduced. *Frontiers in Psychology*, *5*. https://doi.org/10.3389/fpsyg.2014.00190

Michie, S., & Abraham, C. (2008). Advancing the science of behaviour change: a plea for scientific reporting. *Addiction*, *103*(9), 1409–1410. https://doi.org/10.1111/j.1360-0443.2008.02291.x

Michie, S., Abraham, C., Whittington, C., McAteer, J., & Gupta, S. (2009). Effective techniques in healthy eating and physical activity interventions: a meta-regression. *Health Psychology: Official Journal of the Division of Health Psychology, American Psychological Association*, *28*(6), 690–701. https://doi.org/10.1037/a0016136

Michie, S., Ashford, S., Sniehotta, F. F., Dombrowski, S. U., Bishop, A., & French, D. P. (2011). A refined taxonomy of behaviour change techniques to help people change their physical activity and healthy eating behaviours: The CALO-RE taxonomy. *Psychology & Health*, *26*(11), 1479–1498. https://doi.org/10.1080/08870446.2010.540664

Michie, S., Johnston, M., Francis, J. J., Hardeman, W., & Eccles, M. P. (2008). From theory to intervention: Mapping theoretically derived behavioural determinants to Behaviour Change Techniques. Retrieved from http://aura.abdn.ac.uk/handle/2164/302

Michie, S., Richardson, M., Johnston, M., Abraham, C., Francis, J., Hardeman, W., … Wood, C. E. (2013). The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. *Annals of Behavioral Medicine: A Publication of the Society of Behavioral Medicine*, *46*(1), 81–95. https://doi.org/10.1007/s12160-013-9486-6

Michie, S., van Stralen, M. M., & West, R. (2011). The behaviour change wheel: A new method for characterising and designing behaviour change interventions. *Implementation Science : IS*, *6*, 42. https://doi.org/10.1186/1748-5908-6-42

Michie, S., Yardley, L., West, R., Patrick, K., & Greaves, F. (2017). Developing and Evaluating Digital Interventions to Promote Behavior Change in Health and Health Care: Recommendations Resulting From an International Workshop. *Journal of Medical Internet Research*, *19*(6), e232. https://doi.org/10.2196/jmir.7126

Miller, G. (2012). The smartphone psychology manifesto. *Perspectives on Psychological Science*, *7*(3), 221–237. https://doi.org/10.1177/1745691612441215

Moffitt, R., Brinkworth, G., Noakes, M., & Mohr, P. (2012). A comparison of cognitive restructuring and cognitive defusion as strategies for resisting a craved food. *Psychology & Health*, *27 Suppl 2*, 74–90. https://doi.org/10.1080/08870446.2012.694436

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & PRISMA Group. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Medicine*, *6*(7), e1000097. https://doi.org/10.1371/journal.pmed.1000097

Moldovan, A. R., & David, D. (2012). Features of automaticity in eating behavior. *Eating Behaviors*, *13*(1), 46–48. https://doi.org/10.1016/j.eatbeh.2011.09.006

Moller, A. C., Deci, E. L., & Ryan, R. M. (2006). Choice and ego-depletion: the moderating role of autonomy. *Personality & Social Psychology Bulletin*, *32*(8), 1024–1036. https://doi.org/10.1177/0146167206288008

Moore, G. F., Audrey, S., Barker, M., Bond, L., Bonell, C., Hardeman, W., … Baird, J. (2015). Process evaluation of complex interventions: Medical Research Council guidance. *BMJ*, *350*, h1258. https://doi.org/10.1136/bmj.h1258

Morenga, L. T., Mallard, S., & Mann, J. (2013). Dietary sugars and body weight: systematic review and meta-analyses of randomised controlled trials and cohort studies. *BMJ*, *346*, e7492. https://doi.org/10.1136/bmj.e7492

Morgan, L., & Dent, M. (2010). *The economic burden of obesity*. Oxford: National Obesity Observatory.

Morris, M. E., & Aguilera, A. (2012). Mobile, social, and wearable computing and the evolution of psychological practice. *Professional Psychology: Research and Practice*, *43*(6), 622–626. https://doi.org/10.1037/a0029041

Murphy, E., Dingwall, R., Greatbatch, D., Parker, S., & Watson, P. (1998). Qualitative research methods in health technology assessment: a review of the literature. *Health Technology Assessment (Winchester, England)*, *2*(16), iii–ix, 1–274.

Must, A., Spadano, J., Coakley, E. H., Field, A. E., Colditz, G., & Dietz, W. H. (1999). The disease burden associated with overweight and obesity. *JAMA*, *282*(16), 1523–1529.

Nahum-Shani, I., Smith, S. N., Spring, B. J., Collins, L. M., Witkiewitz, K., Tewari, A., & Murphy, S. A. (2016). Just-in-Time Adaptive Interventions (JITAIs) in mobile health: Key components and design principles for ongoing health behavior support. *Annals of Behavioral Medicine: A Publication of the Society of Behavioral Medicine*. https://doi.org/10.1007/s12160-016-9830-8

National Institute for Health and Care Excellence. (2014). *Weight Management: Lifestyle Services for Overweight or Obese Adults.* NICE Guideline (PH53).

Nederkoorn, C., Braet, C., Van Eijs, Y., Tanghe, A., & Jansen, A. (2006). Why obese children cannot resist food: The role of impulsivity. *Eating Behaviors*, *7*(4), 315–322. https://doi.org/10.1016/j.eatbeh.2005.11.005

Nederkoorn, C., Guerrieri, R., Havermans, R., Roefs, A., & Jansen, A. (2009). The interactive effect of hunger and impulsivity on food intake and purchase in a virtual supermarket. *International Journal of Obesity (2005)*, *33*(8), 905–912. https://doi.org/10.1038/ijo.2009.98

Nederkoorn, C., Smulders, F. T. Y., & Jansen, A. (2000). Cephalic phase responses, craving and food intake in normal subjects. *Appetite*, *35*(1), 45–55. https://doi.org/10.1006/appe.2000.0328

NHS Digital. (n.d.-a). Digital Apps Library. Retrieved July 7, 2017, from https://apps.beta.nhs.uk/

NHS Digital. (n.d.-b). Mobile Health Apps and National Systems. Retrieved August 7, 2017, from https://developer.nhs.uk/apps/

NHS England. (n.d.). NHS England » NHS Diabetes Prevention Programme (NHS DPP). Retrieved April 3, 2018, from https://www.england.nhs.uk/diabetes/diabetes-prevention/

NHS England. (2014). Five Year Forward View, 41.

NICE. (2013). BMI: Preventing Ill Health and Premature Death in Black, Asian, and Other Minority Ethnic Groups. NICE. Retrieved from https://www.nice.org.uk/guidance/ph46/chapter/1-recommendations

O'Cathain, A., Murphy, E., & Nicholl, J. (2010). Three techniques for integrating data in mixed methods studies. *BMJ*, *341*, c4587. https://doi.org/10.1136/bmj.c4587

Odom, J., Zalesin, K. C., Washington, T. L., Miller, W. W., Hakmeh, B., Zaremba, D. L., … McCullough, P. A. (2010). Behavioral predictors of weight regain after bariatric surgery. *Obesity Surgery*, *20*(3), 349–356. https://doi.org/10.1007/s11695-009-9895-6

Oh, Hans, Rizo, C., Enkin, M., Jadad, A., Powell, J., & Pagliari, C. (2005). What is eHealth (3): A systematic review of published definitions. *Journal of Medical Internet Research*, *7*(1). https://doi.org/10.2196/jmir.7.1.e1

Oh, Hwajung, & Taylor, A. H. (2013). A brisk walk, compared with being sedentary, reduces attentional bias and chocolate cravings among regular chocolate eaters with different body mass. *Appetite*, *71*, 144–149. https://doi.org/10.1016/j.appet.2013.07.015

Oh, Hwajung, & Taylor, A. H. (2014). Self-regulating smoking and snacking through physical activity. *Health Psychology: Official Journal of the Division of Health Psychology, American Psychological Association*, *33*(4), 349–359. https://doi.org/10.1037/a0032423

Onakpoya, I. J., Heneghan, C. J., & Aronson, J. K. (2016). Post-marketing withdrawal of anti-obesity medicinal products because of adverse drug reactions: a systematic review. *BMC Medicine*, *14*. https://doi.org/10.1186/s12916-016-0735-y

Orbell, S., & Sheeran, P. (1998). ‘Inclined abstainers’: A problem for predicting health-related behaviour. *British Journal of Social Psychology*, *37*(2), 151–165. https://doi.org/10.1111/j.2044-8309.1998.tb01162.x

Pagoto, S. L., & Schneider, K. L. (2014). *Leveraging mobile technology and social media in behavioural research.* Presented at the CREATE workshop at the 28th annual conference of the European Health Society, Innsbruck, Austria. Retrieved from https://www.ehps.net/content/leveraging-mobile-technology-and-social-media-behavioural-research

Pagoto, S. L., Schneider, K. L., Oleski, J. L., Luciani, J. M., Bodenlos, J. S., & Whited, M. C. (2012). Male inclusion in randomized controlled trials of lifestyle weight loss interventions. *Obesity*, *20*(6), 1234–1239. https://doi.org/10.1038/oby.2011.140

Painter, J. E., Wansink, B., & Hieggelke, J. B. (2002). How visibility and convenience influence candy consumption. *Appetite*, *38*(3), 237–238. https://doi.org/10.1006/appe.2002.0485

Palfai, T. P., Colby, S. M., Monti, P. M., & Rohsenow, D. J. (1997). Effects of suppressing the urge to drink on smoking topography: A preliminary study. *Psychology of Addictive Behaviors*, *11*(2), 115–123. https://doi.org/10.1037/0893-164X.11.2.115

Papies, E. K. (2016). Health goal priming as a situated intervention tool: How to benefit from nonconscious motivational routes to health behavior. *Health Psychology Review*, *0*(ja), 1–35. https://doi.org/10.1080/17437199.2016.1183506

Papies, E. K., Barsalou, L. W., & Custers, R. (2012). Mindful attention pevents mindless impulses. *Social Psychological and Personality Science*, *3*(3), 291–299. https://doi.org/10.1177/1948550611419031

Papies, E. K., Stroebe, W., & Aarts, H. (2007). Pleasure in the mind: Restrained eating and spontaneous hedonic thoughts about food. *Journal of Experimental Social Psychology*, *43*(5), 810–817. https://doi.org/10.1016/j.jesp.2006.08.001

Patrick, V. M., & Hagtvedt, H. (2012). “I don’t” versus “I can’t”: When empowered refusal motivates goal-directed behaviour. *Journal of Consumer Research*, *39*(2), 371–381.

Patton, J. H., Stanford, M. S., & Barratt, E. S. (1995). Factor structure of the Barratt impulsiveness scale. *Journal of Clinical Psychology*, *51*(6), 768–774.

Peterhänsel, C., Petroff, D., Klinitzke, G., Kersting, A., & Wagner, B. (2013). Risk of completed suicide after bariatric surgery: a systematic review. *Obesity Reviews: An Official Journal of the International Association for the Study of Obesity*, *14*(5), 369–382. https://doi.org/10.1111/obr.12014

Picot, J., Jones, J., Colquitt, J., Gospodarevskaya, E., Loveman, E., Baxter, L., & Clegg, A. (2009). The clinical effectiveness and cost-effectiveness of bariatric (weight loss) surgery for obesity: a systematic review and economic evaluation. *Health Technology Assessment*, *13*(41). https://doi.org/10.3310/hta13410

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: a critical review of the literature and recommended remedies. *The Journal of Applied Psychology*, *88*(5), 879–903. https://doi.org/10.1037/0021-9010.88.5.879

Poirier, P., Giles, T. D., Bray, G. A., Hong, Y., Stern, J. S., Pi-Sunyer, F. X., & Eckel, R. H. (2006). Obesity and cardiovascular disease: Pathophysiology, evaluation, and effect of weight loss. *Circulation*, *113*(6), 898–918. https://doi.org/10.1161/CIRCULATIONAHA.106.171016

Poppitt, S. D., & Prentice, A. M. (1996). Energy density and its role in the control of food intake: Evidence from metabolic and community studies. *Appetite*, *26*(2), 153–174. https://doi.org/10.1006/appe.1996.0013

Preacher, K. J., & Hayes, A. F. (2004). SPSS and SAS procedures for estimating indirect effects in simple mediation models. *Behavior Research Methods, Instruments, & Computers*, *36*(4), 717–731. https://doi.org/10.3758/BF03206553

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods*, *40*(3), 879–891. https://doi.org/10.3758/BRM.40.3.879

Preacher, K. J., Rucker, D. D., & Hayes, A. F. (2007). Addressing moderated mediation hypotheses: Theory, methods, and prescriptions. *Multivariate*

Behavioral Research, *42*(1), 185–227. https://doi.org/10.1080/00273170701341316

Prentice, A. M., & Jebb, S. A. (2003). Fast foods, energy density and obesity: a possible mechanistic link. *Obesity Reviews*, *4*(4), 187–194. https://doi.org/10.1046/j.1467-789X.2003.00117.x

Prestwich, A., & Kellar, I. (2014). How can the impact of implementation intentions as a behaviour change intervention be improved? *Revue Européenne de Psychologie Appliquée/European Review of Applied Psychology*, *64*(1), 35–41. https://doi.org/10.1016/j.erap.2010.03.003

Prestwich, A., Sniehotta, F. F., Whittington, C., Dombrowski, S. U., Rogers, L., & Michie, S. (2014). Does theory influence the effectiveness of health behavior interventions? Meta-analysis. *Health Psychology: Official Journal of the Division of Health Psychology, American Psychological Association*, *33*(5), 465–474. https://doi.org/10.1037/a0032853

Prochaska, J. O., & DiClemente, C. C. (1983). Stages and processes of self-change of smoking: toward an integrative model of change. *Journal of Consulting and Clinical Psychology*, *51*(3), 390–395.

Prospective Studies Collaboration, Whitlock, G., Lewington, S., Sherlicker, P., Clarke, R., Emberson, J., … Peto, R. (2009). Body-mass index and cause-specific mortality in 900 000 adults: collaborative analyses of 57 prospective studies. *The Lancet*, *373*(9669), 1083–1096. https://doi.org/10.1016/S0140-6736(09)60318-4

Public Health England. (n.d.). Obesity and Alcohol. Retrieved February 1, 2017, from https://www.noo.org.uk/uploads/doc/vid_14627_Obesity_and_alcohol.pdf

Ranganathan, P., Pramesh, C. S., & Buyse, M. (2015). Common pitfalls in statistical analysis: “P” values, statistical significance and confidence intervals. *Perspectives in Clinical Research*, *6*(2), 116–117. https://doi.org/10.4103/2229-3485.154016

Raska, D., & Nichols, B. S. (2012). Using subtle reminders of love to foster healthy snack choices. *Journal of Consumer Behaviour*, *11*(6), 432–442. https://doi.org/10.1002/cb.1381

Rebar, A. L., Dimmock, J. A., Jackson, B., Rhodes, R. E., Kates, A., Starling, J., & Vandelanotte, C. (2016). A systematic review of the effects of non-conscious regulatory processes in physical activity. *Health Psychology*

Review, *10*(4), 395–407. https://doi.org/10.1080/17437199.2016.1183505

Renehan, A. G., Tyson, M., Egger, M., Heller, R. F., & Zwahlen, M. (2008). Body-mass index and incidence of cancer: a systematic review and meta-analysis of prospective observational studies. *The Lancet*, *371*(9612), 569–578. https://doi.org/10.1016/S0140-6736(08)60269-X

Rieber, N., Giel, K. E., Meile, T., Enck, P., Zipfel, S., & Teufel, M. (2013). Psychological dimensions after laparoscopic sleeve gastrectomy: reduced mental burden, improved eating behavior, and ongoing need for cognitive eating control. *Surgery for Obesity and Related Diseases*, *9*(4), 569–573. https://doi.org/10.1016/j.soard.2012.05.008

Robinson, T. E., & Berridge, K. C. (1993). The neural basis of drug craving: an incentive-sensitization theory of addiction. *Brain Research. Brain Research Reviews*, *18*(3), 247–291.

Rodríguez-Martín, B. C., Gómez-Quintana, A., Díaz-Martínez, G., & Molerio-Pérez, O. (2013). Bibliotherapy and food cravings control. *Appetite*, *65*, 90–95. https://doi.org/10.1016/j.appet.2013.02.006

Rolls, B. J., Morris, E. L., & Roe, L. S. (2002). Portion size of food affects energy intake in normal-weight and overweight men and women. *The American Journal of Clinical Nutrition*, *76*(6), 1207–1213.

Scarborough, P., Bhatnagar, P., Wickramasinghe, K. K., Allender, S., Foster, C., & Rayner, M. (2011). The economic burden of ill health due to diet, physical inactivity, smoking, alcohol and obesity in the UK: an update to 2006-07 NHS costs. *Journal of Public Health (Oxford, England)*, *33*(4), 527–535. https://doi.org/10.1093/pubmed/fdr033

Schaalma, H., & Kok, G. (2009). Decoding health education interventions: the times are a-changin’. *Psychology & Health*, *24*(1), 5–9. https://doi.org/10.1080/08870440903126348

Schulz, K. F., Chalmers, I., Hayes, R. J., & Altman, D. G. (1995). Empirical evidence of bias: Dimensions of methodological quality associated with estimates of treatment effects in vontrolled trials. *JAMA*, *273*(5), 408–412. https://doi.org/10.1001/jama.1995.03520290060030

Schulz, R., Czaja, S. J., McKay, J. R., Ory, M. G., & Belle, S. H. (2010). Intervention Taxonomy (ITAX): Describing essential features of interventions (HMC). *American Journal of Health Behavior*, *34*(6), 811–821.

Sheeran, P., Gollwitzer, P. M., & Bargh, J. A. (2013). Nonconscious processes and health. *Health Psychology: Official Journal of the Division of Health Psychology, American Psychological Association*, *32*(5), 460–473. https://doi.org/10.1037/a0029203

Shiffman, S., Stone, A. A., & Hufford, M. R. (2008). Ecological momentary assessment. *Annual Review of Clinical Psychology*, *4*, 1–32.

Sim, J., & Lewis, M. (2012). The size of a pilot study for a clinical trial should be calculated in relation to considerations of precision and efficiency. *Journal of Clinical Epidemiology*, *65*(3), 301–308. https://doi.org/10.1016/j.jclinepi.2011.07.011

Sjöström, C. D., Lissner, L., Wedel, H., & Sjöström, L. (1999). Reduction in incidence of diabetes, hypertension and lipid disturbances after intentional weight loss induced by bariatric surgery: the SOS intervention study. *Obesity Research*, *7*(5), 477–484. https://doi.org/10.1002/j.1550-8528.1999.tb00436.x

Sjöström, L., Lindroos, A.-K., Peltonen, M., Torgerson, J., Bouchard, C., Carlsson, B., … Wedel, H. (2004). Lifestyle, diabetes, and cardiovascular risk factors 10 years after bariatric surgery. *New England Journal of Medicine*, *351*(26), 2683–2693. https://doi.org/10.1056/NEJMoa035622

Sniehotta, F. F., Scholz, U., & Schwarzer, R. (2005). Bridging the intention–behaviour gap: Planning, self-efficacy, and action control in the adoption and maintenance of physical exercise. *Psychology & Health*, *20*(2), 143–160. https://doi.org/10.1080/08870440512331317670

Spence, M., Livingstone, M. B. E., Hollywood, L. E., Gibney, E. R., O'Brien, S. A., Pourshahidi, L. K., & Dean, M. (2013). A qualitative study of psychological, social and behavioral barriers to appropriate food portion size control. *The International Journal of Behavioral Nutrition and Physical Activity*, *10*, 92. https://doi.org/10.1186/1479-5868-10-92

Spinella, M. (2007). Normative data and a short form of the Barratt Impulsiveness Scale. *International Journal of Neuroscience*, *117*(3), 359–368. https://doi.org/10.1080/00207450600588881

Spring B, Duncan JM, Janke E, & et al. (2013). Integrating technology into standard weight loss treatment: A randomized controlled trial. *JAMA*

Internal Medicine, *173*(2), 105–111. https://doi.org/10.1001/jamainternmed.2013.1221

Stanford, M. S., Mathias, C. W., Dougherty, D. M., Lake, S. L., Anderson, N. E., & Patton, J. H. (2009). Fifty years of the Barratt Impulsiveness Scale: An update and review. *Personality and Individual Differences*, *47*(5), 385–395. https://doi.org/10.1016/j.paid.2009.04.008

Stapleton, P., Sheldon, T., Porter, B., & Whitty, J. (2011). A randomised clinical trial of a meridian-based intervention for food cravings with six-month follow-up. *Behaviour Change*, *28*(1), 1–16. https://doi.org/10.1375/bech.28.1.1

Steel, D., Kemps, E., & Tiggemann, M. (2006). Effects of hunger and visuo-spatial interference on imagery-induced food cravings. *Appetite*, *46*(1), 36–40. https://doi.org/10.1016/j.appet.2005.11.001

Stein, E. M., & Silverberg, S. J. (2014). Bone loss after bariatric surgery: Causes, consequences and management. *The Lancet. Diabetes & Endocrinology*, *2*(2), 165–174. https://doi.org/10.1016/S2213-8587(13)70183-9

Stevens, V. J., Obarzanek, E., Cook, N. R., Lee, I.-M., Appel, L. J., Smith West, D., … Cohen, J. (2001). Long-term weight loss and changes in blood pressure: Results of the trials of hypertension prevention, Phase II. *Annals of Internal Medicine*, *134*(1), 1–11. https://doi.org/10.7326/0003-4819-134-1-200101020-00007

Stillman, T. F., Tice, D. M., Fincham, F. D., & Lambert, N. M. (2009). The psychological presence of family improves self-control. *Journal of Social and Clinical Psychology*, *28*(4), 498–529. https://doi.org/10.1521/jscp.2009.28.4.498

Strack, F., & Deutsch, R. (2004). Reflective and impulsive determinants of social behavior. *Personality and Social Psychology Review: An Official Journal of the Society for Personality and Social Psychology, Inc*, *8*(3), 220–247. https://doi.org/10.1207/s15327957pspr0803_1

Strazzullo, P., D’Elia, L., Cairella, G., Garbagnati, F., Cappuccio, F. P., & Scalfi, L. (2010). Excess body weight and incidence of stroke: meta-analysis of prospective studies with 2 million participants. *Stroke*, *41*(5), e418-426. https://doi.org/10.1161/STROKEAHA.109.576967

Strecher, V. J., McClure, J., Alexander, G., Chakraborty, B., Nair, V., Konkel, J., … Pomerleau, O. (2008). The role of engagement in a tailored web-based smoking cessation program: randomized controlled trial. *Journal of Medical Internet Research*, *10*(5), e36. https://doi.org/10.2196/jmir.1002

Stubbs, R. J., & Whybrow, S. (2004). Energy density, diet composition and palatability: influences on overall food energy intake in humans. *Physiology & Behavior*, *81*(5), 755–764. https://doi.org/10.1016/j.physbeh.2004.04.027

Stunkard, A. J., & Messick, S. (1985). The three-factor eating questionnaire to measure dietary restraint, disinhibition and hunger. *Journal of Psychosomatic Research*, *29*(1), 71–83.

Sturm, R. (2002). The effects of obesity, smoking, and drinking on medical problems and costs. *Health Affairs (Project Hope)*, *21*(2), 245–253.

Sutin, A. R., Ferrucci, L., Zonderman, A. B., & Terracciano, A. (2011). Personality and obesity across the adult life span. *Journal of Personality and Social Psychology*, *101*(3), 579–592. https://doi.org/10.1037/a0024286

Swinburn, B. A., Caterson, I. D., Seidell, J. C., & James, W. P. . (2004). Diet, nutrition and the prevention of excess weight gain and obesity. *Public Health Nutrition*, *7*(1a), 123–146. https://doi.org/10.1079/PHN2003585

Tang, J. C. H., Abraham, C., Greaves, C. J., & Nikolaou, V. (2016). Self-directed interventions to promote weight loss: a systematic review and meta-analysis. *Health Psychology Review*, *10*(3), 358–372. https://doi.org/10.1080/17437199.2016.1172979

Tang, J. C. H., Abraham, C., Greaves, C. J., & Yates, T. (2014). Self-Directed Interventions to Promote Weight Loss: A Systematic Review of Reviews. *Journal of Medical Internet Research*, *16*(2), e58. https://doi.org/10.2196/jmir.2857

Tang, J. C. H., Abraham, C., Stamp, E., & Greaves, C. J. (2015). How can weight-loss app designers' best engage and support users? A qualitative investigation. *British Journal of Health Psychology*, *20*(1), 151–171. https://doi.org/10.1111/bjhp.12114

Tate, D. F., Wing, R. R., & Winett, R. A. (2001). Using Internet Technology to Deliver a Behavioral Weight Loss Program. *JAMA*, *285*(9), 1172–1177. https://doi.org/10.1001/jama.285.9.1172

Taylor, A. H., & Oliver, A. J. (2009). Acute effects of brisk walking on urges to eat chocolate, affect, and responses to a stressor and chocolate cue. An experimental study. *Appetite*, *52*(1), 155–160. https://doi.org/10.1016/j.appet.2008.09.004

Teixeira, P. J., Going, S. B., Sardinha, L. B., & Lohman, T. G. (2005). A review of psychosocial pre-treatment predictors of weight control. *Obesity Reviews*, *6*(1), 43–65. https://doi.org/10.1111/j.1467-789X.2005.00166.x

Teixeira, Pedro J., Carraça, E. V., Marques, M. M., Rutter, H., Oppert, J.-M., De Bourdeaudhuij, I., … Brug, J. (2015). Successful behavior change in obesity interventions in adults: a systematic review of self-regulation mediators. *BMC Medicine*, *13*, 84. https://doi.org/10.1186/s12916-015-0323-6

Thayer, R. E., Peters, D. P., Takahashi, P. J., & Birkhead-Flight, A. M. (1993). Mood and behavior (smoking and sugar snacking) following moderate exercise: A partial test of self-regulation theory. *Personality and Individual Differences*, *14*(1), 97–104. https://doi.org/10.1016/0191-8869(93)90178-6

Tindle, H. A., Omalu, B., Courcoulas, A., Marcus, M., Hammers, J., & Kuller, L. H. (2010). Risk of suicide after long-term follow-up from bariatric surgery. *The American Journal of Medicine*, *123*(11), 1036–1042. https://doi.org/10.1016/j.amjmed.2010.06.016

Townsend, C., & Liu, W. (2012). Is planning good for you? The differential impact of planning on self-regulation. *Journal of Consumer Research*, *39*(4), 688–703. https://doi.org/10.1086/665053

Trope, Y., & Fishbach, A. (2000). Counteractive self-control in overcoming temptation. *Journal of Personality and Social Psychology*, *79*(4), 493–506.

Tuomilehto, J., Lindström, J., Eriksson, J. G., Valle, T. T., Hämäläinen, H., Ilanne-Parikka, P., … Uusitupa, M. (2001). Prevention of Type 2 Diabetes Mellitus by changes in lifestyle among subjects with impaired glucose tolerance. *New England Journal of Medicine*, *344*(18), 1343–1350. https://doi.org/10.1056/NEJM200105033441801

Ukoumunne, O. C., Warren, F. C., Taylor, R. S., & Ewings, P. (2015). How to use feasibility studies to derive parameter estimates in order to power a full trial. In D. A. Richards & I. R. Hallberg (Eds.), *Complex Interventions in Health: An Overview of Research Methods*. Oxon.

van Beurden, S. B., Greaves, C. J., Smith, J. R., & Abraham, C. (2016). Techniques for modifying impulsive processes associated with unhealthy eating: A systematic review. *Health Psychology*, *35*(8), 793–806. https://doi.org/10.1037/hea0000337

van Beurden, S. B., Simmons, S. I., Tang, J. C. H., Mewse, A. J., Abraham, C., & Greaves, C. J. (2018). Informing the development of online weight management interventions: a qualitative investigation of primary care patient perceptions. *BMC Obesity*, *5*, 7. https://doi.org/10.1186/s40608-018-0184-6

van Beurden, S. B., Smith, J. R., Lawrence, N. S., Abraham, C., & Greaves, C. J. (2018). Randomised controlled feasibility trial of ImpulsePal: A smartphone app-based weight management intervention to reduce impulsive eating in overweight adults. *Manuscript in Preparation*.

Van Dillen, L. F., Papies, E. K., & Hofmann, W. (2013). Turning a blind eye to temptation: how cognitive load can facilitate self-regulation. *Journal of Personality and Social Psychology*, *104*(3), 427–443. https://doi.org/10.1037/a0031262

van Gemert-Pijnen, J. E. V., Kelders, S. M., & Bohlmeijer, E. T. (2014). Understanding the usage of content in a mental health intervention for depression: An analysis of log data. *Journal of Medical Internet Research*, *16*(1), e27. https://doi.org/10.2196/jmir.2991

Van Gucht, D., Baeyens, F., Vansteenwegen, D., Hermans, D., & Beckers, T. (2010). Counterconditioning reduces cue-induced craving and actual cue-elicited consumption. *Emotion (Washington, D.C.)*, *10*(5), 688–695. https://doi.org/10.1037/a0019463

Van Gucht, D., Vansteenwegen, D., Beckers, T., Hermans, D., Baeyens, F., & Van den Bergh, O. (2008). Repeated cue exposure effects on subjective and physiological indices of chocolate craving. *Appetite*, *50*(1), 19–24. https://doi.org/10.1016/j.appet.2007.05.003

van Koningsbruggen, G. M., Stroebe, W., Papies, E. K., & Aarts, H. (2011). Implementation intentions as goal primes: Boosting self-control in tempting environments. *European Journal of Social Psychology*, *41*(5), 551–557. https://doi.org/10.1002/ejsp.799

van Koningsbruggen, G. M., Veling, H., Stroebe, W., & Aarts, H. (2014). Comparing two psychological interventions in reducing impulsive processes of eating behaviour: Effects on self-selected portion size. *British Journal of Health Psychology*, *19*(4), 767–782. https://doi.org/10.1111/bjhp.12075

van Strien, T., & Ouwens, M. A. (2003). Counterregulation in female obese emotional eaters: Schachter, Goldman, and Gordon's (1968) test of psychosomatic theory revisited. *Eating Behaviors*, *3*(4), 329–340. https://doi.org/10.1016/S1471-0153(02)00092-2

Veling, H., Aarts, H., & Papies, E. K. (2011). Using stop signals to inhibit chronic dieters' responses toward palatable foods. *Behaviour Research and Therapy*, *49*(11), 771–780. https://doi.org/10.1016/j.brat.2011.08.005

Veling, H., Aarts, H., & Stroebe, W. (2013). Using stop signals to reduce impulsive choices for palatable unhealthy foods. *British Journal of Health Psychology*, *18*(2), 354–368. https://doi.org/10.1111/j.2044-8287.2012.02092.x

Veling, H., van Koningsbruggen, G. M., Aarts, H., & Stroebe, W. (2014). Targeting impulsive processes of eating behavior via the internet. Effects on body weight. *Appetite*, *78*, 102–109. https://doi.org/10.1016/j.appet.2014.03.014

Verplanken, B., & Aarts, H. (1999). Habit, attitude, and planned behaviour: Is habit an empty construct or an interesting case of goal-directed automaticity? *European Review of Social Psychology*, *10*(1), 101–134. https://doi.org/10.1080/14792779943000035

Vidal, J. (2002). Updated review on the benefits of weight loss. *International Journal of Obesity & Related Metabolic Disorders*, *26*. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&profile=ehost&scope=site&authtype=crawler&jrnl=03070565&AN=8854574&h=JC97wlxSwxLwpVS9GaFWE27ixCIfDJPPaVT5XkMr9yyKdGcFSS%2B7x0%2FymLo1bmc%2FROrcu0tHSsRcI8KEGIaPng%3D%3D&crl=c

Vohs, K. D., & Heatherton, T. F. (2000). Self-regulatory failure: A resource-depletion approach. *Psychological Science*, *11*(3), 249–254. https://doi.org/10.1111/1467-9280.00250

Wadden, T. A., & Butryn, M. L. (2003). Behavioral treatment of obesity. *Endocrinology and Metabolism Clinics of North America*, *32*(4), 981–1003, x.

Wang, Y. C., McPherson, K., Marsh, T., Gortmaker, S. L., & Brown, M. (2011). Health and economic burden of the projected obesity trends in the USA and the UK. *The Lancet*, *378*(9793), 815–825. https://doi.org/10.1016/S0140-6736(11)60814-3

Wansink, B., Painter, J. E., & North, J. (2005). Bottomless bowls: why visual cues of portion size may influence intake. *Obesity Research*, *13*(1), 93–100. https://doi.org/10.1038/oby.2005.12

Ware, J. H. (2003). Interpreting incomplete data in studies of diet and weight loss. *The New England Journal of Medicine*, *348*, 2136–2137.

Webb, T. L., Joseph, J., Yardley, L., & Michie, S. (2010). Using the internet to promote health behavior change: a systematic review and meta-analysis of the impact of theoretical basis, use of behavior change techniques, and mode of delivery on efficacy. *Journal of Medical Internet Research*, *12*(1).

Webb, T. L., & Sheeran, P. (2006). Does changing behavioral intentions engender behavior change? A meta-analysis of the experimental evidence. *Psychological Bulletin*, *132*(2), 249–268. https://doi.org/10.1037/0033-2909.132.2.249

Wegner, D. M. (1994). Ironic processes of mental control. *Psychological Review*, *101*(1), 34–52.

Welbourn, R., Fiennes, A., Kinsman, R., & Walton, P. (2010). The United Kingdom national bariatric surgery registry. *First Registry Report to March*, *2010*. Retrieved from https://www.researchgate.net/profile/Kamal_Mahawar/publication/277557570_2nd_Registry_Report_of_The_United_Kingdom_National_Bariatric_Surgery_Registry_(2014)/links/556cb8dd08aeab7772231a5d.pdf

Wenzlaff, R. M., & Wegner, D. M. (2000). Thought suppression. *Annual Review of Psychology*, *51*(1), 59–91. https://doi.org/10.1146/annurev.psych.51.1.59

West, R., & Michie, S. (2016). *A Guide to Development and Evaluation of Digital Behaviour Change Interventions in Healthcare* (First). London: Silverback Publishing.

Whitehead, D., Taket, A., & Smith, P. (2003). Action research in health promotion. *Health Education Journal*, *62*(1), 5–22. https://doi.org/10.1177/001789690306200102

Whybrow, S., Mayer, C., Kirk, T. R., Mazlan, N., & Stubbs, R. J. (2007). Effects of two weeks' mandatory snack consumption on energy intake and energy balance. *Obesity (Silver Spring, Md.)*, *15*(3), 673–685. https://doi.org/10.1038/oby.2007.567

Wieland, L. S., Falzon, L., Sciamanna, C. N., Trudeau, K. J., Folse, S. B., Schwartz, J. E., & Davidson, K. W. (2012). Interactive computer-based interventions for weight loss or weight maintenance in overweight or obese people. *The Cochrane Database of Systematic Reviews*, *8*, CD007675. https://doi.org/10.1002/14651858.CD007675.pub2

Wiers, R. W., Eberl, C., Rinck, M., Becker, E. S., & Lindenmeyer, J. (2011). Retraining automatic action tendencies changes alcoholic patients' approach bias for alcohol and improves treatment outcome. *Psychological Science*, *22*(4), 490–497. https://doi.org/10.1177/0956797611400615

Wiers, R. W., Rinck, M., Kordts, R., Houben, K., & Strack, F. (2010). Retraining automatic action-tendencies to approach alcohol in hazardous drinkers. *Addiction (Abingdon, England)*, *105*(2), 279–287. https://doi.org/10.1111/j.1360-0443.2009.02775.x

Williamson, D. A., Bray, G. A., & Ryan, D. H. (2015). Is 5% weight loss a satisfactory criterion to define clinically significant weight loss? *Obesity*, *23*(12), 2319–2320. https://doi.org/10.1002/oby.21358

World Cancer Research Fund, & American Institute for Cancer Research (Eds.). (2007). *Food, Nutrition, Physical Activity and the Prevention of Cancer: A Global Perspective.* Washington, D.C: American Institute for Cancer Research.

World Health Organisation. (2003). WHO technical report series 916. Diet, nutrition and the prevention of excess weight gain and obesity. Report of a joint WHO/FAO expert consultation. World Health Organisation.

World Health Organization. (2016). Obesity and Overweight Factsheet No. 311. World Health Organization. Retrieved from http://www.who.int/mediacentre/factsheets/fs311/en/

Yanovski, S. Z., & Yanovski, J. A. (2014). Long-term drug treatment for obesity: A systematic and clinical review. *JAMA*, *311*(1), 74–86. https://doi.org/10.1001/jama.2013.281361

Yardley, L., Ainsworth, B., Arden-Close, E., & Muller, I. (2015). The person-based approach to enhancing the acceptability and feasibility of interventions. *Pilot and Feasibility Studies*, *1*, 37. https://doi.org/10.1186/s40814-015-0033-z

Yardley, L., & Bishop, F. (2008). Mixing Qualitative and Quantitative Methods: A Pragmatic Approach. In C. Willig & W. Stainton-Rogers, *The SAGE Handbook of Qualitative Research in Psychology* (pp. 352–371). 1 Oliver’s Yard, 55 City Road, London England EC1Y 1SP United Kingdom: SAGE Publications Ltd. https://doi.org/10.4135/9781848607927.n20

Yardley, L., Morrison, L., Bradbury, K., & Muller, I. (2015). The person-based approach to tntervention development: Application to digital health-related behavior change interventions. *Journal of Medical Internet Research*, *17*(1), e30. https://doi.org/10.2196/jmir.4055

Yardley, L., Spring, B. J., Riper, H., Morrison, L. G., Crane, D. H., Curtis, K., … Blandford, A. (2016). Understanding and promoting effective engagement with digital behavior change interventions. *American Journal of Preventive Medicine*, *51*(5), 833–842. https://doi.org/10.1016/j.amepre.2016.06.015

Yeomans, M. R. (2004). Effects of alcohol on food and energy intake in human subjects: evidence for passive and active over-consumption of energy. *The British Journal of Nutrition*, *92 Suppl 1*, S31-34.

Zizza, C., Siega-Riz, A. M., & Popkin, B. M. (2001). Significant increase in young adults’ snacking between 1977–1978 and 1994–1996 represents a cause for concern! *Preventive Medicine*, *32*(4), 303–310. https://doi.org/10.1006/pmed.2000.0817