The Role of Diet-Congruent Cues in Short Term Food Intake

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The candidate confirms that the work submitted is her own work, except where work which has been formed part of jointly authored publications has been included. The contribution of the candidate and the authors to this work has been explicitly indicated below. The candidate confirms that appropriate credit has been given within the thesis where reference has been made to the work of others.

Chapter 3 of this thesis is based in part on the jointly-authored publication:

Buckland, N.J., Finlayson, G., Edge, R. & Hetherington, M.M. (2014). Dieters reduce energy intake after exposure to diet-congruent food images compared to control non-food images. *Appetite*, 73, 189-196.

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The candidate confirms that her contribution was primarily intellectual and she took a primary role in the production of the substance and writing of each of the above. Her co-authors confirm that their contribution to each of the articles was in guiding the research presented and its evaluation as well as editing drafts of the manuscripts.

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Abstract

Weight loss attempts and weight loss maintenance are often unsuccessful in part due to dieters' vulnerability to palatable food cues. Exposure to diet-congruent cues has thus been proposed as a goal priming strategy to counteract this vulnerability. Diet-congruent cues increase the salience of diet thoughts and reduce subsequent snack intake in restrained eaters. However, little is known about the impact of diet-congruent cue exposure on food intake in those actively dieting. Given that dieters hold goals to lose weight, diet-congruent cues might be particularly salient to dieters and cue diet-consistent behaviour when dieters are conflicted by food temptations. Thus, the current thesis aimed to examine the effects of diet-congruent cues on subsequent energy intake in dieting and non-dieting women. Specifically, as food is closely associated with dieting, the current research tested the effects of diet-congruent food cues. The salience of diet and tempting thoughts were also assessed to identify the potential mechanism of goal priming.

Two online surveys identified snacks (Chapter 4; n = 157) and meal related foods (Chapter 6; n = 230) that women most associated with dieting to lose weight or temptation. Using these databases, four laboratory studies were conducted. Using a between-subjects design, Chapter 3 showed that subtle exposure to diet-congruent images reduced dieters' intake of a LFSW snack by 40% compared to dieters exposed to non-food control images. Chapter 4 adopted a within-subjects design and exposed participants to the sight and smell of a diet-congruent (fresh orange) or tempting (chocolate orange) food. Dieters consumed 40% less chocolate after exposure to the diet-congruent cue compared to the tempting cue. However, when this study was replicated with an additional non-food control condition, dieters' intake was unaffected by the diet-congruent odour, possibly due to a lower motivational state. Chapter 6 measured the effects of consuming a diet-congruent preload on meal intake in a repeated measures design, and found dieters reduced meal intake by 21% compared to intake of a tempting and control preload. Contrary to predictions, dieters' reduced energy intake did not correspond with increased salience of diet thoughts in diet-congruent conditions relative to control or tempting conditions (Chapters 3, 5 and 6). However, consistent with a goal priming explanation, only

dieters were responsive to diet-congruent cues, whereas, non-dieters' energy intake did not differ after diet-congruent cue exposure compared to tempting or control cues.

This thesis has identified diet-congruent food cues which improve dieters' short term control over food intake in laboratory settings. Future research should examine the efficacy of diet-congruent cues to reduce the energy intake of active dieters in more naturalistic and applied settings and contribute to their attempts to resist temptation.

Publications and presentations

Publications

- **Buckland, N.J.**, Finlayson, G., Edge, R. & Hetherington, M.M. (2014). Dieters reduce energy intake after exposure to diet-congruent food images compared to control non-food images. *Appetite*, 73, 189-196.
- **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, 249 – 254.
- **Buckland, N.J.**, Finlayson, G. & Hetherington, M.M. (2013). Slimming Starters: Intake of a diet-congruent food reduces meal intake in active dieters, *Appetite*, 71, 430.437.
- **Buckland, N.J.** & Hetherington, M.M. (2012). Resisting the temptation to eat: can exposure to a healthy food cue reduce intake in dieters? *Appetite*, 59, 621. Abstract.

Oral and Poster Presentations

Oral Presentations

- "Slimming Starters: diet-congruent preloads and meal intake". Presented at *British Psychological Society research seminar*, University of Leeds, October 2013.
- "Can exposure to diet-congruent food reduce restrained eaters' and dieters' intake of tempting foods?" Presented at *Society for the Study of Ingestive Behavior, New Orleans*, USA, August 2013.
- "Slimming Starters: Effects of a diet-congruent preload on test meal intake". Presented at *Faculty Conference*, University of Leeds, UK, July, 2013.
- "Does exposure to diet-congruent food cues improve dieters' regulation of energy intake?" Presented at *British Psychological Society research seminar*, University of Leeds, February, 2013.
- "Using diet-congruent food as a strategy to reduce dieters' energy intake". Presented at "*Regulation of energy intake: the role of product properties*," Wageningen, The Netherlands, November, 2012.

- “Using diet cues as a strategy for weight management”. Presented at The Coca-Cola Company, London, September 2012.
- “Resisting the temptation to eat: can exposure to a healthy food cue reduce intake in dieters?” Presented at *British Feeding and Drinking Group*, March 2012.
- “Priming diet goals”. Presented at *Institute of Psychological Sciences, Postgraduate Conference*, University of Leeds, UK, October 2011.

Poster Presentations

- “Slimming Reminders: How diet-related food reduces dieters’ food intake.” Poster presented at *Postgraduate Research Conference*, University of Leeds, UK, December 2013.
- “Diet-congruent cue exposure as a strategy for improved appetite control in restrained eaters”. Poster presented at *Canadian Student Obesity Meeting*, Edmonton, Canada, June 2012.
- “Does exposure to diet-congruent images improve appetite control in dieters?” Poster presented at *Treatment of Obesity Conference,* Birmingham, UK, June 2012.
- “Exposure to diet-congruent food images improves appetite control in female dieters: Implications for diet compliance and weight management.” Poster presented at *European Congress on Obesity,* Liverpool, UK, May 2012.

Prizes and Awards

- University of Leeds Postgraduate Research Conference. Best poster presentation — December 2013
- Leeds for Life Conference Award — August 2013
- University of Leeds Faculty conference. Best oral Presentation — July 2013
- Canadian Student Obesity Meeting. Best PhD poster presentation — June 2012
- British Feeding and Drinking Group. Travel bursary — March 2012

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List of abbreviations

ANCOVA	Analysis of covariance
ANOVA	Analysis of variance
BMI	Body mass index
CCK	Cholecystokinin
DEBQ	Dutch Eating Behaviour Questionnaire
DEBQ-re	DEBQ-restraint
DEBQ-em	DEBQ-emotional
DEBQ-ex	DEBQ-external
EI	Energy intake
GLP-1	glucagon-like peptide-1
HARU	Human Appetite Research Unit
HFSA	High fat savoury
HFSW	High fat sweet
HRLD	High restraint low disinhibition
HRHD	High restraint high disinhibition
Kcal	Calories
kg	kilogram
LFSA	Low fat savoury
LFSW	Low fat sweet
LRHD	Low restraint low disinhibition
LRLD	Low restraint low disinhibition
m	metres
mm	Millimetres
ms	Milliseconds
MS	Microsoft
PFS	Power of food scale
PPY	Peptide YY
PSRS	Perceived self-regulatory success
SD	Standard deviation
SEM	Standard error of the mean
SSS	Sensory specific satiety
TFEQ	Three Factor Eating Questionnaire
TFEQ-d	TFEQ-disinhibition
TFEQ-Hunger	TFEQ- hunger
TFEQ-re	TFEQ-restraint
VAS	Visual analogue scale
UK	United Kingdom
WS	Weight suppression

Chapter 1

Introduction

Obesity is defined as excessive or abnormal fat accumulation and is internationally determined based on body mass index (BMI) (WHO, 2013). Obesity has been linked to a number of health problems such as the development of cardiovascular disease, Type 2 diabetes and cancer (Dixon, 2010). Prevalence is high and rising (WHO, 2013) and reducing obesity rates is a current public health concern (Gortmaker, et al., 2011).

Importantly, overweight or obesity strongly predicts morbidity and mortality (Hainer & Aldhoon-Hainerova, 2013; Standl, Erbach, & Schnell, 2013), and measurable benefits can be seen with relatively small amounts of weight loss of around 10% of starting body weight for improving cardiovascular risks (Sjostrom, et al., 2012; Wing, et al., 2011), cancer (Sjostrom, et al., 2009) and Type 2 diabetes (Carlsson, et al., 2012). This urges the need to understand the causes of obesity and to develop strategies to prevent and minimise weight gain.

The rise in weight gain has been attributed in part to the obesogenic environment (Swinburn, et al., 2009; Wadden, Brownell, & Foster, 2002) which encourages a positive energy balance. In simple terms, if energy intake exceeds energy output a positive energy balance results. In the obesogenic environment the omnipresence and widespread availability of high energy dense and palatable foods encourages excess food intake in some individuals. Simultaneously, a sedentary lifestyle is promoted with low physical activity levels relative to food intake (Westerterp & Speakman, 2008). Thus the combination of food cues and low energy expenditure facilitates a positive energy balance. Of course, this is an over simplistic account of the rise in obesity; there are a multitude of factors including genetics, environmental and social factors that determine body weight. Nevertheless, this idea demonstrates the potency of the environment to influence food intake and exert its dominance over internal homeostatic regulation of food intake.

1.1 Individual differences in response to an obesogenic environment

There are strong individual differences in response to the obesogenic environment (Finlayson, Cecil, Higgs, Hill, & Hetherington, 2012). This large variation in body weight suggests that some individuals are more susceptible to the obesogenic environment than others. Those more susceptible to the availability of tempting food cues might be more likely to gain weight and consequently engage in restrictive diet plans to counter and prevent further weight gain.

1.2 Dieting

The opposing pressures of an obesogenic environment and society's slim ideal female body size (Rodin, 1993) has led to a drive in dieting behaviour to counteract weight gain. There are several approaches to weight control and restricting food intake is the most popular method. More women report dieting than men (Lemon, Rosal, Zapka, Borg, & Andersen, 2009; Wardle, et al., 2004) and at any one time 1 in 4 women are dieting to lose weight (NICE, 2006).

A key characteristic of weight loss diets is that in the short term there is a high chance of success but in the long term rates of successful weight loss maintenance are low (Elfhag & Rossner, 2005). Many dieters re-gain weight originally lost within the first year (Mann, et al., 2007; Thomas, 1995). For instance, only 1 in 20 males and females lost and maintained weight successfully over 3 years (Crawford, Jeffery, & French, 2000) and dieters' BMI and weight was higher than non-dieters over 1, 7 (Field, et al., 2007) and 10 years (Neumark-Sztainer, Wall, Story, & Standish, 2012). Furthermore despite dieting to lose weight, women gained weight in 4 years (Field, Haines, Rosner, & Willett, 2010; Savage & Birch, 2010). Dieting relapse can be psychologically detrimental resulting in guilt and self-hatred (Polivy & Herman, 2002) and minimises the chances of achieving a healthy weight. It is therefore important to understand both *why* dieters struggle to lose and then maintain weight and *what* strategies can be developed based on this to improve dieting success.

1.2.1 The controversy of dieting

An "anti-diet movement" among health professionals and lay people raised doubts about the benefits of dieting and linked dieting to a number of aversive health, behavioural and psychological outcomes (Brownell & Rodin, 1994; Lowe & Levine, 2005). Dieting has been identified as playing a causal role in the development of eating disorders, particularly bulimia nervosa (Fairburn & Beglin, 1990). The cycle of restriction and indulgence leading to restraint and binge eating has been considered a risk factor for bulimia nervosa (Grilo & Masheb, 2000; Grilo, Masheb, & Wilson, 2001; Manwaring, et al., 2006). There is also concern that repeated cycles of weight loss and weight regain can lead to metabolic changes that impede subsequent weight loss attempts as found in rats (Brownell, Greenwood, Stellar, & Shrager, 1986), and that such yo-yo dieting is detrimental to health (Hamm, Shekelle, & Stamler, 1989; Lissner, Andres, Muller, & Shimokata, 1990). The "anti-dieting movement" also questioned the value of dieting efforts due to claims that dieting tends to be ineffective (Garner & Wooley, 1991; Mann, et al., 2007) with only 1 in 20 males and females losing and maintaining weight successfully over 3 years (Crawford, et al., 2000).

However, claims that dieting causes eating pathologies are not substantiated with causal evidence (Casazza, et al., 2013; Stice, Burton, Lowe, & Butryn, 2007). On the contrary, adopting low calorie diets has been shown to reduce binge eating in obese (Reeves, et al., 2001) and overweight samples (Klem, Wing, SimkinSilverman, & Kuller, 1997). Furthermore, other studies do not report detrimental effects of dieting on health outcomes (Li, Hong, Wong, Maxwell, & Heber, 2007; Mason, et al., 2013).

Counter to the “anti-dieting movement”, Lowe & Levine (2005) emphasised that when considering the healthiness of dieting a critical point is whether there is a need to diet. A distinction between lean dieters who may be more motivated to control food intake for aesthetic motivations and overweight dieters with genuine health concerns must be made (Lowe, 2003). Dieting might be harmful for aesthetically motivated adolescent females desiring a weight too low for their height. Whereas, for overweight health motivated people, dieting will likely be beneficial and outweigh any costs of dieting (Brownell & Rodin, 1994). Thus, developing strategies to assist dieters to regulate food intake is currently needed.

1.2.2 Conceptualising Dieting

1.2.2.1 Restrained eating and the Boundary Model of Eating

Restrained eating refers to volitional efforts to restrict food intake to control weight (Herman & Mack, 1975) and has historically been used as an assessment for diet behaviour. Early preload studies revealed that after consuming a large milkshake preload, individuals scoring high in restrained eating counter-regulated and subsequently consumed more snacks compared to when eating a small preload or no preload. In contrast, unrestrained eaters compensated for a preload by reducing subsequent intake (Herman & Mack, 1975; Herman, Polivy, & Esses, 1987). Herman and Polivy (1984) explained the paradoxical preload effect with “The Boundary Model of Eating” which proposed that food intake is controlled by homeostatic signals which apply opposing pressures to avoid states of hunger and satiety and maintain an individual in an area of ‘biological indifference’. Restrained eaters’ dismiss such internal signals and use cognitive restrictions to prematurely terminate food intake in order to lose weight (see Figure 1.1). Such cognitive restrictions facilitate restrained eating most of the time however, once these cognitive restrictions are violated with the consumption of diet forbidden food, restrained eaters experience “what the hell” cognitions, forget about their dieting intentions and eat liberally (Herman & Polivy, 1984). The abandonment of diet plans is most likely to occur when a preload is diet-forbidden (Knight & Boland, 1989), perceived to be high in calories (Polivy, 1976; Spencer & Fremouw, 1979) and is perceived to be a large portion size (Polivy, Herman, & Deo, 2010). Additionally, cognitive restriction requires cognitive resources and under states of cognitive depletion such as cognitive load (Bellisle & Dalix, 2001; Boon, Stroebe, Schut, & Ijntema, 2002), emotional strain (Macht, 2008) and stress (Lattimore & Caswell, 2004) restrained eaters have difficulty implementing these self-imposed restrictions and overeat.

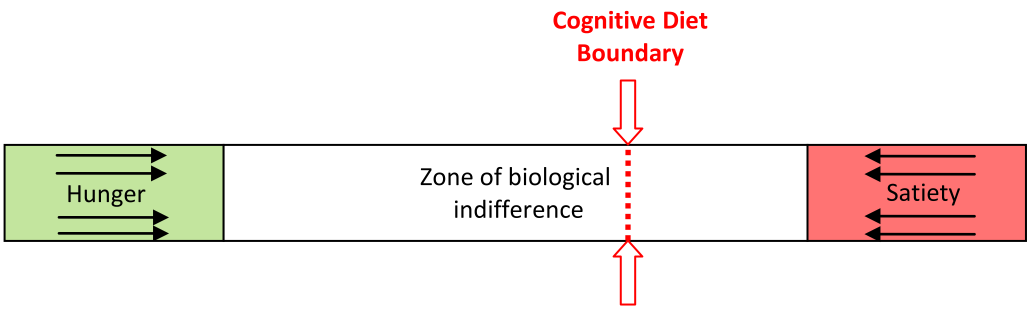

Figure 1.1. Restraint and the boundary model of eating

1.2.2.2 Flexible and rigid control

Extending the traditional classification of restrained eating Westenhoefer et al. (1991) sub-grouped restrained eaters as using either flexible or rigid controls for eating. Flexible restrained eaters use a graduated approach to regulating food intake, permitting small intake of diet-forbidden food (Westenhoefer, 1991) and do not show counter-regulatory eating (Westenhoefer, Broeckmann, Münch, & Pudel, 1994). In contrast, rigid restraint is characterised as using dichotomous, all-or-nothing rules to dictate eating behaviour (Westenhoefer, 1991) and counter-regulation following preloads (Westenhoefer, et al., 1994). Higher scores in rigid control are also associated with disinhibited eating while higher flexible control scores are associated with less disinhibited eating (Stewart, Williamson, & White, 2002; Timko & Perone, 2005; Westenhoefer, Stunkard, & Pudel, 1999). Some studies also report that higher rigid control scores are associated with higher BMI scores (Gallant, et al., 2010; Provencher, et al., 2004; Shearin, Russ, Hull, Clarkin, & Smith, 1994; Timko & Perone, 2005), although this relationship is not reported by all studies (Masheb & Grilo, 2002; McGuire, Jeffery, French, & Hannan, 2001). Thus, rather than all restrained eaters being prone to overconsumption, those scoring high in rigid control might be most susceptible to counter-regulation following a preload compared to those scoring higher in flexible control.

1.2.2.3 Limitations of restraint theory

A limitation of restraint theory is that there is no evidence for the “what the hell” explanation of restrained eaters’ diet violations. Consuming a diet-forbidden preload did not increase restrained eaters’ explicit reporting of “what the hell” cognitions (Jansen, Merckelbach, Oosterlaan, Tuiten, & Vandenhout, 1988), did not increase intake of forbidden food relative to low calorie food (French, 1992) and did not increase the motivational value of food (Sin & Vartanian, 2012) after a tempting preload compared to control preloads as the “what the hell” cognition would predict. Thus, the mechanism for counter-regulation in restrained eating lacks substantive evidence.

Another limitation is that some studies do not report counter-regulation in restrained eaters following a preload (Jansen, et al., 1988; Lowe & Kleifield, 1988; Ouwens, van Strien, & van der Staak, 2003; Timko, Juarascio, & Chowansky, 2012), especially when alternative restraint scales such as the Three Factor Eating Questionnaire (TFEQ) (Lowe & Kleifield, 1988; Morgan & Jeffrey, 1999; Stunkard & Messick, 1985) or the Dutch Eating Behaviour Questionnaire (DEBQ) (Dritschel, Cooper, & Charnock, 1993; Jansen, et al., 1988; Ouwens, et al., 2003; van Strien, Frijters, Bergers, & Defares, 1986; Wardle & Beales, 1987). Thus, different restraint scales likely measure different types of dieters.

1.2.3 Restraint and disinhibition

As the Restraint Scale measures both weight fluctuations and concern for dieting it has been suggested that restrained eating is confounded with disinhibition and identifies a subgroup of restrained eaters prone to disinhibition (Stunkard & Messick, 1985; Wardle & Beales, 1987). In contrast, the TFEQ and DEBQ have separate subscales that distinguish between restrained eating and tendency to overeat (TFEQ has a disinhibition subscale; DEBQ has emotional and external subscales). A high restraint score paired with a high disinhibition score (HRHD) as measured with the TFEQ is a marker for unsuccessful attempts at restricting food intake (Westenhoefer, 1991). Disinhibition refers to the tendency to overeat and HRHD eaters have been found to overeat in response to preloads (Westenhoefer, et al., 1994), palatable foods (Yeomans, Tovey, Tinley, & Haynes, 2004), stress (Haynes, Lee, & Yeomans, 2003; Yeomans & Coughlan, 2009) and negative affect (Fay & Finlayson, 2011). HRHD is also associated with weight gain over a 6 year period (Savage, Hoffman, & Birch, 2009). Conversely, the combination of high restraint and low disinhibition (HRLD) is a marker for successful restrained eating as food intake is unaffected by potential disinhibitors (Haynes, et al., 2003; Yeomans, et al., 2004). The combination of restraint and overeating tendency has also been shown when using the DEBQ (Van Strien, Cleven, & Schippers, 2000). Thus, compared to the original Restraint Scale the combination of restrained eating and disinhibition as identified on the TFEQ seems to be a more fitting measure to identify those who attempt to restrict food intake but experience intermittent episodes of disinhibited eating.

1.2.4 Restrained eating *Vs* dieting

Another concern for the predictive power of restraint theory is the assumption that high restraint scores are a proxy for active weight-loss efforts. The interchangeable use of the terms ‘restrained eaters’ and ‘dieters’ was apparent in the early preload studies (Polivy, Herman, & Howard, 1988) and is still often observed in contemporary writing (for example: Girz, Polivy, Herman, & Lee, 2012; van Koningsbruggen, Stroebe, & Aarts, 2011). However, restrained eating and active weight loss efforts can be quantitatively and qualitatively distinguished as separate constructs. Firstly, scoring high on restrained eating scales may reflect ongoing trait-related behaviours to maintain body weight rather than active attempts to lose weight (Dritschel, et al., 1993; Lowe, Whitlow, & Bellwoar, 1991). Secondly, high restrained eaters are not in an energy deficit as weight loss attempts would predict (Lowe, 2009). Rather, in laboratory and natural settings restrained eaters do not restrict food intake but eat similar amounts to unrestrained eaters (Huberts, Evers, & de Ridder, 2013; Stice, Fisher, & Lowe, 2004; Stice, Cooper, Schoeller, Tappe, & Lowe, 2007; Stice, Sysko, Roberto, & Allison, 2010). Thus, the construct “restrained eating” refers more to intentional vigilance around eating or simply watching food intake, rather than having a weight related diet goal (Reid, Hammersley, & Rance, 2005). Thirdly, self-reported beverage intake differs between dieters losing weight and restrained eaters with dieters reporting less intake of sugar-sweetened beverages compared to restrained eaters (Goldstein, Katterman, & Lowe, 2013). Thus, restrained eaters in contrast to active dieters are not seeking out diet beverages as a weight loss behaviour. Finally, a free living study showed there to be more differences between dieters and non-dieters compared to restrained and unrestrained eaters for BMI scores and TFEQ-disinhibition (Rideout & Barr, 2009), suggesting dieters might be more prone to weight gain than restrained eaters. Therefore, although often conflated in the literature there is evidence that dieting and restrained eating should be considered as distinct and separate constructs.

1.2.5 Active dieting

Lowe (1993) developed the Three Factor Model of Dieting to assess three dimensions of dieting behaviour, namely history of dieting, weight suppression and current diet status. A history of dieting refers to previous diet attempts. It is associated with disinhibition (Gallant, et al., 2012) and identifies those with a history of dieting as susceptible to weight gain (Lowe, 1993; Witt, Katterman, & Lowe, 2013). Weight suppression refers to the difference between current weight and heaviest previous weight (excluding pregnancy).

Studies of weight suppression provide mixed results with some suggesting that high suppression scores lead to lower consumption compared to low suppression scores (Lowe & Kleifield, 1988). Others suggest that high suppression scores predict future weight gain (Lowe, et al., 2006; Stice, Durant, Burger, & Schoeller, 2011).

Current diet status refers to whether individuals are actively engaged in efforts to lose weight, maintain weight or not dieting at a given time. Compared to non-dieters, dieters have higher BMI and disinhibition scores (Rideout & Barr, 2009) indicating that dieters are prone to overconsumption and weight gain. The demands between losing weight and maintaining weight are different such that, dieting to lose weight requires a negative energy balance and challenges the homeostatic system, whereas equilibrium between intake and energy expenditure is needed for weight maintenance (Lowe, 2009; Rosenbaum, 1998). Such differences translate to observed behavioural and psychometric differences between dieters losing weight and maintaining weight. Dieters losing weight have higher BMI scores, adopt a wider range of weight-loss behaviours such as, a low or no carbohydrate diet (Timko, Perone, & Crossfield, 2006) and report more cravings compared to dieters maintaining weight (Massey & Hill, 2012). Studies comparing food intake between dieters losing weight and maintaining weight are inconsistent; some find that dieters losing weight report less food intake (Timko, et al., 2012) while others report greater food intake (Goldstein, et al., 2013) compared to dieters maintaining weight. Despite unclear findings on the distinct differences between dieters losing weight and those maintaining weight it is likely that each subgroup needs to be examined separately rather than combining dieters losing and maintaining weight as a homogenous group (Witt et al., 2013). However, many studies examining diet behaviour have merged dieters losing and maintaining weight together posing question over the generalisability of the research findings to dieters losing weight (for example: Giesen, Havermans, Nederkoorn, Strafaci, & Jansen, 2009; Lowe, 1995; Lowe, et al., 1991).

There is also variation within dieters in terms of weight loss behaviours and the duration of active dieting reported (Emmons, 1992; French, Jeffery, & Murray, 1999; Kruger, Galuska, Serdula, & Jones, 2004). Thus, when investigators use a dichotomous assessment of dieting (Lowe, 1993) this fails to account for these variations in dieting behaviour (Martz 1994). Confusion among dieters is observed when some might claim to be dieting when they are simply careful about intake (Nichter, Ritenbaugh, Vuckvoic, & Aickin, 1995; Ogden, 1993). To address such issues a continuous scale to assess diet behaviour has been developed (Martz, Sturgis, & Gustafson, 1996). However, few researchers have adopted this measure and Witt et al. (2013) argue that the dichotomous method is a valid measure of dieting behaviour. Indeed, the dichotomous classification of diet behaviour is preferable to a continuous assessment because it offers a simple approach to defining dieting, despite its limitations and this explicitly assesses behavioural efforts to restrict food intake and it is not confounded with other factors such as disinhibition (Witt, et al., 2013).

1.2.6 Active dieters and food intake

It has been suggested that being on a diet is protective of overconsumption (Lowe, 1993; Lowe & Timko, 2004). This claim has arisen because preliminary reports on preload studies suggest that dieters (no distinction between those dieting to lose and maintain weight) do not counter-regulate in response to palatable preloads (Lowe, 1995; Timko, et al., 2012). There is also some evidence that dieters show less wanting for palatable food compared to restrained and unrestrained eaters; in a reinforcement schedule task which presented images of palatable and healthy food and required a fixed amount of keyboard presses to receive points for palatable food, dieters responded with fewer presses compared to restrained and unrestrained eaters, indicating less willingness by dieters to work for palatable food (Giesen et al. 2009). However, caution is needed in the interpretation of this finding as the reinforcement trials featured images of healthy food alongside the palatable food and this might have primed dieters to work less for palatable food compared to restrained and unrestrained eaters (Stroebe, Mensink, Aarts, Schut, & Kruglanski, 2008).

Conversely, experimental studies show dieters are vulnerable to overconsumption in the short term. Dieters overconsumed when not preloaded (Lowe, 1995; Lowe, et al., 1991) and when self-control resources were low; when trained to use self-control resources prior to a snack test, dieters consumed more snacks compared to when trained with impulsivity (Guerrieri, Nederkoorn, Schrooten, Martijn, & Jansen, 2009). Thus counter to the suggestion that being on a diet can foster regulated intake, dieters can violate restrictive eating plans when confronted with palatable food. Such short term diet violations reflect low compliance rates of diet regimens (Dansinger, Gleason, Griffith, Selker, & Schaefer, 2005; Heshka, et al., 2003). Low compliance is associated with lower weight loss (Alhassan, Kim, Bersamin, King, & Gardner, 2008) and fewer fulfilled weight loss goals (Knauper, Cheema, Rabiau, & Borten, 2005) compared to higher compliance and urges research to identify reasons why diets are unsuccessful and to develop behavioural strategies to improve adherence to diet plans.

1.3 Why diets are unsuccessful

Unsuccessful dieting might be attributable to a number of factors involved in the regulation of food intake. Food intake is determined by the complex convergence between physiological, psychological and cultural systems. Although genetics contributes some role in the propensity for weight gain (O'Rahilly, 2009) physiological and psychological responses to restricted food intake are much more likely to determine the success of losing and maintaining weight (see Figure 1.2).

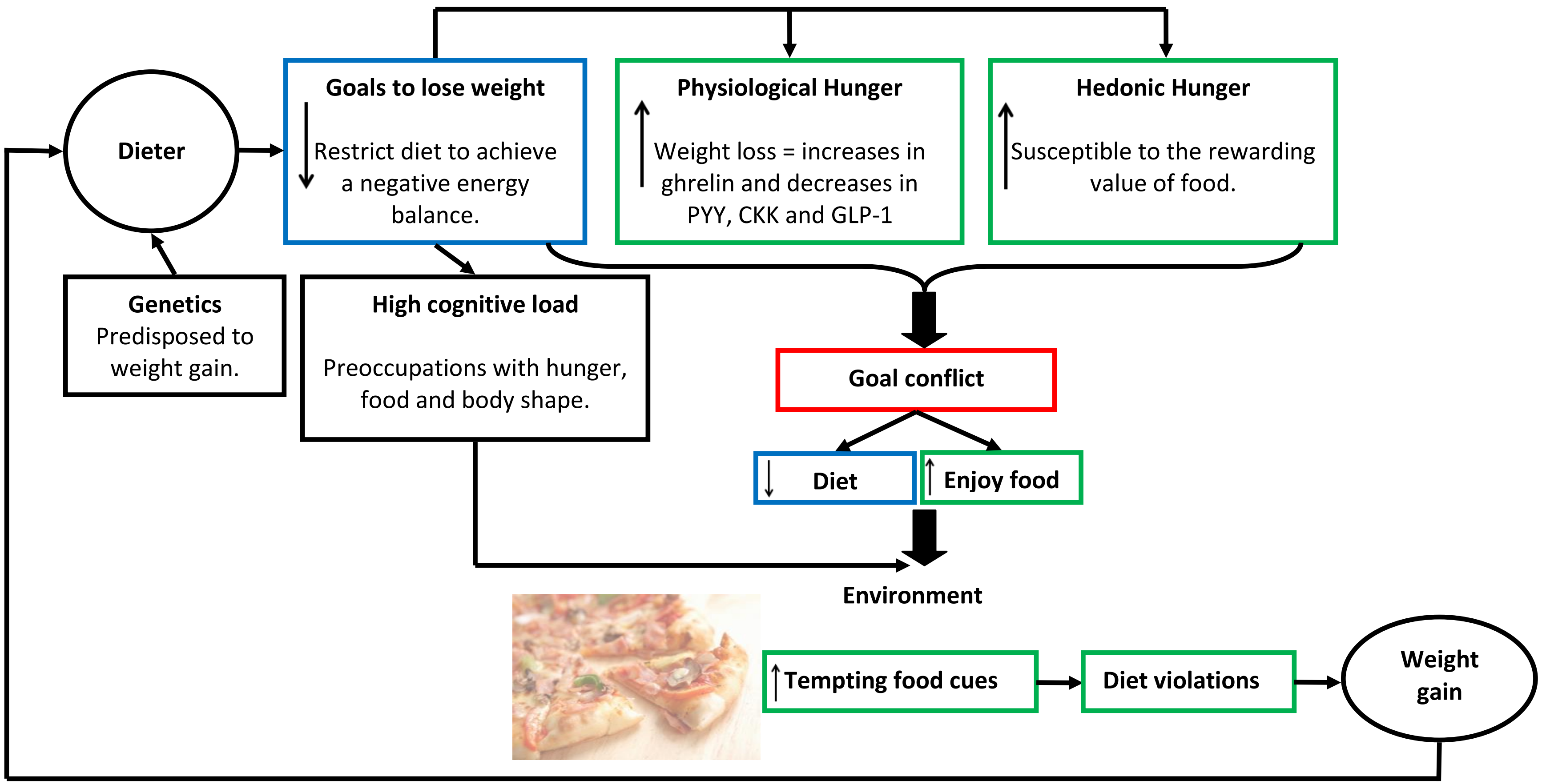

Figure 1.2. Schematic illustration of factors associated with failed weight loss attempts

Arrows pointing down show factors that reduce food intake (↓); Arrows pointing up show factors that increase food intake (↑).

1.3.1 Physiological hunger in response to weight loss

Hunger is one of the main reasons given for failed weight loss attempts (Stubbs, et al., 2012; Womble, Williamson, Greenway, & Redmann, 2001) and seems to arise partly from physiological responses to weight loss.

Weight loss challenges the maintenance of homeostasis and leads to physiological compensatory adaptations that encourage weight regain. The physiological system underpinning hunger and satiety is mediated by positive and negative feedback from the gut to the brain which stimulates and inhibits appetite respectively (Smith, 1996). The gastric hormone ghrelin is an important determinant of meal initiation (Cummings, et al., 2001; Wren, et al., 2001) and levels of circulating ghrelin have been consistently shown to increase following weight loss diets (Cummings, et al., 2002; de Luis, Sagrado, Conde, Aller, & Izaola, 2009; Heinonen, et al., 2009; Olivan, et al., 2009) with the exception of ketogenic (metabolites of fatty acid) low carbohydrate diets (Ratliff, Mutungi, Puglisi, Volek, & Fernandez, 2009; Sumithran, et al., 2013). In synchrony, hormones signalling short term inhibition of energy intake such as, cholecystokinin (CCK) (Chearskul, Delbridge, Shulkes, Proietto, & Kriketos, 2008), peptide YY (PYY) (Chan, Stoyneva, Kelesidis, Raciti, & Mantzoros, 2006) and glucagon-like peptide-1 (GLP-1)(Larder & O'Rahilly, 2012) decrease during weight loss induced diets. These changes in appetite hormones can persist up to 1 year after weight loss (Sumithran, et al., 2011) and promote hunger, reduce satiety and consequently encourage weight gain. These physiological changes correspond with subjective reports of increased hunger, desire to eat and prospective consumption in dieters following weight loss diets (Doucet, et al., 2000; Duckworth, et al., 2009; Rodriguez-Rodriguez, Aparicio, Bermejo, Lopez-Sobaler, & Ortega, 2009).

Yet, not all physiological changes are in favour of weight regain. Following a 4 week low calorie diet obese patients’ gastric capacity was reduced by 27% compared to before dieting (Geliebter et al. 1996). Considering subjective reports of increased appetite following weight loss diets it is likely that gastric capacity plays a small role in reducing appetite following weight loss. Thus, to lose weight and maintain weight loss, dieters need to override physiological hunger.

1.3.2 Susceptibility to tempting food cues

Alongside physiological hunger, hedonic hunger could be another factor explaining low rates of dieting success. It has been suggested that dieting might reflect susceptibility to the rewarding properties of food and a predisposition to weight gain (Hill, 2004; Lowe, 2003; Lowe & Levine, 2005). Behavioural evidence shows that overweight and restrained eaters find palatable food more rewarding (Burger & Stice, 2011; Epstein, Leddy, Temple, & Faith, 2007; Saelens & Epstein, 1996), and show increased preference for high fat sweet foods (Drewnowski, Kurth, & Rahaim, 1991) than lean participants. Neuroimaging data also shows increased activation in brain reward areas in response to pictures (Martin, et al., 2010; Rothemund, et al., 2007; Stoeckel, et al., 2008), anticipation (Ng, Stice, Yokum, & Bohon, 2011; Stice, Spoor, Bohon, Veldhuizen, & Small, 2008) and odours (Bragulat, et al., 2010) of palatable foods in obese compared to lean participants. Restricting intake of such rewarding foods could lead dieters to experience hedonic hunger (perceived deprivation) as they eat less food than they hedonically desire (Lowe & Levine, 2005; Timmerman & Gregg, 2003).

Indeed, the rewarding value of food appears to be attenuated following periods of restricted diets. The liking of palatable food (Cameron, Goldfield, Cyr, & Doucet, 2008) and the rewarding value of food (Epstein, Truesdale, Wojcik, Paluch, & Raynor, 2003; Raynor & Epstein, 2003) has increased relative to non-deprived periods. These behavioural observations have been corroborated with functional magnetic resonance imaging (fMRI) showing that those in a negative energy balance had greater activation in brain areas associated with reward, motivation and attention in response to the anticipation and receipt of palatable food (Burger & Stice, & Yokum, 2013). Thus, weight loss diets appear to increase motivation for high energy dense and palatable food.

Gut peptide signalling might explain the rewarding value of food as this typical neural pattern of activity found in overweight individuals ceases with surgical weight loss. After gastric bypass surgery, obese patients showed less activity in neural reward centres when exposed to palatable food images compared to pre-surgery (Ochner, et al., 2011) and compared to non-surgery and gastric band patients (Scholtz, et al., 2011). Gastric bypass patients also consumed less fat, rated food as less pleasant and appealing and scored lower in restrained eating compared to non-surgery and gastric band patients (Scholtz, et al., 2011). These reductions in hedonic responding to food corresponded with increased activation in inhibitory control regions when viewing images of food compared to non-food images (Bruce, et al., 2012).

Diet induced weight loss has also resulted in changes in the pattern of neural activity. Although weight loss maintainers do not show declines in reward centres of the brain after weight loss, interestingly, weight loss maintainers show increased activation in inhibitory control areas of the brain in response to food images (Sweet, et al., 2012). This co-activation of reward centres and inhibitory control areas imply that diet induced weight losers experience a hedonic response to foods but simultaneously engage self-control processes to achieve weight loss maintenance. Therefore, identifying strategies that improve self-control might increase dieters' resistance of palatable food.

1.3.3 Goal conflict and environmental cues

Dieters' susceptibility to hedonic food cues and simultaneous weight loss goals presents the dieter with a goal conflict. A dieter cannot achieve weight loss whilst fulfilling hedonic desires. The goal conflict theory has been proposed to explain how this conflict is resolved, placing an emphasis on the role of environmental cues to determine the behavioural outcome (Stroebe, et al., 2008; Stroebe, van Koningsbruggen, Papies, & Aarts, 2013). This approach is rooted in goal theory which suggests that goals are cognitive structures that strive for a desired outcome (Hull, 1931) and drive behaviour. Mentally, goals are closely linked with stored knowledge structures about situations and environmental cues that are associated and instrumental to goal achievement (Aarts & Dijksterhuis, 2003; Shah & Kruglanksi, 2002). For example, weight control goals might have close mental links to cognitive structures about low calorie foods, exercise, weighing scales and physical appearance. Such connectivity between goals and associated constructs means that exposure to environmental cues associated with a goal can increase the salience of the goal (prime) and lead to goal-directed behaviour (Aarts & Diksterhuis, 2000, Bargh & Gollwitzer 1994).

According to the goal conflict theory, weight loss goals are perpetually active (Stroebe, et al., 2008; Stroebe, van Koningsbruggen, Papies, & Aarts, 2013). Thus, dieters are continuously occupied with thoughts about their weight and the types and amounts of foods to consume (Kemps, Tiggemann, & Marshall, 2005; Stroebe, et al., 2008). This preoccupation with hunger (Green, Elliman, & Rogers, 1997) and body shape (Green & Rogers, 1998; Vreugdenburg, Bryan, & Kemps, 2003) place dieters under high cognitive load which reduces dieters' cognitive capacity in working memory tasks (Green, et al., 1997). Under high cognitive load dieters narrow their attention to cues salient in the environment (Mann & Ward, 2004). Under these conditions, tempting food cues increase the salience of eating enjoyment goals and simultaneously inhibit diet goals (Forster, Liberman, & Friedman, 2007; Shah & Kruglanski, 2002; Stroebe, et al., 2008; Stroebe, et al., 2013). Consequently, when confronted with palatable food cues, diet goals are momentarily displaced and eating enjoyment goals are pursued (Stroebe, et al., 2008; Stroebe, et al., 2013). However, the theory also suggests that diet cues in the environment can reinstate diet goals and encourage dieters to limit food intake and successful adhere to diet plans in tempting food situations (Stroebe, et al., 2008; Stroebe, et al., 2013).

The impact of diet and tempting cues is limited to dieters because non-dieters do not experience a conflict between eating enjoyment and diet goals and therefore, such cues are not of salience to non-dieters (Custers & Aarts, 2010; Stroebe, et al., 2008; Stroebe, et al., 2013).

1.3.3.1 Goal conflict and overeating - the evidence

Qualitative reports from dieters suggest a mental conflict between enjoying food and diet adherence (Green, Larkin, & Sullivan, 2009). Experimental studies on goal conflict have mostly been studied in restrained eaters who evaluate palatable food with ambivalent attitudes that is both strong positive and negative attitudes (Sparks, Conner, James, Shepherd, & Povey, 2001). This ambivalence has been shown when measuring ambivalence with explicit rating scales of food (Stroebe, et al., 2008; Urland & Ito, 2005) and with the implicit affective priming task (Papies, Stroebe, & Aarts, 2009; Stroebe, et al., 2008; Urland & Ito, 2005). Restrained eaters' automatic recall also show ambivalence as dieters recall more conflicting thoughts about the hedonic value of food and health conscious thoughts compared to unrestrained eaters (Keller & van der Horst, 2013). Other studies fail to support restrained eaters' ambivalent attitudes to food (Roefs, Herman, MacLeod, Smulders, & Jansen, 2005) and some find restrained eaters have more positive attitudes to palatable food than negative (Hoefling & Strack, 2008; Houben, Roefs, & Jansen, 2010; Veenstra & de Jong, 2010). Mixed findings might be explained by differences in methodologies adopted with some studies assessing relative scores between positive and negative evaluations and others using non-relative scores (Houben, et al., 2010).

In relation to the prediction that tempting food increases the salience of tempting thoughts it has been demonstrated that reading scenarios about palatable foods (Papies, Stroebe, & Aarts, 2007) and viewing a gourmet magazine (Pelaez-Fernandez & Extremera, 2011) increased restrained eaters' spontaneous thoughts about food. Increased salience of tempting thoughts has been shown to orient perceptual biases to food. For instance, exposure to a gourmet magazine increased restrained eaters' perception size of a muffin compared to a control magazine indicating that perceptual orientation has been enhanced to detect cues in the environment that were instrumental to fulfilling the eating enjoyment goal (Bruner, 1957). Furthermore, exposure to tempting food words increased restrained eaters' attention to palatable food words as a function of their palatability (Papies, Stroebe, & Aarts, 2008a) and increased efforts to obtain palatable food (Van Koningsbruggen, Stroebe, & Aarts, 2013) compared to non-food exposure. Also, once the eating enjoyment goal was activated in response to tempting food, restrained eaters were unable to reduce hedonic responding to palatable food, whereas unrestrained eaters' response to palatable food typically declined with time (Hofmann, van Koningsbruggen, Stroebe, Ramanathan, & Aarts, 2010). Thus, heightened vigilance to food has been observed following exposure to tempting food. However, it is important to consider that this research is based purely in restrained eaters without evidence that it occurs in dieters.

Similarly, evidence that tempting food cues inhibit the salience and value of diet goals has mostly been examined in restrained eaters. Pre-exposure to tempting food words delayed restrained eaters' recognition times to diet words in lexical decision tasks (Papies, Stroebe, & Aarts, 2008b; Stroebe, et al., 2008), reduced restrained eaters' perception size of an apple compared to a control magazine (van Koningsbruggen, et al., 2011), and devalued weight control words (slim, thin, fit, diet) in restrained eaters (Pelaez-Fernandez & Extremera, 2011) and participants with goals to lose or maintain weight (Palfai & Macdonald, 2007). This inhibition of diet goals has even decreased restrained eaters' motivation to obtain healthy food as measured with a handgrip force task (van Koningsbruggen, Stroebe, & Aarts, 2012a). Thus, exposure to palatable food cues appear to be detrimental to restrained eaters' diet goals and this effect remains to be clarified in active dieters.

The effects of tempting food cues to increase the salience of tempting thoughts and inhibit diet thoughts is predicted to lead to increased food intake (Stroebe, et al., 2008; Stroebe, et al., 2013). In restrained eaters, a number of studies have shown increased food intake following exposure to the sight and smell of food (Fedoroff, Polivy, & Herman, 1997; Fedoroff, Polivy, & Herman, 2003; Harris, Bargh, & Brownell, 2009; Jansen & van den Hout, 1991; Pelaez-Fernandez & Extremera, 2011; Rogers & Hill, 1989; Stirling & Yeomans, 2004) and exposure to food adverts (Shimizu & Wansink, 2011) compared to control or no exposure. In contrast, unrestrained eaters' intake were unaffected by tempting food cues. Exposure to an overweight experimenter also increased restrained eaters' snack intake compared to a normal weight experimenter (McFerran, Dahl, Fitzsimons, & Morales, 2010). The presence of an overweight experimenter might have provided a sufficient permissive cue to encourage restrained eaters' snack intake. Thus, exposure to a number of cues associated with food enjoyment or temptation have been associated with increased food intake in restrained eaters.

However, stimulating effects of tempting food cues do not always increase food intake. Some theorists suggest that over time tempting cues become associated with dieting efforts and trigger counteractive self-control processes to limit food intake (Trope & Fishbach, 2000). For example, incidental exposure to a tempting food odour (cookies) increased weight control goals in unrestrained eaters compared to no cue (defined by rated value of losing weight, dieting, devoting efforts to eating less, maintaining a diet when others around them are eating unhealthy food, being thin and overcoming urges to eat) (Coelho, Polivy, Herman, & Pliner, 2008) and reduced restrained eaters' energy intake of a cued cookie compared to restrained eaters not exposed to a food odour (Coelho, Polivy, Herman, & Pliner, 2009). Interestingly, the more tempting the food cue the more effective the cue was to reduce consumption in a student sample (Kroese, Evers, & De Ridders, 2011). The operation of self-control processes in response to tempting food cues has also been demonstrated in a functional magnetic resonance imaging (fMRI) study. Higher self-reported weight control goals were associated with relative increased activation in the lateral prefrontal cortex, an area involved in self-control in response to viewing tempting foods (Smeets, Kroeseb, Evers, & de Ridder, 2013). Thus, it seems that exposure to tempting food can sometimes activate diet goals and reduce food intake in those with high weight concerns and restrained eaters.

However, few studies have shown evidence for counter-active control in response to tempting food cues and these results are likely due to variations within restrained eaters. Restrained eaters who score high in perceived self-regulatory success (PSRS) (Fishbach, Friedman, & Kruglanski, 2003) appear to activate both eating enjoyment goals and diet goals in the face of temptations. For example, it has been found individuals scoring high in PSRS are faster to recognise diet words after exposure to tempting food words (Fishbach, et al., 2003; Papies, et al., 2008b), perceive an apple to be larger when primed with a gourmet magazine (van Koningsbruggen, et al., 2011), self-report lower food intake over a 2 week period (Papies, et al., 2008b), and have a lower BMI than those scoring low in PSRS (Meule, Papies, & Kuebler, 2012; Papies, et al., 2008b; van Koningsbruggen, et al., 2011; van Koningsbruggen, Stroebe, Papies, & Aarts, 2011). These restrained eaters seem able to activate diet goals in response to tempting food cues and this seems to facilitate the control of food intake. It might be that the studies demonstrating counter-active control have a high proportion of these types of restrained eaters. These findings on successful restrained eaters mirror fMRI data on weight loss maintainers showing increased activation in inhibitory control brain areas in response to palatable food (Sweet, et al., 2012). Taken together this evidence suggests that increasing the salience of diet goals might initiate self control processes and facilitate dieters to control food intake in tempting situations.

1.4 Successful weight loss

Promisingly, despite dieters' conflict between eating enjoyment goals and diet goals, successful weight loss maintenance is achievable. The National Weight Control Registry documents 6000 successful weight loss individuals who have maintained weight loss for an average of 6.5 ± 8.1 years (McGuire, Wing, Klem, & Hill, 1999). Therefore, although dieters might be prone to physiological and psychological hunger which conflicts with their diet goals weight loss is achievable and identifying effective strategies is currently needed.

1.5 Strategies for successful weight loss diets

1.5.1 Diet-congruent cues

Exposure to diet-congruent cues might be an effective strategy to increase dieters' self-control in tempting situations (Stroebe, et al., 2008; Stroebe, et al., 2013). Exposure to diet words can prevent attentional biases to food (Papies, et al., 2008a) in restrained eaters and devalue attitudes to diet forbidden foods in participants with pre-existing positive attitudes (Connell & Mayor, 2013). Furthermore, diet-congruent cues might override eating enjoyment goals to improve healthy food choice and reduce food intake. Diet cues in a restaurant menu such as "low in calorie" messages improved restrained eaters' and dieters' choice of healthy foods compared to neutral "special offer" messages (Papies & Veling, 2013). Similar findings have also been found for an exercise magazine and diet flyers (Fishbach, et al., 2003). However, measures of food choice provide no indication of energy intake. Measures of energy intake show that exposure to commercials with healthy foods (Harris, et al., 2009) slim models and diet products (Anschutz, Van Strien, & Engels, 2008) and a slimming recipe poster (Papies & Hamstra, 2010) reduced restrained eaters' food intake. In general samples, the discrete presence of weighing scales (Brunner, 2010), subtle exposure to images of slim models (Brunner & Siegrist, 2012), and the combination of weighing scales, diet books and a tempting recipe (Mann & Ward, 2004) reduced snack consumption. However, effects of diet-congruent cues (diet magazines) on snack intake are not always reported (Pelaez-Fernandez & Extremera, 2011). Moreover, following a milkshake preload, exposure to commercials featuring diet products and slim models increased restrained eaters' subsequent snack intake compared to control commercials (Strauss, Doyle & Kreipe, 1994). These discrepant findings suggest that the impact of diet-congruent cues might be minimal if participants do not engage with diet-congruent cues (Pelaez-Fernandez & Extremera, 2011) and if they are preceded by more potent tempting cues such as intake of a tempting preload (Strauss, Doyle & Kreipe, 1994). Additionally, exposure to diet-congruent cues might be most beneficial when self-control resources are low. Two separate studies showed participants reduced snack intake after exposure to healthy food adverts (study 1) and health words (study 2) compared to participants exposed to tempting or non-food adverts or words in the afternoon, but not when tested in the morning (Boland, Connell, & Vallen, 2013). In the afternoon self-control resources are likely to be depleted (Baumeister, 2002) compared to the morning meaning that when most vulnerable to overconsumption diet-congruent cues can enhance self-control and reduce food intake.

Cues instrumental to weight loss might also prime food intake. Watching exercise commercials reduced lunch intake in high BMI participants (van Kleef, Shimizu, & Wansink, 2011). In contrast, other studies report increased snack intake after exposure to exercise commercials (Albarracin, Wang, & Leeper, 2009) and thinking about exercise (Werle, Wansink, & Payne, 2011) compared to control. Participants also consumed more food from a 'fitness' labelled snack compared to a control labelled snack (Koenigstorfer, Groeppel-Klein, Kettenbaum, & Klicker, 2013). Thus, although exercise is instrumental to weight loss this evidence suggests that not all cues closely associated with weight loss can be effective cues to reduce food intake. Research is needed to evidence cues that are effective to prime reduced food intake.

1.5.1.1 Limitations of diet-congruent research

Currently, evidence that cues trigger goals to affect food intake is mostly based on studies examining early processes involved in food intake such as attention and perception. Preliminary studies on food intake suggest diet-congruent cues affect restrained eaters' food intake (Anschutz, et al., 2008; Harris, et al., 2009; Papies & Hamstra, 2010). Effects in dieters have only been examined in one study on food choice (Papies & Veling, 2013). Yet, as dieters are susceptible to food cues (Cameron, et al., 2008) and hold goals to lose weight, diet-congruent cues might be particularly salient to dieters. Thus, it will be interesting to examine whether diet-congruent cues can reduce dieters' food intake. It will also be important to test whether any effects on food intake are mediated by diet goal salience. The literature so far tests food choice and food intake in restrained eaters without measuring corresponding goal salience. To be confident that effects of diet-congruent cues are due to goal activation it is necessary to examine both food intake and goal activation within the same study. Further gaps in the goal priming literature need to be addressed. Firstly, all of the research examines snacking however, meals represent a greater percentage of overall energy intake compared to snacks (Bellisle, et al., 2003) and given the greater percentage of energy attributable to meals within the diet, diet-congruent cues to reduce dieters' meal intake might be of greater benefit than to reduce snack intake. Secondly, none of the goal priming studies assess subjective appetite sensations in relation to diet-congruent cue exposure. Considering that hunger is one of the major reasons given for terminating diets it is important to assess whether diet cues can have measurable impact upon dieters' subjective sensations of appetite.

1.5.2 Food as a diet-congruent cue

Items most closely linked to dieting should be the most effective cues to reduce food intake (Loersch & Payne, 2011). Given that food is instrumental to achieving weight loss goals and is frequently thought about by dieters (Vreugdenburg, et al., 2003) it could be an effective cue to trigger thoughts about dieting in tempting eating situations. Several studies have shown indirect exposure to diet-congruent food, such as through television commercials reduced restrained eaters' snack intake (Anschutz, et al., 2008; Boland, et al., 2013; Harris, et al., 2009). Yet, direct interaction with diet-congruent food might be much more potent to reduce food intake because it stimulates a number of modalities such as visual, odour, feel and taste. Thus, if foods are associated with dieting, this might offer a potential diet-congruent cue.

1.5.3 Perceptions of food

Information learnt about foods is stored in cognitive schemas and is retrieved on subsequent encounters to simplify the 200 decisions people make about food a day (Wansink & Sobal, 2007). Within cognitive schemas foods can be categorised dichotomously as either fattening or dieting (Carels, Konrad, & Harper, 2007; Sobal & Cassidy, 1987) healthy or unhealthy, meals or snacks (Wadhera & Capaldi, 2012), liked or disliked, (Blake, Bisogni, Sobal, Devine, & Jastran, 2007; Furst, Connors, Sobal, Bisogni, & Falk, 2000).

These categorisations of food influence food intake. For instance, the perception of foods as meals compared to snacks reduced food intake (Capaldi, Owens, & Privitera, 2006; Pliner & Zec, 2007) likely due to learnt expectations that meals are larger than snacks and more satiating (Decastro, 1987). Accordingly, food categorised in the diet category might trigger thoughts about dieting constructs and influence subsequent intake.

There is general consensus about foods categorised as diet-congruent. Fruit, vegetables, fish, yoghurt and salad were frequently named as foods associated with dieting by undergraduate students (Carels, et al., 2007; Sobal & Cassidy, 1987, 1990). Foods labelled as diet-congruent had a low energy density, low carbohydrate and low fat content (Sobal & Cassidy, 1987, 1990). Importantly, no foods appeared in both the diet and fattening category (Sobal & Cassidy, 1987, 1990) suggesting that diet/fattening is a salient food category and thus, some foods can be diet-congruent cues.

Yet, data on the diet-congruent perception of food is based on undergraduate students and it is difficult to know whether these prototypical examples of diet foods can be generalised to non-student samples. Sobal and Cassidy (1987; 1990) did not report the number of dieters in their sample and Carels et al. (2007) had a relatively small sample drawn from active dieters. For example, of the 101 male and female students examined by Carels et al. (2007) only 35% were dieters, and given differences in dieters' and non-dieters' classifications of foods (Carels, et al., 2007; King, Herman, & Polivy, 1987), differences between males' and females' knowledge about foods (Oakes & Slotterback, 2001) and eating styles (Rolls, Fedoroff, & Guthrie, 1991) it is important to test the effects beyond convenience samples. Nevertheless, foods can be classified as diet-congruent and further investigation is needed to identify which foods are *most* diet-congruent and how effective exposure to diet-congruent food is in reducing food intake.

1.5.4 Expectations of diet-congruent food

The effect of foods perceived as diet-congruent or healthy on food intake have mostly been explored with explicit information such as labels. Fruit beverages labelled as "satiating" reduced hunger and increased fullness compared to "diet" or "supermarket branded" labels (Fay, Hinton, Rogers, & Brunstrom, 2011). Labels about the nutritional contents of food have also impacted subsequent intake. Low fat labelled preloads increased subsequent meal intake compared to isocaloric high fat labelled preloads (Shide & Rolls, 1995; Wooley, Wooley, & Dunham, 1972). However, findings are mixed, as some studies report no effect of labels on food intake (Ebneter, Lather, & Nigg, 2013; Kral, Roe, & Rolls, 2002; Yeomans, Lartamo, Procter, Lee, & Gray, 2001) and others report effects of labels for low calorie foods but not high calorie foods (Hogenkamp, et al., 2013). Thus, explicit labels might only have an effect in the absence of alternative stronger satiety cues, such as high energy contents. In addition to fat labels, "healthy" labels have also been shown to increase (Cavanagh & Forestell, 2013; Irmak, Vallen, & Robinson, 2011; Provencher, Polivy,

& Herman, 2009) and decrease snack intake (Belei, Geyskens, Goukens, Ramanathan, & Lemmink, 2012).

The inconclusive findings on the effects of labels on food intake might be due to limitations of using labels to manipulate the health perception of foods. Labels might result in demand characteristics (Brunstrom, Brown, Hinton, Rogers, & Fay, 2011), and might create an ambiguous situation if the type of food is matched with an inconsistent label. Therefore, examining food intake as a consequence of participants' personal perceptions of foods might be more informative than the use of explicit labels to create expectations.

1.5.5 Potency of diet-congruent cues

The sensory modality affected by diet-congruent food might impact the extent diet-congruent foods cues affect subsequent intake. This idea is based on research with tempting food and the cephalic phase response. The cephalic phase response is a physiological response which prepares the body to ingest nutrients (Power & Schulkin, 2008). The cephalic phase response includes increased salivation (Nederkoorn, Smulders, & Jansen, 2000), increased gastric acid (Feldman & Richardson, 1986), the release of hormones such as insulin (Teff, 2000), glucagon, ghrelin (Cummings, et al., 2001), CCK (Power & Schulkin, 2008), increased blood pressure, and postprandial thermogenesis (Leblanc & Brondel, 1985). The magnitude of the cephalic phase response depends on the potency of the food cue. For example, it is assumed that consumption of food is more potent than merely chewing, tasting (Raynor & Epstein, 2000), smelling, seeing (Feldman & Richardson, 1986; Wooley & Wooley, 1973) and thinking (Morewedge, Huh, & Vosgerau, 2010) about food (Nederkoorn & Jansen, 1999). A combination of modalities stimulated, such as both sight and odour also leads to an increased cephalic phase response compared to exposure to a single modality (Feldman & Richardson, 1986). Thus, the more potent the food cue, the larger the cephalic phase response.

In a similar manner, it might be that diet-congruent cues follow this linear pattern of response, such that diet-congruent images have the least efficacy of action and intake of diet-congruent food has the greatest in terms of reducing subsequent intake. In support, cognitive expectations have been shown to influence the cephalic phase response. Consuming a "low calorie" 140-kcal labelled milkshake produced a flatter ghrelin response (small increase followed by small decrease to similar level as pre-consumption) compared to consuming an "indulgent" 620-kcal labelled milkshake (sharp increase in ghrelin followed by sharp decrease to lower than pre-consumption levels) (Crum, Corbin, Brownell, & Salovey, 2011). A flatter ghrelin response after consuming the healthy milkshake might lead to less subsequent intake compared to the steep rise and fall implicated with the indulgent milkshake. This study suggests that cognitive processes can influence internal responses to food and suggests that cognitions about diet-congruency might also influence appetite signals and thus food intake.

1.5.6 Intake of low energy dense food

As intake might be the most potent form of food cues and foods perceived as diet-congruent tend to be low in energy density this might have physiological implications. Energy density is the amount of energy provided per 1 gram of food. It has been repeatedly shown that consumption of low energy dense foods reduces energy intake. For instance, increasing amounts of low energy dense foods by adding pureed vegetables (Blatt, Roe, & Rolls, 2011; Kral, et al., 2002; Leahy, Birch, Fisher, & Rolls, 2008), cooked vegetables (Rolls, Roe, & Meengs, 2010), reducing fat and sugar and increasing fruit, increasing vegetables (Leahy, Birch, & Rolls, 2008; Rolls, Roe, & Meengs, 2006) in meals, eating a first course high volume low calorie salad (Rolls, Roe, & Meengs, 2004) and increasing air in snacks (Osterholt, Roe, & Rolls, 2007) reduced participants' energy intake compared to higher energy dense foods (Drewnowski, Almiron-Roig, Marmonier, & Lluch, 2004; Kral & Rolls, 2004; Yao & Roberts, 2001).

Short term laboratory have been supported with long term weight loss programs integrating low energy dense diets. For instance, low energy dense diets reduced weight when incorporated in to 1 year weight loss programs (Rolls, Roe, Beach, & Kris-Etherton, 2005; Saquib, et al., 2008; Schusdziarra, et al., 2011). It also seems that adopting multiple low energy dense strategies is more effective than one. Participants lost more weight when they adopted two low energy density strategies (fat reduction and an increase in water rich vegetables) compared to only one (reduce fat only) (Ello-Martin, Roe, Ledikwe, Beach, & Rolls, 2007).

These effects of low energy dense food on food intake might be explained with a volumetrics account (Rolls, 2010). As a larger volume of low energy dense food can be consumed for equivalent energy as high energy dense foods, low energy dense foods can increase gastric distension and promote negative feedback (De Castro, 2005; Roll & Roe, 2002). Larger volumes of food also increase bulk and extend oral processing times to reduce food intake (De Graaf, 2012). Thus, intake of diet-congruent food might help to reduce dieters' food intake due to increasing the salience of diet thoughts and promoting negative feedback.

1.6 Summary and directions for future research

Overall low rates of dieting success might be due to dieters experiencing physiological and psychological hunger which gives rise to a conflict between diet and eating enjoyment goals. To resolve this conflict, dieters' narrow attention detects either tempting or diet cues in the environment (Mann & Ward, 2004) to determine goal directed behaviour (Stroebe, et al., 2008; Stroebe, et al., 2013). Tempting food cues increase the salience of eating enjoyment goals and reduce the salience of diet thoughts. Thus, dieters lose sight of long term weight loss goals and overeat. Yet, the presence of diet-congruent cues can reinstate diet goals and prevent dieters overeating. Research on diet-congruent cues is constrained to restrained eaters, however, due to the conflict of goals experienced by dieters (Green, et al., 2009) it is likely that diet-congruent cues can also facilitate dieters. Food can be associated with dieting (Carels, et al., 2007; Sobal & Cassidy, 1987, 1990) and might act as an effective diet-congruent cue to increase the salience of diet thoughts in tempting situations. Diet-congruent food can be delivered to target different sensory modalities (sight, smell, and taste) and based on the potency of each type of stimulation to determine the cephalic phase response there might be a linear relationship between the potency of diet-congruent food cues and decrements in energy intake.

1.7 Aims of current research

Based on the current literature review, the main aim of the current research was to:

- Examine whether diet-congruent food cues reduce dieters' short term energy intake (snack and meal) compared to tempting food cues and non-food control cues.

Specific aims included:

- Identify foods (and beverages) associated with dieting to lose weight and temptation.

- Test whether exposure to diet-congruent food cues increase the salience of dieters' diet thoughts and inhibits eating enjoyment thoughts compared to exposure to tempting and non-food control cues.

- Identify whether appetite sensations change in response to diet-congruent food cues compared to tempting and non-food control cues.

- Assess whether there is a dose response to diet-congruent cues based on the potency of diet-congruent food cues (for example testing whether the effect increases from images to the sight and smell to consumption).

- Examine whether diet-congruent food cues can affect short term food intake in individuals scoring in high in markers of unsuccessful dieting (HRHD).

To address these aims, 4 laboratory-based studies, 2 pilot studies and 3 online surveys were conducted (see Figure 1.3).

1.8 Clarifying terms

Throughout the remaining thesis cues referring to the eating enjoyment goal will be defined as tempting cues. Conditions involving exposure to tempting cues will be referred to as the tempting condition. Similarly, cues associated with the diet goal will be referred to as diet-congruent cues. Conditions involving exposure to diet-congruent cues will be referred to as the diet condition

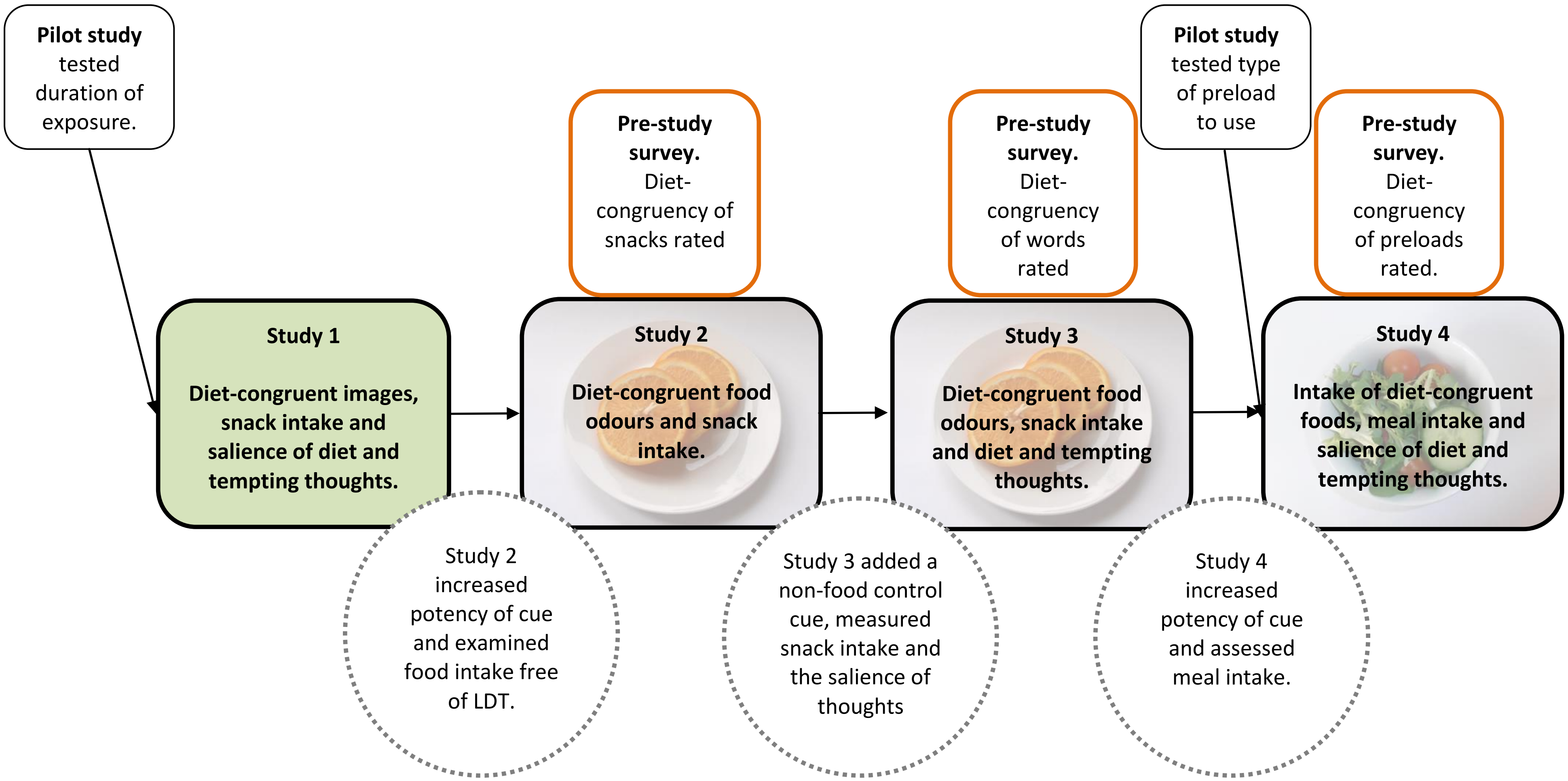

Figure 1.3. Progression of studies within this thesis

Chapter 2

General Methodology

2.1 Ethics

The studies in this thesis were reviewed and approved by the University of Leeds Institute of Psychological Sciences ethics committee. Each study was conducted in accordance with local ethical guidelines and followed the code of ethics and conduct of the British Psychological Society. All recruitment advertisements specified the ethics committee approval number, the duration of the study, any rewards offered, and the name and email address of the researcher. Participants were informed about all study procedures and consent was obtained from all participants prior to testing. In each study the fact that food intake was being measured was withheld from participants until the debrief session. Participants were identified with a unique code to preserve anonymity and participants were informed they were free to withdraw themselves or their data from the study at any time. At the end of the study, written debrief was provided and participants had the opportunity to discuss the research with the experimenter. Participants were compensated with either monetary rewards or course credits (see Chapter 3, 4, 5 and 6 for specific details).

2.1 Participants

Females aged 18 – 55 years were recruited for the studies. Females were selected because dieting behaviours tend to be reported at higher rates by women than men (Lemon, et al., 2009) and previous research has also tended to use women only samples. The age restriction of the sample was applied to ensure a pre-menopausal sample.

Participants were recruited through the University of Leeds research databases, email distribution lists, poster advertisements distributed around the University campus, posting advertisements on online forums, and using an online classifieds website specifically for the Leeds, UK area.

2.2 Exclusion criteria

Respondents to recruitment adverts were emailed and screened for eligibility. Exclusion criteria for all studies included food allergies, pregnancy, lactating, diabetes, a history of eating disorders (ED) or current mental health problems, taking any medication known to affect appetite, disliking study foods, and a BMI above 18.5 and below 40kg/m^2 calculated by the researcher from self-reported height and weight. Additionally, in Chapters 3, 5 and 6 a lexical decision task was administered and participants who were not fluent English speakers or reported reading problems were screened out to control for factors that might influence word processing speed.

2.3 Laboratory Assessment of Food Intake

Laboratory assessment of food intake provides a highly controlled setting to examine variability in eating behaviour. The effect of an independent variable on food intake and appetite sensations can be precisely measured in isolation from a multitude of factors incurred in free living environments. The measurement of food intake is largely preferable to self-report measures of food intake as self-report food intake measures tend to be underreported (Macdiarmid & Blundell, 1998) especially in dieters (Bothwell, et al., 2009; Hill & Davies, 2001; Klesges, Eck, & Ray, 1995; Maurer, et al., 2006).

Obtaining precise measurements of eating behaviour in laboratory settings is costly to the naturalness of the eating environment and limits the external validity of laboratory studies (Blundell, Finlayson, Halford, Hetherington, & King, 2009). Therefore, an alternative to laboratory studies is to examine eating behaviour in the free living environment to improve external validity. However, it is difficult to measure food intake, particularly energy intake, with high precision and accuracy in the free living environment. Furthermore, disentangling individual components that influence food intake from the myriad of factors in the natural environment is extremely difficult. To obtain highly accurate measurements of food intake in response to diet-congruent preloads, the studies reported in this thesis used laboratory-based assessments.

The current laboratory studies took place at the Human Appetite Research Unit (HARU), Institute of Psychological Sciences at the University of Leeds. The HARU is a purpose-built research laboratory which provides facilities to conduct highly controlled research studies. The laboratory includes a kitchen, in which all foods in the current studies were prepared and weighed. Participants were tested in individual cubicles that contained bare walls, a desk and computer to achieve an environment free from extraneous variables such as noise, visual distractions, odours and social interaction which may influence food intake.

2.3.1 Preload/food prime study design

A preload is a small amount of food that precedes the administration of an ad-libitum snack test or test meal. A food prime is the acute presence of a food or food cue such as a food image or odour. Manipulating a single property in a preload or food prime over one or more experimental conditions allows researchers to examine the role that property has on subsequent food intake. Due to its simplicity the preload-test meal paradigm has been frequently used in appetite research (Blundell et al. 2010). To minimise the influence of non-systematic variables, the design of preload studies should account for a number of factors. For example, it is important to select foods that are appropriate for consumption at the time of day that testing is scheduled for. The interval between preload and snack test or test meal administration is also critical because with a longer interval the effect of the preload on subsequent intake may diminish (Rolls, Kim, et al., 1991). To assess the impact of food cues via processes such as cognitions, the food prime-meal interval should usually be less than 30 minutes (Blundell et al. 2010).

In the current studies, the diet-congruency of image food cues, odour cues and preloads were manipulated to examine the effect of diet-congruent food cues and preloads on subsequent snack and test meal intake. The interval between preload/food cue and assessment of food intake ranged from immediate (Chapter 4) to 5 minutes (Chapter 3, 5 and 6) depending on other measures administered during this interval (lexical decision task). This interval was selected based on previous goal priming research which examines the effect of diet-congruent cues on immediate subsequent intake (Papies & Hamstra, 2010; Anschutz et al. 2008; Brunner, 2010; 2011).

2.3.2 Nature of the test meal

To assess the impact of a preload on subsequent intake the nature of the snack test or test meal needs to be sensitive to the experimental manipulation. *Ad libitum* access to a selection of foods, including sweet and savoury high and low fat alternatives can be offered to prevent participants' intake being constrained by minimal experimental choice and quantity of food provided. Careful consideration of the types of foods provided is required as there are a number of food properties known to affect food intake. For example, palatability (De Graaf, De Jong, & Lambers, 1999), texture, variety and flavour intensity (Bolhuis, Lakemond, de Wijk, Luning, & de Graaf, 2012) of the foods offered all need to be considered. Environmental factors such as portion sizes and the size of serving plates can also affect food intake (Wansink, 2004). In the current studies, when food choice was provided in Chapters 3, 4, and 5, the amounts of each snack food were visually similar, and all snacks were served using the same serving bowls or plates.

2.3.3 Assessment of *ad libitum* intake

The current studies offered *ad libitum* access to snack or test meal foods. Examining intake in response to *ad libitum* snack and test meals permits quantitative analysis of food intake. Foods are weighed before and after consumption (to nearest 0.1g) to accurately determine the weight of food consumed (Obarzanek & Levitsky, 1985). The weight consumed is converted to energy (kcal) using the values provided from manufacturers' nutritional information.

The use of *ad libitum* snack tests and meals is labour intensive, costly and can incur high wastage as a large proportion of the prepared food will not be eaten. Yet the benefits of collecting objective, quantitative data that accurately reflects the impact of an independent variable on eating behaviour makes this an ideal approach for the studies in the current thesis.

2.3.4 Taste Test

In each study, participants were given *ad libitum* access to foods with the instructions to help themselves to as much or as little of the food as they liked. To prevent demand characteristics that food intake was being measured, the food was presented as a bogus taste test. Bogus taste tests are used widely in appetite research (Fedoroff, et al., 1997; Higgs, 2002) and mask the purpose of measuring food intake by informing the participant that taste perception is the variable of interest. Participants evaluate taste properties (e.g. sweet, salty, and bitter) for each of the foods provided on rating scales (for details about specific food types provided and specific rating scales used in each study see experimental chapters). The duration of the taste task is either set to a specified time limit or the participant is given control to determine when the eating episode is over.

2.3.5 Controls of food intake

In preload-test meal paradigm it is important to control for appetite levels, time elapsed since the last meal and exertion through physical activity across study conditions (Blundell et al. 2010). In the current studies, several controls were applied to achieve good levels of standardisation.

2.3.6 Fixed meals

Fixed energy meals can be used to standardise appetite across participants and conditions. A fixed meal provides a set amount of energy content and volume to be consumed by participants, giving the researcher more certainty over the participants' internal state. In Chapters 4, 6 and 7 fixed lunches were provided to standardise appetite levels (see each Chapter for specific lunch details).

2.3.7 Energy depletion and self-reported prior food intake

To control for energy depletion across conditions, the studies in this thesis required participants to keep physical activity levels constant across test days and to avoid alcohol the night before and morning of test day. Participants were required to fast for two hours prior to the start of the study session. Two hours was considered sufficient to ensure participants were in a similar state of moderate hunger and was consistent with previous research (Fedoroff, et al., 1997). At the start of each study session adherence to fasting requirements was confirmed by obtaining a written self-report on foods previously eaten that day and the time of consumption.

2.3.8 Subjective Appetite Ratings

Standardisation of appetite levels can also be examined by measuring subjective appetite sensations. Appetite sensations (hunger, fullness and desire to eat) can be measured using visual analogue scales (VAS). VAS require participants to quantify their subjective appetite sensations using a 100 mm horizontal line that is anchored from left to right with the statements "not at all" to "extremely." Each anchored point represents the most extreme sensation imaginable and participants are required to mark the horizontal line with a vertical mark at the point that best reflects the extent that the sensation is currently being experienced. The questions used in the studies were "How hungry do you feel RIGHT NOW?"; "How full do you feel RIGHT NOW?" and "How strong is your desire to eat RIGHT NOW?"

VAS have been widely adopted in the field of appetite research. For the participant, VAS are intuitive and easy to complete. Most importantly, VAS ratings of appetite have been found to be replicable in both within-subjects (Flint, Raben, Blundell, & Astrup, 2000) and between-subjects designs (Stubbs, et al., 2000) and their predictive validity in relation to food intake has been well established (Blundell, et al., 2010; Drapeau, et al., 2005; Flint, et al., 2000; Stubbs, et al., 2000). VAS have been criticised because measuring the lines, entering the data and checking for human errors is time consuming (Blundell, et al., 2009). The current studies administered appetite VAS at pre-determined time points throughout each study (see specific chapters for details).

2.3.9 Mood

States of happiness, sadness, relaxation, anxiousness, alertness, and tiredness were measured at the same time and by the same VAS method as appetite ratings in each study. Mood and emotion are factors known to affect appetite (Evers, Adriaanse, de Ridder, & de Witt Huberts, 2013) therefore mood was measured to examine whether the experimental manipulations affected any of the mood states and to check for similar mood levels across participants and conditions.

2.4 Lexical decision task

The lexical decision task is an implicit task which is thought to assess the salience of thoughts in the minds of participants (Neely, 1991). A number of studies have used the lexical decision task to specifically measure the salience of diet goals (Kroese, et al., 2011; Papies, et al., 2008b; Pelaez-Fernandez & Extremera, 2011; Stroebe, et al., 2008). Lexical decision tasks present a string of letters on screen which form either a word or a non-word, and participants are instructed to decide as quickly and accurately as possible whether the letters form a word or not by pressing a corresponding key on the keypad. The words used in lexical decision tasks comprise critical words (e.g. diet or temptation words) and neutral words (not related to the critical words). Assessing reaction times to detect diet words provides an indication of how salient diet thoughts are in the minds of participants, such that faster reaction times indicate increased salience of diet thoughts in the mind.

A lexical decision task was used in Chapters 3, 5 and 6 to examine the salience of diet and tempting thoughts after exposure to diet-congruent images. Each task included diet, tempting, neutral and non-words. For details about how diet and tempting words were generated please see Chapters 3, 5, and 6. Neutral words were generated using a lexical database (Wordcount, 2003) and non-words were generated using the ARC non-word database (2004).

Each trial commenced with a fixation mark (+) presented for 1500 ms to focus participants' attention followed by a string of letters (see Figure 2.1). Participants pressed 'W' for words and 'O' for non-words on the keypad. The words remained on screen until participants provided a response. Submission of a response was followed with the next trial. All letter strings were presented in lower case, black Arial font in the centre of the screen. In each study participants completed the lexical decision task in their own time. The lexical decision task was completed on a desktop computer (Stone Group, 2012) with Microsoft Windows XP operating system. The task was designed and delivered using E-prime 2.0 software (Psychology Software Tools, Inc).

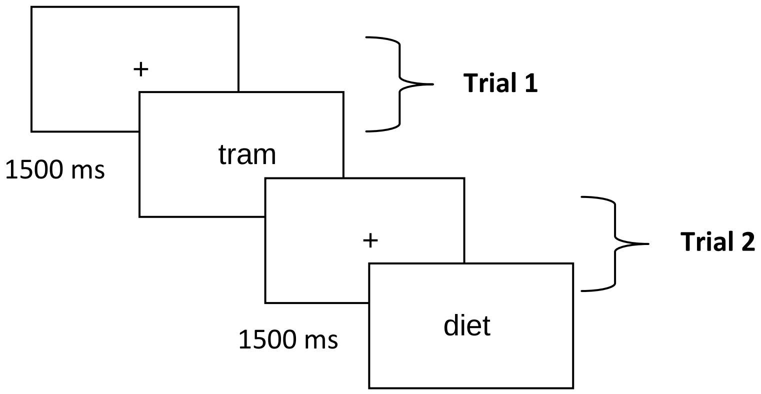

Figure 2.1 Example of lexical decision task (2 trials).

2.5 Individual differences in eating behaviour.

In order to examine individual differences in eating behaviour traits, validated psychometric questionnaires were used in each study. Measures for individual differences in eating behaviour were measured at the end of each study to avoid demand characteristics or priming thoughts about dieting or eating which may have influenced eating behaviour.

2.5.1 Three Factor Eating Questionnaire (TFEQ)

The TFEQ (Stunkard & Messick, 1985) is a 51-item scale that measures three eating behaviour traits: cognitive restraint, disinhibition and hunger. Of the 51 items, 21 measure cognitive restraint, 16 measure disinhibition and 14 assess susceptibility to hunger.

Questions 1 – 36 consist of statements which require true of false responses. The remaining questions provide a choice of 4 answers which range on a continuum. The cognitive restraint subscale has been identified as a valid tool to assess dieting intentions (Williamson, et al., 2007), and the overall scale has been shown to have high internal validity (Stunkard & Messick, 1985).

In addition to analysing restraint and disinhibition of restraint separately, it has been recognised that examining the combination of restraint and disinhibition subtypes provides a more accurate marker of susceptibility to overeating (Westenhoefer, et al., 1994). Following previous research, the current studies used median splits to classify participants as high or low in restraint and disinhibition. The combination of high and low scores for restraint and disinhibition yielded 4 subtypes: high restraint high disinhibition (HRHD), high restraint low disinhibition (HRLD), low restraint, high disinhibition (LRHD) and low restraint low disinhibition (LRLD).

The use of median splits to categorise restraint and disinhibition scores is controversial as restraint and disinhibition are continuous variables (Cohen, 1983). However, as median splits are predominantly used in the literature (Polivy, et al., 1988; Westenhoefer, et al., 1994; Yeomans, et al., 2004), and research which compares the use of median splits to entering restraint as a continuous variable has shown no difference in outcomes (Anderson, Shapiro, Lundgren, Spataro, & Frye, 2002), the current study used median splits to categorise participants.

The Cognitive Restraint subscale of the TFEQ can be further sub-categorised to assess 'rigid' and 'flexible' restrained eating (Westenhoefer, 1991). Rigid restrained eaters are characterised by an "all or nothing" approach to eating and dieting (for example "I count calories as a conscious means of controlling my weight"). Whilst, flexible eaters utilise a more lenient approach to food intake, such as permitting the intake of high fat foods in low quantities (for example "While on a diet, if I eat food that is not allowed I consciously eat less for a period of time to make up for it"). A flexible approach to eating has been found to be associated with lower BMI scores (Shearin, et al., 1994; Westenhoefer, et al., 1999; Westenhoefer, et al., 2013) and more successful weight loss in the long term (Westenhoefer, et al., 2013). There is speculation that rigid restraint may be a proxy for dieters with the objective to lose weight, whilst flexible eating is related to dieters who wish to maintain weight (Timko & Perone, 2006).

In the current studies, the TFEQ subscales were used to examine group differences between dieters and non-dieters. The combination of restraint and disinhibition was used as a between-subject factor to examine the impact of these combination traits on energy intake. Additionally, the associations between energy intake and restraint, disinhibition, hunger, flexible and rigid restraint were examined in each of the studies. For internal reliability of the three subscales see Chapters 3, 4, 5 and 6.

2.5.2 Dutch Eating Behaviour Questionnaire (DEBQ)

The Dutch Eating Behaviour Questionnaire consists of 33 items that require responses on a 5-point Likert scale ranging from 1 (never) to 5 (very often). The scale includes 10 items that measure restraint, 10 items referring to external eating and 13 items that measure emotional eating. Higher scores on each of the subscales indicate higher responsiveness to restraint, external eating and emotional eating. The scale has good internal and external validity and has been shown to be reliable (van Strien, et al., 1986; Wardle & Beales, 1987). In each of the studies the association between food intake and restraint, external eating and emotional eating were examined. The DEBQ was also included to assess differences between dieters and non-dieters.

2.5.3 Power of Food Scale (PFS)

The Power of Food Scale examines the motivation to eat in a ‘food abundant environment’ (Lowe, et al., 2009). The scale assesses hedonic motivation for food readily available in the environment, food when present but not tasted, and food when tasted. The PFS includes 21 items and prompts responses on a 5-point Likert scale ranging from 1 (“Do not agree at all”) to 5 (“Strongly agree”). Higher scores indicate higher responsiveness to the food environment compared to lower scores. The PFS has been found to have good reliability and validity (Cappelleri, et al., 2009; Lowe, et al., 2009). The PFS has been found to be positively associated with TFEQ-hunger (Lowe et al. 2009) and disinhibition (Finlayson, et al., 2012; Lowe, et al., 2009). However, some studies have found no effects of PFS on participants’ food intake in response to environmental food cues (Thomas, Doshi, Crosby, & Lowe, 2011).

The scale was particularly relevant to the current studies’ examination of food cue exposure and was included to identify any relationships between energy intake and the PFS subscales, and to examine group differences.

2.5.4 Current Diet Status

Current diet status was determined by participants' response to the question "Are you currently on a diet to lose weight, maintain weight or not dieting?" which was recorded at the end of each study. This method has been used previously (Lowe, 1993) and despite criticisms that such dichotomous categorisation of dieting neglects variations in the degree of dieting intensity and different types of dieting behaviours amongst dieters (Martz, et al., 1996) this method is considered a valid assessment of dieting that can be dissociated from restrained eating (Witt, et al., 2013). As there is a large variation in the types of behaviours adopted for diets (Timko, et al., 2006), participants were asked to describe the nature of their type of diet, provide the length of time they had been on their current diet, estimate the amount of weight they had lost and provide their intended weight loss goal.

Diet status was used as a between-subjects factor in each of the experimental studies. Diet status is presented in each empirical chapter to corroborate classification of dieting to lose weight. The length of time participants had been dieting was recorded to check that dieters were engaged in diet behaviour throughout the course of each study.

2.5.5 Frequency of Dieting

Frequency of dieting was assessed by asking all participants "Have you ever dieted before?" All affirmative responses were further prompted to indicate how often they had dieted (always, more than once per year, once per year or less) and to describe the nature of previous diets. Frequency of dieting was included to demonstrate the repeated diet efforts by most dieters in the current samples. Each chapter details the percentage of dieters and non-dieters who reported previously dieting and frequency of previous diets.

2.5.6 Weight Suppression

To measure weight suppression, participants were asked to provide their heaviest weight (excluding pregnancy). Weight suppression was calculated by subtracting current weight from heaviest weight reported (Lowe, 1993). Weight suppression is presented in each chapter to show any associations between weight suppression and food intake in the current studies.

2.5.7 Perceived Self-Regulatory Success (PSRS)

The PSRS scale reflects perceived success at adhering to diet behaviours (Fishbach et al. 2003). The scale comprises of three items (“How successful are you at losing weight?”; “How successful are you at watching your weight?” and “How difficult do you find it to stay in shape?”) and responses are recorded on a 7-point scale ranging from 1 (not successful) to 7 (very successful). Low scores on PSRS are associated with greater self-reported food intake (Papies, et al., 2008a), higher BMI scores (Meule, et al., 2012; van Koningsbruggen, et al., 2011) and responsiveness to diet cues (Koningsbruggen, Stroebe, & Aarts). Initial reports suggest the scale has good reliability and validity (Meule, et al., 2012) and the scale is recognised as a relevant assessment to include in studies examining dieting behaviour (Witt, et al., 2013). The PSRS was used in each chapter to assess the relationship between perceived self-regulatory success and food intake. For internal reliability of the scale for each study reported see Chapters 3, 4, 5 and 6.

2.6 Height, weight and BMI

In each of the studies height and weight were measured by the experimenter. It is important to objectively measure height and weight because self-report measures tend to be misreported. Specifically, height tends to be overestimated while weight is underestimated (Ambwani & Chmielewski, 2013; Connor Gorber, Tremblay, Moher, & Gorber, 2007; Engstrom, Paterson, Doherty, Trabulsi, & Speer, 2003). Furthermore, inaccurate reports of body weight and height tend to be more common in women (Cash, Grant, Shovlin, & Lewis, 1992) and restrained eaters (McCabe, McFarlane, Polivy, & Olmsted, 2001). Height was collected using a wall mounted stadiometer (to the nearest centimetre). Weight was measured in grams (to nearest 0.1kg) using electronic scales. Both height and weight were recorded with no shoes and light clothing. Individual body mass index (BMI) score was then calculated by the following algorithm:

$$\text{BMI} = \text{weight (kg)} / \text{height (m}^2\text{)}$$

2.7 Study Purpose

In each of the studies a cover story was employed to prevent participants being aware of the true purpose of the study. To check whether participants believed the cover story, at the end of the study, participants were probed about the perceived purpose of the study.

2.8 Online Surveys

In chapters 4, 5 and 6 pre-study online surveys were used to validate study materials and included psychometric measures to gauge individual differences. Online surveys are widely used in academic research (Buchanan & Hvizdak, 2009) and the advantages are plentiful. Online surveys provide an opportunity to obtain large samples sizes. Surveys incur little cost as they can be distributed widely without using paper and printing resources. Surveys are also time efficient as data is collected electronically and can instantly be exported to statistical programs, also minimising data entry errors (Schmidt, 1997).

However, despite the merits of online surveys, respondents may represent a biased sample that have access to the internet, and are willing and able to invest time to complete the research. Additionally, with the rise in the use of online surveys a number of traditional pen and paper psychometric scales have been validated for online use (Buchanan, Johnson, & Goldberg, 2005; Hewson & Charlton, 2005). However, psychometric questionnaires for eating behaviour are yet to be validated for online use, and despite the majority of research implying similar results regardless of data collection method (Birnbaum, 2000) caution must still be exercised when interpreting the outcome of eating behaviour psychometric scales that have not been validated for online use (Buchanan & Smith, 1999). The surveys in Chapters 4, 5 and 6 were designed and distributed using Qualtrics Labs, Inc, version 12018.

2.9 Strategy for data analysis

All data was analysed using Statistical Package for the Social Sciences v 20 (SPSS; IBM Corporation, Somers, New York). Data collected in E-Prime 2.0 was merged using E-Merge (Psychology Software Tools) and exported to MS Excel 2007. Data from online surveys was downloaded from Qualtrics version 2012 (Provo, Utah, USA.) and exported to MS Excel. Calculations for psychometric scales were conducted in MS Excel according to the original authors' instructions. The data was then transferred to SPSS. All charts were produced using MS Excel by copying and pasting the relevant descriptive statistics from SPSS. For power calculations, G*Power (version 3.1.7) was used (Faul, Erdfelder, Lang & Buchner, 2007). The statistical analysis is described in more detail in each of the study chapters.

Chapter 3

Inhibitory Images: The role of diet-congruent image cues on snack intake.

3.1 Abstract

Exposure to images of palatable food has been found to lead to disinhibitory eating in restrained and normal individuals. However, recent studies suggest that in some cases subtle exposure to diet-congruent cues might increase the salience of diet goals and reduce restrained eaters' snack intake. It is relatively unknown how diet-congruent images affect dieters' control over food intake. Using a between-subjects design, the current study examined the effect of exposure to either diet-congruent food and beverage images or non-food images on i) high/ low fat sweet/savoury snack intake and ii) the salience of diet and tempting thoughts measured with a lexical decision task, in dieters (n = 26) and non-dieters (n = 41). Dieters exposed to diet-congruent images consumed 29% less energy from snacks compared to dieters exposed to non-foods, whereas non-dieters' snack intake did not differ between conditions. The reduction in dieters' snack intake was accounted for by 40% suppression of low fat sweet food following exposure to diet-congruent images compared to control. According to the combination traits of restraint and disinhibition, only HRHD eaters reduced snack intake following exposure to diet-congruent images compared to control. In the lexical decision task, all participants were faster to detect diet words compared to tempting and neutral words across conditions suggesting increased salience of these words regardless of cue exposure or dieting status.

3.1 Introduction

The obesogenic environment is rich in visual cues of palatable foods that appear in a variety of explicit and subtle forms, such as television adverts, outdoor advertising, on the internet, and on food packaging (Chandon & Wansink, 2012). Exposure to visual palatable food cues presents a reminder of the availability of such foods and poses a temptation to individuals who are trying to lose weight. For example, exposure to television commercials featuring food has been found to increase snack intake in obese individuals (Falciglia & Gussow, 1980), restrained eaters (Shimizu & Wansink, 2011), external eaters (van Strien, Herman, & Anschutz, 2012), normal weight females (Anschutz, Engels, van der Zwaluw, & Van Strien, 2011) and general student samples (Bodenlos & Wormuth, 2013) compared to non-food adverts.

The goal conflict theory suggests that diet-congruent cues can prevent tempting food images from undermining diet plans (Stroebe, et al., 2008; Stroebe, et al., 2013). According to the theory, exposure to a diet-congruent cue can increase the salience of diet thoughts and reduce dieters' consumption in tempting situations (Stroebe, et al., 2008; Stroebe, et al., 2013). The effect of diet-congruent cues on the salience of diet thoughts has been evidenced with studies on perceptual biases and attention biases to food. For instance, exposure to diet-congruent cues increased restrained eaters' perception size of an apple (van Koningsbruggen, et al., 2011) and eliminated attention biases to palatable food words typically found in restrained eaters' after exposure to tempting cues (Papies, et al., 2008a). However, relatively little is known about whether such changes might affect eating behaviour. The only study that has assessed the salience of diet thoughts and food intake found exposure to a diet magazine did reduce restrained eaters' reaction times to the word "diet" but had no effect on restrained eaters' snack intake compared to exposure to a gourmet magazine and control magazine (Pelaez-Fernandez & Extremera, 2011).

In studies where goal salience has not been assessed, subtle exposure to a nutrition message (Harris, et al., 2009), the combination of slim models and diet products in television commercials (Anschutz, et al., 2008) and a poster featuring "slimming" recipes (Papies & Hamstra, 2010) has been shown to reduce restrained eaters' snack intake. The effects of diet-congruent visual cues have also been reported in general samples in response to a screensaver featuring slim models (Brunner & Siegrist, 2012). These diet-congruent cues affected snack intake despite attention not being explicitly directed towards the cues (Anschutz, et al., 2008; Brunner & Siegrist, 2012; Harris, et al., 2009; Papies & Hamstra, 2010) and in some instances participants were even unaware of the presence of diet-congruent cues (Papies & Hamstra, 2010). Yet, visual diet-congruent cues are not always effective, especially after intake of a tempting preload. Strauss, Doyle and Kreipe (1994) showed that diet-congruent cues presented after intake of a tempting preload, doubled restrained eaters' snack intake. Thus, not all studies have demonstrated a suppressant effect of diet-congruent cues on food intake.

The inconsistent findings on visual diet-congruent cues might be due to the research being constrained mostly to restrained eaters identified on the Restraint Scale (Herman & Polivy, 1980). This narrow examination of diet-congruent cues is problematic because the psychometric properties of the Restraint Scale have been criticised (Stunkard & Messick, 1985; Wardle & Beales, 1987) and restrained eating is not synonymous with dieting behaviour (Lowe, 1993; Lowe, et al., 1991). Thus, diet goals might be absent in some restrained eaters, meaning that diet-congruent cues will have little effect on diet salience and food intake (Stroebe, et al., 2008; Stroebe, et al., 2013).

As dieters hold goals to lose weight yet are susceptible to tempting food cues and prone to weight gain (Hill, 2004; Mann, et al., 2007; Thomas, 1995), it might be useful to examine whether subtle exposure to diet-congruent images can curb dieters' snack intake. Similarly, it could be insightful to examine restrained eating in conjunction with disinhibition. The combination of high restraint and high disinhibition (HRHD) is a marker for unsuccessful dieting (Soetens, Braet, Van Vlierberghe, & Roets, 2008; Westenhoefer, et al., 1994; Yeomans, et al., 2004). Therefore, it is important to identify strategies that could help HRHD eaters to control food intake.

3.2 Study Aims

The main aim of the current study was to test the hypothesis that dieters exposed to diet-congruent image cues would subsequently reduce snack intake compared to dieters exposed to neutral image cues. The specific objectives were to: a) measure the salience of diet and tempting thoughts after diet-congruent image exposure compared to control images; b) assess subjective sensations in response to diet-congruent images; c) examine the effect of diet-congruent images on intake of different snack types; and d) examine the influence of restraint and disinhibition subtypes on responsiveness to diet-congruent images.

3.3 Method

3.3.1 Participants

Participants were staff and students from the University of Leeds that met study eligibility requirements (see Chapter 2) (see Figure 3.1). At study completion participants were compensated with £5.

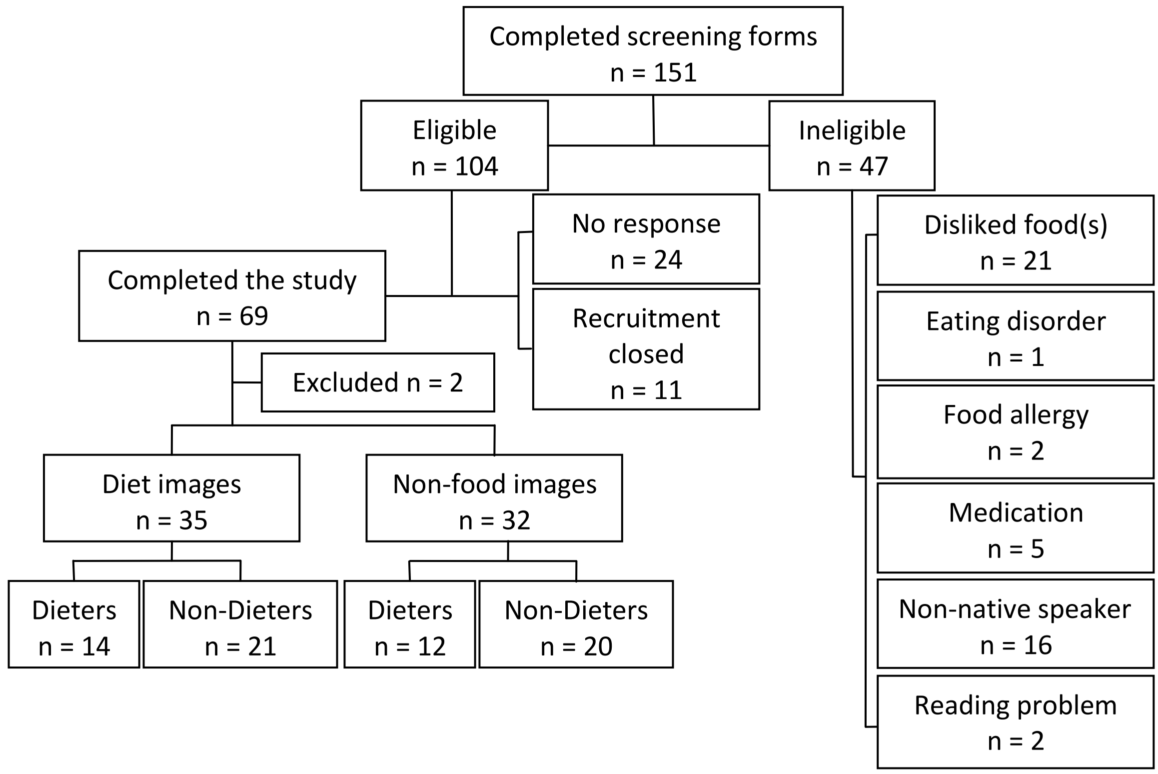

Figure 3.1. Process of recruitment.

3.3.2 Design

A 2 x 2 between-subjects design was used with condition (diet-congruent food, non-food images) and diet status (dieting to lose or maintain weight, not dieting) as independent variables. A between-subjects design was chosen to reduce transfer effects from the likelihood of participants guessing the aim of the study. Participants were randomly allocated to either be exposed to diet-congruent food images or non-food control images. To avoid participants being aware of the study purpose, they were informed that the study aim was to examine the effect of snack foods on cognitive performance

3.3.3 Materials

3.3.3.1 Images

The diet-congruent images consisted of nine low calorie food and beverage items. Previous research has shown that females define a food as diet-congruent based on calorie and fat content (Sobal & Cassidy, 1987, 1990), therefore low calorie and low fat foods and beverages were used. Fruit and yoghurt have been specifically named as foods associated with dieting (Carels, et al., 2007; Sobal & Cassidy, 1987, 1990) and rice cakes were ranked highly as a food associated with health by women (Oakes & Slotterback, 2001). Importantly there is a large overlap between foods associated with health and those associated with dieting (Carels, et al., 2007). Therefore of the food items used in the present study, 2 images consisted of fruit, 1 of yoghurt and 3 were low calorie rice cake based foods. Beverages were included in the study as diet versions might be sought by dieters to replace sugar sweetened drinks (Goldstein, et al., 2013). The three beverage images consisted of a commercial weight loss shake, a diet branded beverage and a fruit based drink.

Each diet-congruent image was matched as closely as possible for size, shape and brightness to a non-food object, which formed the control images (see Figure 3.2). The images were taken with an Olympus Stylus Tough 6000 camera and edited in MS Photo Viewer. All images were presented in 640 x 480 pixels resolution. The images were displayed on a ProLite B1906S iiyama monitor. Each image was displayed 9 times per phase in a random order (total 45 trials per phase at 23 ms, in total 2.08 seconds). For practice trials, different non-food images were used. The selection of images and duration of image exposure were determined from a pilot study involving 173 participants (see Appendix A).

Diet-congruent food images	Non-food control images

Figure 3.2. Diet-congruent and non-food images.

3.3.3.2 Image exposure task

To avoid participants guessing the nature of the study, the images were embedded within a bogus response task. For the first exposure phase, each trial commenced with a fixation cross on the screen (1500ms) and was followed with the short presentation of either a diet-congruent or control image (23ms). The image presentation consisted of a pattern of an asterisk pre-mask of 80ms, followed by an image for 23ms, and followed by an asterisk post-mask of 80ms (see Figure 3.3). Next the name of a coloured word appeared and was printed in either a congruent or incongruent colour to the name of the word. Participants were asked to decide as quickly and accurately as possible whether the meaning of the coloured word was congruent or incongruent to the colour the word was displayed in. Participants were instructed to respond by pressing the numbers on the top of the keypad, specifically to press ‘3’ for congruent pairs and number ‘8’ for incongruent pairs. The colour word remained on screen until the participant made a response. To engage participants in the task each trial concluded with feedback on the accuracy of the task (correct/incorrect). In the second exposure phase, the image exposure pattern was identical, but used a modified bogus response task. Participants were presented with location words (e.g. left, right, top, bottom) and asked to decide whether the location of the word was consistent with the meaning. The duration of the pre and post masking was based on a previous image priming study (Fitzsimons, Chartrand & Fitzsimons, 2008) and the duration (23 ms) of the images were based on previous exposure durations to food words (Stroebe, et al., 2008) and images (Ziauddeen, et al., 2012). The short duration of image exposure was selected for this study to prevent participants becoming aware of the purpose of the study. Both exposure tasks included 7 practice trials and the order of presentation for each image was randomised for each participant.

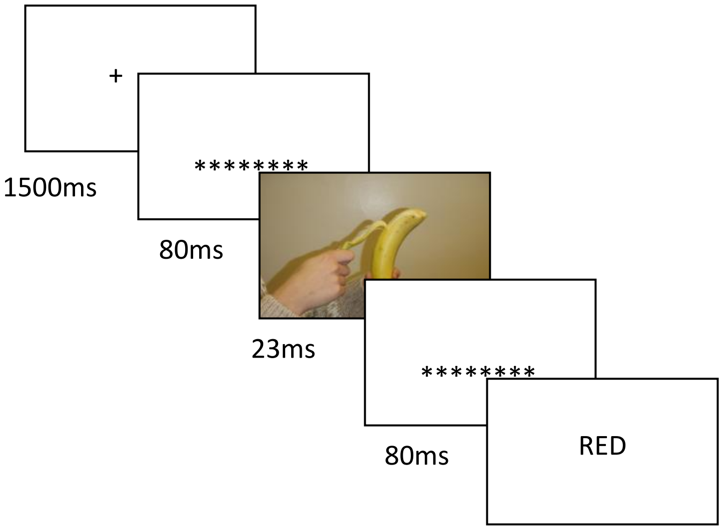

Figure 3.3. **Example image exposure trial**

3.3.4 Measures

3.3.4.1 Snack intake

To provide food choice, participants were provided with bowls of high or low fat, sweet or savoury food. The low fat sweet food (LFSW) was marshmallows (165 g, 340 kcal/100g), the low fat savoury food (LFSA) was salted rice cakes (50g, 406 kcal/100g), the high fat sweet food (HFSW) was chocolate coated hazelnut biscuit bars (215g, 452 kcal/100g) and the high fat savoury food (HFSA) was cheese savouries (105g, 521). The total amount offered was 2283 kcal. Each of the snack foods were presented in bite size pieces to prevent monitored intake. All food was served on a tray with a jug containing 350g of chilled water.

3.3.4.2 Salience of diet, tempting and neutral thoughts

A lexical decision task was used to measure the salience of diet and tempting thoughts. The outcome measure for this task was mean reaction times to 4 diet-congruent words (diet, slim, thin and weight), 4 tempting words (tempting, tasty, delicious and scrumptious), and 48 neutral and 48 non-words. The amount of words for each category and the selection of words were based on previous research (Papies, et al., 2007; Stroebe, et al., 2008). All words were matched on frequency of use in the English language (Francis & Kućera, 1982). Faster reaction times are thought to indicate increased salience of thoughts in the mind of participants (Neely, 1991). For full details of the lexical decision task see Chapter 2).

3.3.4.3 VAS

Appetite sensations and mood were recorded on VAS pre-lunch, post-lunch, pre-cue exposure, pre-snack and post-snack to examine whether they differed as a function of condition or group. See Chapter 2 for more detail on the use of VAS.

3.3.4.4 Image recall

To assess the salience of the images used in the study a memory recall task was administered after the snack rating task. This task was framed as the main cognitive task of the study. However, the purpose of this task was to assess which images, if any, were most prominent. Participants were asked whether they recalled seeing any images during the previous cognitive tasks and if so to list as many items as they could recall. Participants were instructed to notify the experimenter when they could not recall any more items.

3.3.4.5 Individual differences in eating behaviour

The TFEQ (Stunkard & Messick, 1985) was used to measure restraint, disinhibition and hunger. The restraint and disinhibition subscales showed good internal reliability, and the hunger subscale was acceptable (Cronbach's α restraint = .86; disinhibition = .73; hunger = .53).[1] Diet status, weight suppression, nature of diet and history of dieting were recorded (see Chapter 2 for details). To compare perceived success at dieting participants completed the PSRS (Cronbach's α= .67) (Fishbach, et al., 2003). All psychometric scales were completed in paper and pen format at the end of the study. These scales are discussed in more detail in chapter 2.

3.3.5 Procedure

Participants attended the Human Appetite Research Unit between 1200 and 1400 hours to complete the first VAS and to consume a fixed lunch. Lunch consisted of a cheese sandwich (white bread, butter, mayonnaise, cheese and lettuce) and a portion of cherry flavoured yoghurt (total meal energy = 614 kcal). The second VAS were completed and participants then left the laboratory with the instruction to abstain from eating, and returned 2 hours later. After completing the third VAS, participants performed the first bogus cognitive task on the computer which presented either diet-congruent or control images. To prevent any possible priming from the presentation of tempting and diet words on the lexical decision task, the diet-congruent or control images were presented again embedded in another bogus cognitive task. The second bogus task displayed location words (e.g. top, bottom, left

[1] The DEBQ and PFS were also administered to examine group differences. However, these did not enhance study findings and shall not be reported.

and right) in either congruent or incongruent positions on screen and participants were required to respond according to congruency. Similar to the first bogus task the diet-congruent or non-food images were subtly presented at the start of each trial. Next participants completed the fourth VAS and were provided with the snack foods. Participants were instructed to help themselves to as much or as little of the food as they liked but to make sure they sampled each food to complete the ratings. Participants rated each food on personal preference (how tempting, appealing, and desirable the food was), and rated the taste properties of each food (salty, crunchy, sweet, moist, intense, soft, crispy and crumbly) on VAS. Once they had completed all of the ratings, participants were informed they could continue to help themselves to as much or as little of the food as they wished until the experimenter returned. After 10 minutes, the experimenter returned and requested participants to complete the final appetite and mood VAS ratings followed by the memory recall task. Next, participants completed psychometric questionnaires and height and weight was measured by the experimenter (see Chapter 2). Finally, participants were probed about the nature of the study and if they believed exposure to images in the study influenced their food intake. Finally, the diet-congruent and control images were displayed on the computer and participants rated the extent each image was associated with dieting to lose weight, eating enjoyment and fitness (distracter item) on VAS. At the end of the session, participants were debriefed (see Figure 3.4).

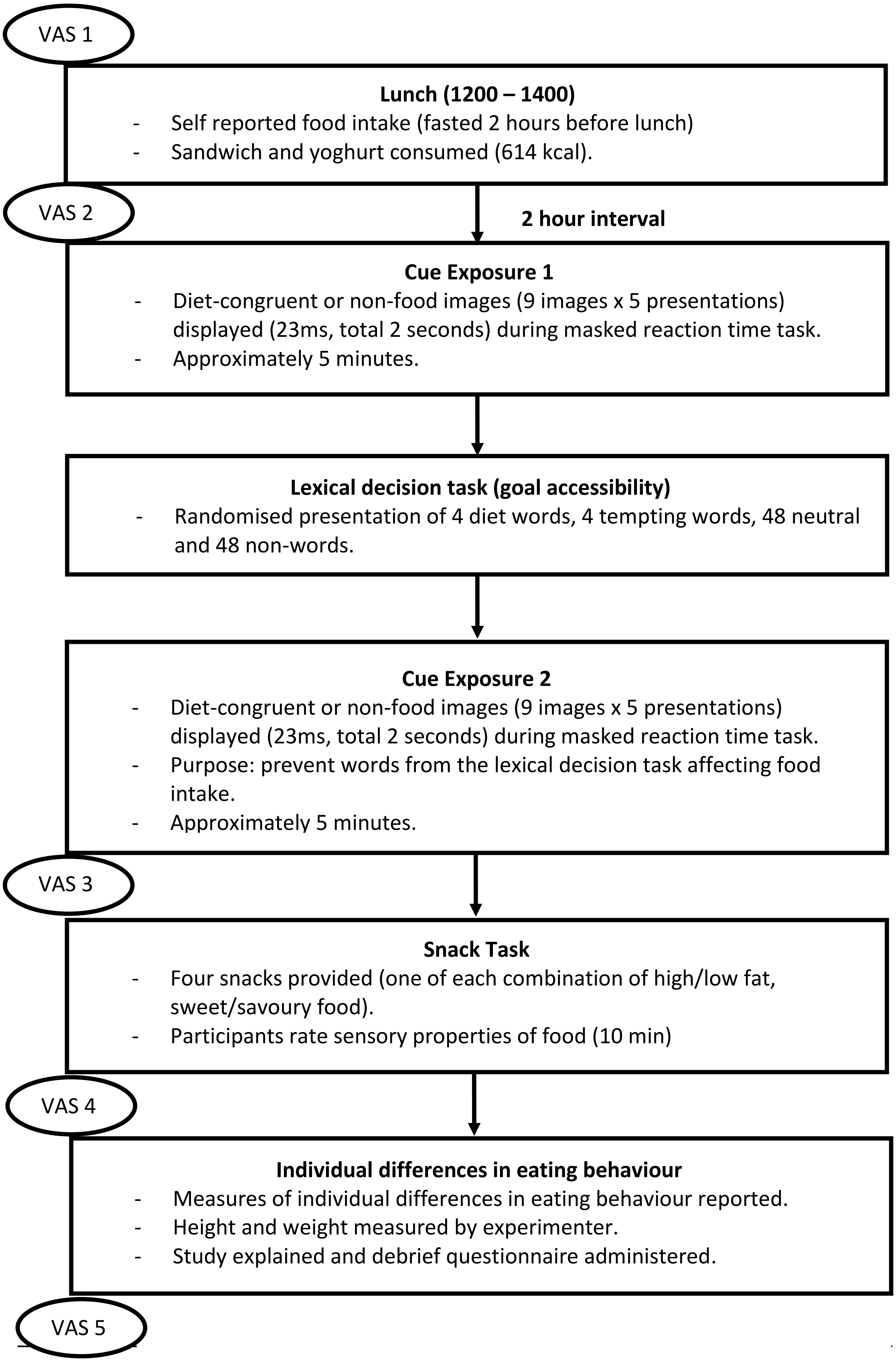

Figure 3.4. Study Procedure.

3.3.6 Data analysis

A series of univariate ANOVAs were used to compare age, BMI, and psychometric scores according to food image condition and diet status. Bivariate correlations were conducted separately on dieters and non-dieters to identify associations between energy intake and psychometric scores in the diet and control conditions. A univariate ANOVA was used to examine main and interaction effects of image exposure and diet status on energy intake. To assess the impact of diet-congruent images on appetite ratings relative to non-food control images, a series of repeated measures ANOVAs were conducted for each appetite item with condition and diet status entered as a between-subject factor. To examine differences in ratings of food a repeated measures ANOVA was conducted with condition and diet status as between-subjects factors. To assess the influence of diet-congruent cues on restraint and disinhibition subtypes, median splits were conducted on the full dataset to dichotomise TFEQ restraint and disinhibition scores (low restraint ≤ 9 and high restraint > 9; low disinhibition ≤ 6 and high disinhibition > 6). These median split values reflect those used in previous TFEQ restraint and disinhibition analyses (Westenhoefer, et al., 1994). Following the approach adopted by Westenhoefer et al. (1994) for between-subject designs, a 3-way ANOVA on condition, restraint and disinhibition was conducted. For the lexical decision task, responses were classified as correct or incorrect. In line with previous research all incorrect (2.93%) and high latency responses (> 3SDs) were excluded (Papies et al.2008b). A mixed factorial ANOVA was used to measure main and interaction effects of image exposure and diet status on reaction times to word types (diet-congruent, tempting and neutral). Repeated measures ANOVA tested whether subjective states changed over time. Condition and diet status were added separately as between-subject factors to check for main effects and interactions on energy intake. If the assumption of sphericity was violated the Greenhouse-Geisser correction was applied. In the absence of sphericity values it was assumed sphericity was met. Bonferroni adjustment was applied for post hoc analyses. Significant interactions were explored using independent or paired samples t-tests. To correct for multiple comparisons alpha was set at $p < .025$ (two conditions within each diet status) with the exception of one tailed hypotheses in which alpha was set at $p < .05$. Data are reported as means ± SEM. Partial eta squared (ηp^2) is reported for effect size and interpreted as small effect = 0.01, medium effect = 0.09 and large effect = 0.25.

3.4 Results

3.4.1 Manipulation check

The diet-congruent images were associated with dieting to lose weight more than non-food control images [diet-congruent: 64.1 ± 1.9 mm; control: 6.27 ± 1.30 mm, t(54) = 28.64, $p < .001$]. Diet-congruent images were associated with dieting to lose weight more than eating enjoyment [dieting to lose weight: 64.12 ± 1.87 mm; eating enjoyment: 43.08 ± 3.13 mm, t(54) = 5.74, $p < .001$. Diet status did not affect image ratings (largest t: t(32) = 1.24, *p* = *ns*).

3.4.2 Participant Characteristics

Sixty-nine females completed the study. Of these, one participant was excluded for unusually high food intake (> 3SDs), and one participant was excluded as an outlier on BMI score (> 3SDs). All reported analyses were conducted on the remaining 67 participants. The sample ranged from 18 - 55 years (M: 23.7 ± 0.7 years) and had a mean BMI of 23.5 ± 0.4kg/m². The sample consisted of 63.8% students.

There were no pre-study differences between conditions for age, BMI or any of the psychometric measures indicating that random allocation of participants to conditions had been successful (largest F: F(1, 63) = 3.84, *p* = *ns*, $\eta p^2 = .06$) (see Table 3.1). Of the sample 15 were dieting to lose weight, 11 were maintaining weight and 41 were not dieting. There were no differences between dieters losing and maintaining weight on any of the psychometric measures, supporting the decision to examine dieting behaviour as a combined variable to increase the power of the design.

Dieters reported multiple behaviours to describe their diets including: low fat diets (n = 4), low calorie diets (n = 4), low carbohydrate diets (n = 3), eating healthily (n = 3), reducing snack intake (n = 3), exercising (n = 2), commercial weight loss program (n = 1), skipping meals (n = 1), eating less (n = 1) and watching food intake (n = 1). Of the dieters, 81% reported previously dieting with 33% reporting dieting more than once a year. For non-dieters, 54% reported previously dieting, of which 17% dieted more than once a year.

As expected of a female and predominantly young sample, both dieters and non-dieters reported the desire to be a lower weight than their current weight (n = 55). The discrepancy between actual weight and desired weight did not differ between groups (dieters: 6.82 ± 0.82 kg; non-dieters: 5.99 ± 0.86 kg). Dieters scored significantly higher in restrained eating on both the TFEQ and DEBQ, rigid and flexible control compared to non-dieters [TFEQ-restrained: F(1, 63) = 18.05, $p < .001$, $\eta p^2 = .22$; DEBQ-restrained: F(1, 63) =

20.01, $p < .001$, $\eta p^2 = .24$; rigid control: $F(1, 63) = 5.31$, $p = .03$, $\eta p^2 = .08$; flexible restraint $F(1, 63) = 6.60$, $p =.01$, $\eta p^2 = .10$]. No other differences were observed between dieters and non-dieters for any other psychometric measures.

3.4.3 Study Compliance

There were no differences between image conditions on the duration since participants last consumed food (diet: 146.3 ± 59.7 minutes; control: 144.5 ± 61.3 minutes) indicating that participants complied with the instruction to fast 2 hours prior to lunch.

Table 3.1. Participant characteristics (mean ± SEM).

	Diet images		Control Images	
	Dieters (n 14)	Non-dieters (n = 21)	Dieters (n = 12)	Non-dieters (n = 20)
Age (years)	24.4 ± 1.6	23.1 ± 0.9	24.0 ± 1.0	23.6 ± 1.9
Height (m)	1.7 ± 0.1	1.6 ± 0.1	1.6 ± 0.1	1.7 ± 0.1
Weight (kg)	64.5 ± 2.1	63.7 ± 2.2	65.3 ± 2.5	64.3 ± 0.2
BMI (kg/m²)	23.7 ± 0.9	23.4 ± 0.7	24.1 ± 1.0	23.0 ± 0.5
TFEQ-re	12.7 ± 1.4[a]	7.1 ± 1.1[b]	11.8 ±1.2[a]	7.1 ± 1.0[b]
Flexible	3.9 ± 0.7[a]	2.6 ± 0.4[b]	4.2 ± 0.5[a]	2.9 ± 0.4[b]
Rigid	3.4 ± 0.6[a]	2.1 ± 0.4[b]	3.7 ± 0.5[a]	2.6 ± 0.5[b]
Internal-d	1.7 ± 0.4	2.3 ± 0.4	3.0 ± 0.6	2.9 ± 2.4
External-d	3.4 ± 0.5	3.4 ±0.4	3.8 ± 0.5	3.0 ±0.3
TFEQ-d	7.4 ± 0.8	6.5 ± 0.8	8.3 ± 1.0	6.7 ± 0.6
TFEQ-Hunger	5.9 ± 0.9	6.8 ± 0.7	7.3 ± 1.0	6.1 ± 0.8
DEBQ-re	3.3 ± 0.2[a]	2.5 ± 0.2[b]	3.3 ± 0.2[a]	2.4 ± 0.2[b]
DEBQ-em	3.1 ± 0.2	2.6 ± 0.2	3.0 ± 0.3	3.0 ± 0.2
DEBQ-ex	3.5 ± 0.2	3.3 ± 0.2	3.6 ± 0.2	3.5 ± 0.1
PFS-available	15.9 ± 1.7	14.7 ± 1.2	19.4 ± 2.0	15.5 ± 1.4
PFS-present	12.4 ± 1.3	12.4 ± 0.9	15.0 ± 1.0	12.2 ± 1.0
PFS-tasted	14.3 ± 1.6	13.8 ± 0.1	16.2 ± 1.4	14.6 ± 1.1
PFS-total	42.6 ± 4.3	40.9 ± 2.8	50.6 ± 3.8	42.2 ± 3.1
PSRS	4.7 ± 0.3	4.4 ± 0.2	4.1 ± 0.4	4.3 ± 0.2
WS	3.4 ± 1.4	1.6 ± 1.0	4.5 ± 1.6	2.4 ± 1.0

Note. TFEQ = Three Factor Eating Questionnaire (Stunkard & Messick, 1985); TFEQ-re = TFEQ-restraint; TFEQ-d = TFEQ-disinhibition; Internal-d = Internal disinhibition; External-d = External disinhibition; DEBQ = Dutch Eating Behavior Questionnaire (van Strien, et al., 1986); DEBQ-re = DEBQ restraint; DEBQ-em = DEBQ-emotional; DEBQ-ex = DEBQ-external; PFS = Power of Food Scale (Lowe, et al., 2009); PSRS = Perceived Self-Regulatory Success (Fishbach et al. 2003); WS = Weight suppression.
Different letters indicate significant differences between groups.

3.4.4 Correlations between energy intake and eating behaviour traits across conditions

For dieters, age was negatively associated with energy intake in the non-food image condition. There were no other relationships between dieters' energy intake, BMI and any psychometric eating behaviour traits in the diet-congruent and non-food image conditions.

For non-dieters, rigid restraint scores were negatively associated with energy intake in the diet-congruent condition (See Table 3.2).

Table 3.2. Correlations between dieters' and non-dieters' characteristics and energy intake across conditions.

Measure	Dieters		Non-dieters	
	Diet (n = 14)	Control (n = 12)	Diet (n = 21)	Control (n = 20)
Age (years)	.16	-.72**	.12	-.11
BMI	.18	.03	.03	.29
TFEQ-re	-.30	-.07	.02	-.08
Flexible	.14	.02	-.37	-.05
Rigid	.10	.11	-.55**	.22
TFEQ-d	-.24	.57	-.19	.32
Internal-d	.07	.25	-.26	-.24
External-d	-.21	.24	-.21	-.01
TFEQ-hunger	-.01	-.04	.10	.27
DEBQ-re	-.25	.12	.17	-.07
DEBQ-em	-.02	.49	-.26	.01
DEBQ-ex	-.03	.44	-.27	.31
PFS-available	.02	.14	-.26	.40
PFS-presented	.19	.37	-.06	.19
PFS-tasted	.22	-.14	-.07	.40
PFS-total	.15	.13	-.16	.38
PSRS	.09	-.22	.18	-.10
WS	.03	-.42	-.09	-.38

Note. TFEQ = Three Factor Eating Questionnaire (Stunkard & Messick, 1985); TFEQ-re = TFEQ-restraint; TFEQ-d = TFEQ-disinhibition; Internal-d = Internal disinhibition; External-d = External disinhibition; DEBQ = Dutch Eating Behavior Questionnaire (van Strien, et al., 1986); DEBQ-re = DEBQ restraint; DEBQ-em = DEBQ-emotional; DEBQ-ex = DEBQ-external; PFS = Power of Food Scale (Lowe, et al., 2009); PSRS = Perceived Self-Regulatory Success (Fishbach et al. 2003); WS = Weight suppression.
**$p < .01$.

3.4.5 Impact of condition and diet status on energy intake

Food intake did not differ by condition, $F(1, 63) = 2.13$, $p = ns$, $\eta p^2 = .05$. There were also no main effects of diet status on energy intake, $F(1, 63) = 0.07$, $p = ns$, $\eta p^2 = .001$. However, the condition x diet status interaction on energy intake approached significance, $F(1, 63) = 3.49$, $p = .07$, $\eta p^2 = .05$. Examination of the means showed that dieters in the diet condition consumed 106 ± 45 kcal less than dieters exposed to control non-food images, ($p = .04$). In contrast, non-dieters showed no difference in energy intake between conditions (see Figure 3.5).

3.4.6 Impact of condition and diet status on type of snack food consumed

There was a main effect of snack type on energy intake, F(2.47, 155.45) = 43.36, $p < .001$, $\eta p^2 = .41$. Intake of the HFSW food was greater than the LFSW ($p = .001$), HFSA and LFSA foods ($p < .001$). Intake of the LFSW food was also greater than the LFSA and HFSA foods ($p < .001$). Intake of the LFSA and HFSA foods did not differ. There were no main effects of condition or diet status on snack intake [condition: F(1, 63) = 2.13, $p = ns$, $\eta p^2 = .03$; diet status: F(1, 63) = .07, $p = ns$, $\eta p^2 = .001$]. A significant condition x diet status x snack type interaction on energy intake approached significance, F(3, 189) = 2.18, $p = .09$, $\eta p^2 = .03$. Comparison of the means showed that dieters in the diet-congruent condition consumed 40% less LFSW food compared to dieters in the non-food control. Intake of the HFSW, LFSA and HFSA foods did not differ between conditions in both dieters and non-dieters (see Figure 3.5).

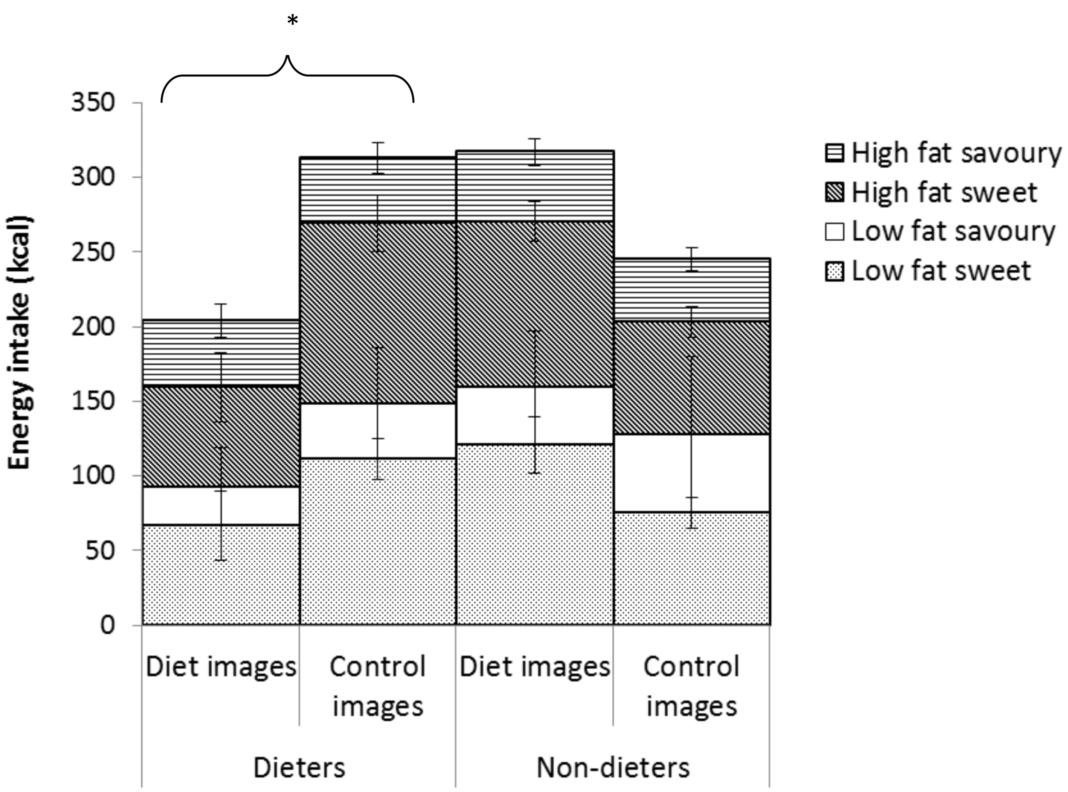

Figure 3.5. Dieters' and non-dieters' mean energy intake (± SEM) for snacks across conditions.

*$p < .05$.

3.4.7 Ratings of snack foods

Temptation, appeal and desire to eat ratings differed between snacks [tempting: $F(2.61, 164.42) = 14.61$, $p < .001$, $\eta p^2 = 0.19$; appeal: $F(3, 189) = 16.72$, $p < .001$, $\eta p^2 = 0.21$; desire to eat: $F(3, 189) = 8.73$, $p < .001$]. The HFSW food was rated as more tempting, appealing and with a stronger desire to eat compared to the HFSA, LFSW and LFSA foods. There were no differences in reported temptation, appeal or desire to eat between conditions [tempting: $F(1, 63) = .05$, $p =$ *ns;* appealing: $F(1, 63) = 0.52$, $p =$ *ns*; desire to eat: $F(1, 63) = 1.0$, $p =$ *ns*] nor between groups [tempting: $F(1, 63) = 1.5$, $p =$ *ns*; appealing: $F(1, 63) = 3.75$, $p =$ *ns*; desire to eat: $F(1, 63) = 2.2$, $p =$ *ns*]. There was a significant food type x group interaction on appeal, temptation and desire to eat [appeal: $F(3, 189) = 4.18$, $p = .007$, $\eta p^2 = 0.06$; temptation: $F(2.61, 164.42) = 4.08$, $p = .01$, $\eta p^2 = 0.06$; desire to eat: $F(3, 189) = 3.44$, $p = .02$, $\eta p^2 = 0.05$]. Dieters rated the HFSW food as more appealing, tempting and with stronger desire to eat compared to HFSA, LFSW and LFSA (all *ps* < .001). However, non-dieters only rated the HFSW as more appealing than the HFSA ($p = .007$) and LFSW ($p = .02$) foods and more tempting compared to the LFSW food ($p = .007$) (see Table 3.3).

Table 3.3. Dieters' and non-dieters' ratings of snack foods (mean ± SEM).

	Dieters				Non-dieters			
	LFSW	HFSW	LFSA	HFSA	LFSW	HFSW	LFSA	HFSA
Tempting	45.6 ± 5.4^{a}	77.9 ± 4.9^{b}	41.3 ± 5.4^{a}	46.4 ± 5.0^{a}	53.3 ± 4.3^{a}	66.6 ± 3.9^{b}	58.4 ± 4.3^{ab}	48.5 ± 4.3^{ab}
Appealing	44.2 ± 5.4^{a}	76.7 ± 4.9^{b}	36.6 ± 5.4^{a}	43.5 ± 5.1^{a}	56.6 ± 4.3^{a}	68.1 ± 3.9^{b}	57.0 ± 4.3^{ab}	51.1 ± 4.0^{a}
Desire	44.2 ± 5.9^{a}	69.7 ± 5.1^{b}	40.1 ± 5.8^{a}	44.2 ± 4.2^{a}	54.1 ± 4.7^{a}	62.0 ± 4.1^{a}	57.5 ± 4.6^{a}	53.6 ± 3.8^{a}

Note. Different superscript letters denote significant differences within groups.

3.4.8 Impact of condition and diet status on appetite sensations

Hunger, desire to eat and fullness ratings changed throughout each session [hunger: $F(2.92, 189.99) = 128.25$, $p < .001$, $\eta p^2 = .66$; desire to eat: $F(3.20, 207.93) = 84.00$, $p < .001$; fullness: $F(3.14, 203.78) = 158.79$, $p < .001$]. The lunch significantly reduced hunger and desire to eat (hunger: 57.5 ± 3.0 mm; desire to eat: 50.7 ± 3.0 mm). Hunger and desire to eat significantly increased from pre-cue exposure to pre-snack (hunger: 8.1 ± 2.0 mm; desire to eat: 8.5 ± 2.0 mm) and declined from pre-snack to post-snack (hunger: 18.6 ± 3.0 mm; desire to eat: 19.0 ± 3.0 mm). Fullness ratings reflected similar changes, with increased fullness after lunch (60.7 ± 2.5 mm), a decline after cue exposure (5.4 ± 2.0 mm) and an increase from pre-snack to post snack (18.7 ± 3.0 mm). There were no differences in hunger, fullness or desire to eat between conditions or groups (largest F: $F(1, 64) = 3.32$, $p = ns$, $\eta p^2 = .05$].

3.4.9 Impact of condition and restraint disinhibition subtypes on energy intake

There were no main effects of condition, restraint or disinhibition on energy intake [condition: $F(1, 59) = 1.39$, $p = ns$, $\eta p^2 = .02$; restraint: $F(1, 59) = 1.07$, $p = ns$, $\eta p^2 = .02$; disinhibition: $F(1, 59) = 0.75$, $p = ns$, $\eta p^2 = .01$]. The condition x restraint and restraint x disinhibition interactions on energy intake were non-significant, [condition x restraint: $F(1, 59) = 2.64$, $p = ns$, $\eta p^2 = .04$; restraint x disinhibition: $F(1, 59) = 0.84$, $p = ns$, $\eta p^2 = .01$]. The condition x disinhibition interaction on energy intake was significant, $F(1, 59) = 5.39$, $p = .02$, $\eta p^2 = .08$. A significant condition x restraint x disinhibition interaction on energy intake was found, $F(1, 59) = 4.14$, $p < .05$, $\eta p^2 = .07$. Comparison of the means showed that in the diet-congruent image condition HRHD eaters consumed less compared to HRHD eaters in the non-food condition. HRLD, LRHD and LRLD eaters consumed similar amounts between conditions (see Figure 3.6).

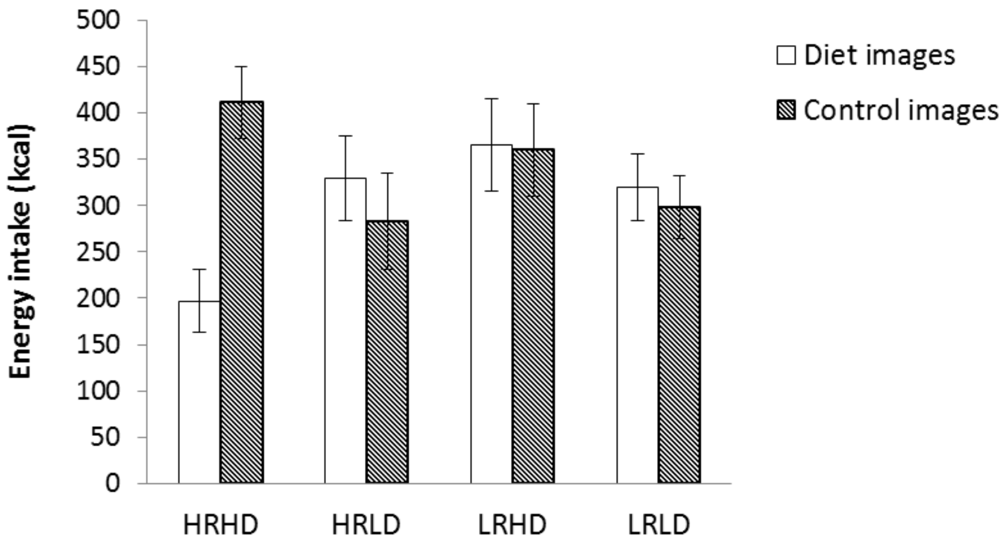

Figure 3.6. Mean energy intake (± SEM) for restraint disinhibition subtypes across conditions.

In the diet condition, HRHD n = 9; HRLD = 9; LRLHD n = 7; LRLD n = 10. In the control condition HRHD n = 7; HRLD n = 7; LRHD n = 7; LRLD n = 11. H = high; L = low; R = restraint' D = disinhibition. H = high; L = low; R = restraint; D = disinhibition.

3.4.10 Impact of condition and diet status on the salience of diet thoughts

There was a main effect of word type on time to recognise words, $F(1.81, 113.89) = 17.80$, $p < .001$, $\eta p^2 = 0.22$ (see Figure 3.7). Diet words were recognised 43 ± 12ms faster than tempting words ($p = .003$) and faster by 66 ± 9 ms compared to neutral words ($p < .001$) across all conditions. There were no differences between reaction times to tempting (598 ± 15 ms) and neutral words (620 ± 12 ms). Reaction times to words did not differ as a function of condition or diet status [condition: $F(1, 63) = 2.25$, $p = ns$, $\eta p^2 = .04$; diet status: $F(1, 63) = 0.87$, $p = ns$, $\eta p^2 = .01$]. The condition x word type interaction on reaction times was non-significant, $F(1.81, 113.99) = 0.10$, $p = ns$, $\eta p^2 = .002$.

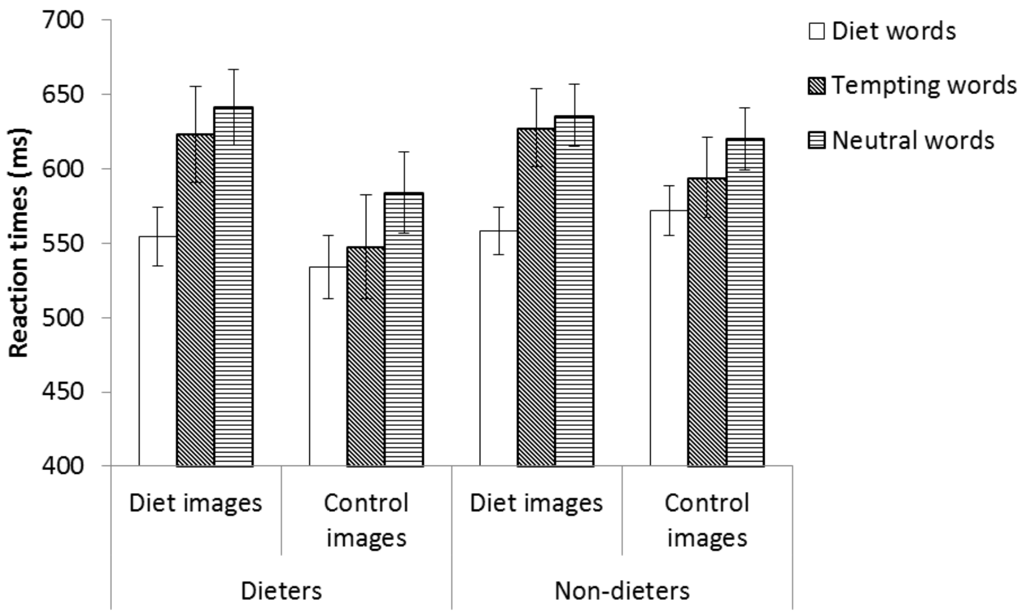

Figure 3.7. Reaction times to diet, tempting and neutral words across conditions (mean ± SEM).

Note: There was a main effect word type ($p < .001$), participants were faster to detect diet words compared to tempting and neutral words across conditions.

3.4.11 Mood.

Mood measures did not differ between conditions nor diet status [condition: happiness: $F(1, 64) = 1.06$, $p = ns$, $\eta p^2 = .02$; relaxed: $F(1.64) = 0.09$, $p = ns$, $\eta p^2 = .001$; anxious: $F(1, 64) = 1.47$, $p = ns$, $\eta p^2 = .02$; tiredness: $F(1 ,64) = 1.54$, $p = ns$, $\eta p^2 = .06$, $\eta p^2 = .004$; alertness: $F(1, 64) = 0.22$, $p = ns$, $\eta p^2 = .003$; sad: $F(1, 64) = 0.33$, $p = ns$, $\eta p^2 = .005$; diet status: happiness: $F(1, 64) = .01$, $p = ns$, $\eta p^2 = 0$; relaxed: $F(1, 64) = 0.05$, $p = ns$, $\eta p^2 = .001$; anxious: $F(1, 65) = 0.88$, $p = ns$, $\eta p^2 = .01$; tiredness: $F(1, 64) = 0.25$, $p = ns$, $\eta p^2 = .01$; alertness: $F(1, 64) = 1.4$, $p = ns$, $\eta p^2 = .02$; sad: $F(1, 64) = .62$, $p = ns$, $\eta p^2 = .01$]. This indicates dieters and non-dieters were in similar mood states between conditions over the course of the study and thus mood is an unlikely explanation for the differences in energy intake reported in the diet-congruent condition.

3.4.12 Awareness of images

Four participants stated that they were unaware of image presentation. Of the remaining participants, 93.65% (n = 59[2]) were aware of the images and of these only one dieter exposed to the diet-congruent images and 5 non-dieters (exposed to diet-congruent images, n = 3) believed the images affected their food intake.

3.4.13 Recall of diet-congruent images

Across conditions participants recalled similar number of images, $F(1, 63) = 0.12$, $p = ns$. In the diet condition the mean number of items recalled from the 9 diet-congruent food items was 2.4 ± 0.2. There were no differences in the number of items recalled between dieters and non-dieters, $F(1, 63) = .01$, $p = ns$. In the diet-congruent condition, the items most recalled by participants were the images of the Diet Coke (n = 26), banana (n = 18) and yoghurt (n = 15). Fewer participants recalled the smoothie drink (n = 13), oranges (n = 6), rice cakes (n = 2), crisp bread (n = 1) and wholegrain flatbread (n = 0). Based on this recall data it suggests that the Diet Coke, banana and yoghurt were the most prominent images of the 9 images.

3.4.14 Awareness of the study purpose

In total 9 participants guessed the purpose of the study or suggested that food intake was being measured. Exclusion of aware participants made no difference to the condition x diet status interaction on energy intake[3].

3.5 Discussion

The current study revealed three key findings. Firstly, dieters exposed to diet-congruent food images consumed less energy from snacks compared to dieters exposed to non-food control images, whereas, non-dieters' snack intake did not differ between conditions. Specifically, dieters consumed less of the LFSW snack after exposure to diet-congruent images relative to non-food control images. While intake of the HFSW, HFSA and LFSA foods did not differ between conditions. Secondly, when assessing restraint disinhibition

[2] Four participants did not respond to this question.

[3] Excluding participants who correctly guessed the purpose of the study did not affect the condition x diet status interaction trend on energy intake, $p = .09$.

subtypes, HRHD eaters reduced snack intake following exposure to diet-congruent images relative to control images. Whereas, HRLD, LRHD and LRLD eaters' snack intake did not differ between conditions. Finally, the lexical decision task revealed no indication that the salience of diet thoughts had increased in dieters in the diet condition relative to control.

In relation to the first two findings, lower snack intake following exposure to diet-congruent cues is consistent with previous research reporting lower intake after exposure to diet-congruent visual cues in restrained eaters (Anschutz, et al., 2008; Harris, et al., 2009; Papies & Hamstra, 2010) and a male and female sample (Brunner & Siegrist, 2012). The current study extends this previous research on diet-congruent visual cues by showing that dieters and HRHD eaters also reduce snack intake following cue exposure. These findings are important for two reasons. Firstly, dieters appear to have a heightened hedonic response to palatable foods and tend to gain weight (Hill, 2004; Lowe, 2003; Lowe & Levine, 2005). Therefore, this study has identified diet-congruent images as a potential strategy to assist dieters to control snack intake when tempted by food. Secondly, previous examination of diet-congruent cues on restrained eaters has been constrained by use of the Restraint Scale, which appears to confound restraint and disinhibition (Stunkard & Messick, 1985; Wardle & Beales, 1987). Whereas, this study distinguished between restrained eaters scoring high and low in disinhibition and found only restrained eaters scoring high in disinhibition were responsive to diet-congruent image cues. This is important because HRHD eaters have been identified as unsuccessful restrained eaters for overeating in response to palatable preloads (Westenhoefer, et al., 1994), 24 hours exposure to tempting food (Soetens, et al., 2008), and stress (Haynes, et al., 2003) compared to control conditions. The finding suggests that diet-congruent cues might be most effective for restrained individuals who are particularly prone to overconsumption. However, it is important to interpret the exploratory finding on HRHD eaters with caution due to the low sample group sizes involved in this analysis.

Dieters' and HRHD eaters' reduced snack intake after diet-congruent cues is not supported by some studies. Two published studies have reported no effects (Pelaez-Fernandez & Extremera, 2011) and even stimulatory effects of diet-congruent cues on snack intake (Strauss, et al., 1994). Differences in methodology might explain the discrepant findings; in Strauss et al. (1994), participants were exposed to diet-congruent cues *after* intake of a palatable food. Strauss et al. (1994) suggested that the diet-congruent adverts featuring slim models might have acted as feedback that intake of the preload had violated restricted eating and that the desired slim body shape was unattainable, thus triggering disinhibition.

Although possible, this explanation cannot explain why diet-congruent cues had no impact on non-preloaded restrained eaters in Pelaez-Fenandez & Extremera (2011). An alternative explanation is that intake of the preload in Strauss et al. (1994) was a more potent stimulatory cue than the subsequent diet-congruent images and cued overconsumption. Thus, when diet-congruent cues were displayed in combination with tempting intake cues, diet-congruent images might have been too subtle to counteract the impact of tempting intake cues on food intake. Similarly, Pelaez-Fenandez & Extremera (2011) acknowledged that a diet magazine without explicit instructions to attend to the magazine might have been too subtle to reduce restrained eaters' intake compared to a control magazine. In contrast, in the current study participants had not been preloaded with a more potent cue and, although exposure was brief, the task participants preformed during cue exposure ensured exposure to the cues was mandatory. Thus, in the current study, subtle diet-congruent cues were attended to and were the most salient cue in the environment to cue diet-directed behaviour.

However, diet-congruent images in the current study were only sufficient to significantly reduce intake of a LFSW food, not a HFSW food. The HFSW snacks were perceived as more tempting, appealing and with greater desire to eat by dieters compared to the LFSW, HFSA and LFSA snacks. One possibility for the selective effect observed is that the diet-congruent images were not sufficiently potent to reduce intake of the most strongly desired food. It might be that intake of the LFSW snacks was easier to control compared to the HFSW snacks. Future research would benefit by examining more potent diet-congruent food cues compared to images.

With regards to the third finding of shorter reaction times to diet words compared to tempting and neutral words in the lexical decision task across conditions, a plausible explanation is that the task in this design was not sufficiently sensitive to detect differences between the salience of thoughts. It is possible that for women in the current sample, diet words were more emotive than tempting or neutral words and thus elicited faster reaction times *per se*. Alternatively, it is possible that the presence of tempting food words in the lexical decision task may have disrupted the priming effect of diet-congruent images on diet-related thoughts. Indeed, other research has shown that mere exposure to tempting food words delayed reaction time in response to diet words (Stroebe et al. 2008; Papies et al., 2009). However, other research has incorporated competing health, tempting and neutral words in a lexical decision task after priming health constructs and observed differences in reaction time to health words across conditions (Belei et al. 2013). Thus, it seems more likely that the lack of difference in reaction time to diet words was due to the heightened salience of diet words within the sample compared to tempting and neutral words.

A limitation of the current findings is that 9 different food or beverage items were used for diet-congruent cues. Therefore it is not possible to determine whether the suppressive effects of exposure to diet-congruent images on dieters' snack intake was due to a combination of all 9 images or whether some of these images were more influential than others. Data from the recall task suggested some variation in the salience of the images. In particular, three items (Diet Coke, banana and yoghurt) were recalled most frequently by participants in the diet condition. It is unclear why these items were most frequently recalled but it could be due familiarity, palatability or prototypical examples of diet-congruent foods. To resolve this question, future studies need to identify which foods are most diet-congruent and frequently used by dieters. Future research should also test the effect of individual diet-congruent cues to establish which types of diet-congruent cues could be most effective for dieters' food intake control.

Due to the risk of demand characteristics and condition transfer effects in the current study, a compromise was made in the use of a fully between-subjects design. Despite no differences in BMI or psychometric scores between conditions it is still feasible that dieters in the diet image condition were more able to regulate food intake compared to those in the control condition. To reduce non-systematic variance between conditions repeated measures designs are frequently advocated for the assessment of eating behaviour (Blundell, et al., 2010). Future studies should consider the trade off between keeping participants blinded to their experimental condition as opposed to the reduction in error variance by participants serving as their own comparison between conditions. To increase group size and improve power, the current study combined dieters losing weight with those maintaining weight. However, there is evidence to suggest that dieters losing weight and those maintaining weight are different in terms of motivation and eating behaviour (Witt, et al., 2013). Therefore in future research it could be beneficial to examine dieters losing weight as a separate category.

A further limitation to the study design was the absence of a tempting food image condition. Without a tempting condition it was unclear whether dieters' reduction in snack intake was due to exposure to diet-congruent food and beverage items or simply food items in general. There is limited evidence to suggest that exposure to tempting food cues can sometimes inhibit food intake (Coelho et al. 2009; Kroese et al. 2011). However, considering the vast amount of research showing that exposure to palatable food stimulates food intake, especially in those who are susceptible to overeating, the most logical interpretation was that the diet-congruence of the images was involved in reducing energy intake in the diet food image condition.

3.6 Directions for future research:

To advance these current findings, future research should test different types of diet-congruent cues to examine their efficacy in improving self-control over snack food intake. Particularly those snacks that pose the biggest threat to dieters' controlled eating plans. This testing of more potent diet-congruent cues would benefit by being carried out in within-subjects designs to further substantiate the findings in the current study. Also, the examination of more diet-congruent cues might focus on individual foods or food cues rather than combining 9 different cues as the current study did. Furthermore, in the current study, the lexical decision task did not provide support for the hypotheses generated by the goal conflict theory (i.e. increased diet goal salience and inhibition of eating enjoyment goal salience). This could be because the diet words were already highly salient to the current sample. Therefore, future studies should modify the lexical decision task to improve its sensitivity. For example, this could be achieved by incorporating more critical stimulus trials.

3.7 Key findings

- In a laboratory setting, dieters (losing weight and maintaining weight) and those scoring high in restrained and disinhibited eating consumed less of a LFSW food after exposure to diet-congruent food and beverage images compared to dieters exposed to non-food control images. Intake of HFSW, HFSA and LFSA food did not differ according to condition.

- Despite differences in dieters' snack intake between conditions there were no effects of the diet-congruent cue on appetite ratings. Dieters and non-dieters reported similar hunger, fullness and desire to eat across all conditions.

- Participants were faster to recognise diet words than tempting and neutral words across all conditions. This increased vigilance to diet words suggests that within this sample, diet words have increased salience compared to tempting and neutral words. The inherently higher salience of diet words may have reduced the sensitivity of the task to detect differences between reaction time across conditions.

Chapter 4

Fruitful odours: diet-congruent odours reduce dieters' energy intake.

4.1 Abstract

Odours from palatable foods can undermine attempts to restrict food intake. On the other hand, food odours associated with dieting might increase the salience of diet thoughts and remind dieters to limit food intake. For the current study, an online survey was conducted to identify foods most associated with dieting to lose weight (e.g. fresh oranges, salad and rice cakes) and foods most associated with temptation and overeating (e.g. chocolate, cake and biscuits). Participants (females n = 157) were shown 27 food and beverage items and were required to select three items most associated with dieting to lose weight and temptation and to indicate whether each item was associated with dieting to lose weight and temptation (yes/no/ not sure). Results indicated that salad vegetables, carrots, rice cakes, grapefruit, tomatoes, oranges and banana were most diet-congruent. Chocolate bars, cupcakes, biscuits, cake, ice cream, pizza and chocolate orange were most tempting. Next, in a repeated measures experimental design, 16 dieters losing weight and 24 non-dieters were exposed to the sight and smell of fresh oranges or chocolate orange. Subsequently, intake of fresh oranges, chocolate and cereal bars was measured. Results showed that when exposed to a fresh orange, dieters reduced their intake compared to exposure to chocolate orange. This suppressed snack intake was driven by a 40% reduction of chocolate after diet-congruent exposure compared to tempting food cue exposure. In contrast, non-dieters' snack intake did not differ between conditions. HRHD were also responsive to diet-congruent odour cues and reduced snack intake in the diet condition relative to the tempting condition. The specific effect of diet-congruent cues on dieters and not non-dieters suggests goal priming could account for these findings.

4.2 Introduction

Individuals attempting to lose weight face a plethora of food temptations in their everyday environment (Wadden, et al., 2002). The impact of food odours on the modulation of food intake has been illustrated in laboratory studies. For instance, acute exposure to the odour of palatable food has increased subsequent food intake in restrained eaters as identified on the Restraint Scale, 1988 (Fedoroff, et al., 1997; Fedoroff, et al., 2003; Jansen & van den Hout, 1991) and the TFEQ (Rogers & Hill, 1989). However, inconsistent reports (Larsen, Hermans, & Engels, 2012) suggest that such effects may be more pronounced in individuals who are restrained or disinhibited eaters. For example, in a study comparing regular exposure to the smell of palatable food over 24 hours relative to no exposure, it was found that only those participants with the high restrained high disinhibited (HRHD) trait combination increased their subsequent snack intake (Soetens, et al., 2008).

Increased snack intake following exposure to palatable food odours can be explained by the goal conflict theory (Stroebe, et al., 2008; Stroebe, et al., 2013). This postulates that tempting food cues, including odours, can simultaneously increase the salience of eating enjoyment goals and temporarily reduce the salience of diet goals. Thus, exposure to tempting food odours leads to the eating enjoyment goal being pursued and overconsumption. However, this overconsumption can be prevented with exposure to diet-congruent cues which can reinstate the salience of diet goals to direct restricted food intake (Stroebe, et al., 2008; Stroebe, et al., 2013).

In accordance with the goal conflict theory, some research suggests that palatable food odours can act as diet-congruent cues to limit food intake. Preliminary findings indicate that exposure to the odour of cookies can increase the strength of unrestrained eaters' weight control goals (Coelho, et al., 2008) and reduce restrained eaters' cookie intake (Coelho, et al., 2009) compared to no cue exposure. Few studies report this inhibitory effect of palatable food odours and this might be because inhibitory effects of palatable food odours only occur after multiple weight loss attempts. The counter-active control theory suggests that after repeated weight loss attempts, the sight and smell of tempting food eventually becomes associated with dieting and restricted food intake (Trope & Fishbach, 2000). However, given the low rates of successful weight loss maintenance (Crawford, et al., 2000) it is likely that very few dieters associate palatable food odours with dieting. Rather, palatable food odours are more likely to stimulate dieters' intake.

Conversely, diet-congruent food odours might be more effective cues to restrict dieters' intake compared to palatable food odours. In support of this idea, exposure to visual diet-congruent cues have reduced snack intake in restrained eaters (Anschutz, et al., 2008; Harris, et al., 2009; Papies & Hamstra, 2010) and general samples (Brunner, 2010; Brunner & Siegrist, 2012; Mann & Ward, 2004). It is unknown whether the findings in restrained eaters can be applied to dieters because restrained eaters tend to be weight-conscious rather than actively engaged in weight loss behaviours (Reid, et al., 2005). However, as dieters also hold weight loss goals, diet-congruent cues such as diet-congruent food odours might be particularly salient to dieters to direct restricted food intake (Stroebe, et al., 2008;

Stroebe, et al., 2013). Thus, it is important to identify whether the beneficial effects of diet-congruent cues can also apply to dieters. This is important because dieting attempts tend to be unsuccessful, possibly due to a heightened hedonic response to palatable food. Therefore, according to the goal conflict theory diet-congruent cues could help dieters to resist snack intake when in tempting environments (Stroebe, et al., 2008; Stroebe, et al., 2013).

Indeed the previous chapter showed that subtle exposure to diet-congruent images reduced dieters' intake of a LFSW snack. However, these cues were not sufficient to reduce intake of a HFSW snack. Diet-congruent food odours could be more potent (Feldman & Richardson, 1986; Jansen & van den Hout, 1991; Mattes, 1997) and less subject to distraction compared to images (Pelaez-Fernandez & Extremera) to effectively to reduce intake of a highly desired food. Chapter 3 also included a lexical decision task and it is possible that exposure to diet and tempting words partially influenced food intake (Stroebe et al. 2013). Thus, it is important to demonstrate the effects of diet-congruent cues on food intake isolated from a lexical decision task. The findings of Chapter 3 can also be enhanced by using a within-subjects design rather than a between-subjects design (Blundell, et al., 2009), and by distinguishing between dieters losing weight from those maintaining weight. Dieters losing weight have been shown to experience more cravings (Massey & Hill, 2012) and engage in more weight control behaviours (Timko, et al., 2006) than those dieting to maintain weight. Therefore, as dieters losing weight are more prone to hedonic cues than dieters maintaining weight, it is important to identify whether diet-congruent food odours can reduce intake in a homogenous group of dieters losing weight. Additionally, as HRHD individuals seem to be particularly vulnerable to exposure to palatable food odours (Soetens, et al., 2008) it is important to identify whether HRHD can benefit from diet-congruent food odours.

Furthermore, food odours that are most strongly linked with diet cognitions should be the most effective cues to reduce dieters' intake (Loersch & Payne, 2011). To date, only two surveys have identified specific foods as diet-congruent (Carels, et al., 2007; Sobal & Cassidy, 1987, 1990). These surveys are limited to undergraduate samples with few female dieters. For example, in one study, of the 101 participants only 35% were male or female dieters (Carels, et al., 2007). Given that young dieters differ in their motivations for weight loss compared to older female dieters (Lowe & Levine, 2005), perceptions of diet-congruent foods in undergraduate samples might not be representative of how non-student female dieters perceive those same foods. Therefore, identification of diet-congruent foods in female dieters is currently needed.

4.3 Study Aims

The aim of the current study was to test whether exposure to the sight and smell of a diet-congruent food[4] would reduce dieters' subsequent snack intake compared to a palatable food odour. To achieve this we firstly identified snack foods that were diet-congruent and tempting that could be used as an odour cue. To do this an online survey asked participants to rate foods for their diet-congruency and temptation. Secondly, an experimental study examined a) food intake following exposure to a diet-congruent odour b) whether dieters' appetite sensations changed in response to a diet-congruent odour compared to a tempting food odour and; c) assessed whether HRHD eaters were responsive to diet-congruent odours. In relation to the overarching aim it was expected that dieters would reduce snack intake after exposure to diet-congruent food odours compared to tempting food.

4.4 Pre-study survey – identification of diet-congruent and tempting foods

4.4.1 Method

4.4.1.1 Participants

There were 195 survey responses. Of the sample, 15 participants were excluded due to a history of eating disorders. Of the remaining sample (n = 180) participants ranged from 19 - 63 years (*M*: 32.4 ± 0.7 years) and 41.7% were students. The sample comprised predominantly of females (n = 157). Of those specifying a food allergy (n = 14) only one participant specified a food used in the study (strawberries n = 1) this participant's response to strawberries was excluded. Participants were recruited via email (53.3%), online forums (18.3%), the social network site Facebook (12.8%), word of mouth (4.4%), University of Leeds participant pool (1.1%) and other sources (10%). At the time of completion, 54 participants were dieting to lose weight (males n = 6), 28 were maintaining weight (males n =1) and 98 were not dieting (males = 16). The remaining analysis is on females losing weight and females not dieting only. Upon completion participants were entered in to a prize draw to win £100.

[4] Subsequent references to this cue will be referred to as diet-congruent odour but please note participants were also exposed to the sight of the food.

4.4.1.2 Materials

The survey was designed using Qualtrics software version 12018 (Provo, Utah, 2009). Average completion time for the survey was 24 minutes and 40 seconds (± 1 minute 44 seconds).

4.4.1.2.1 Foods and beverages

Participants rated 27 food and beverage items which were selected to represent both sweet and savoury foods (see Table 4.1) (See Appendix B). The list of foods was not exhaustive for time considerations to maximise participant engagement and the number of complete responses. Therefore, most of the foods selected were intended to be generic foods which can be assumed to extend to other foods which belong within the same category (King et al. 1987). For example, ratings of fruit items included in the survey such as ratings for a banana are assumed to extend to other fruits such as apples and pears. All foods selected for the survey were items that can practically and conveniently be used in a laboratory study. Some specific food items such as a chocolate orange were selected for their matched flavour with a diet-congruent candidate (fresh oranges) which would be ideal for a controlled laboratory study.

Table 4.1. Candidate diet-congruent and tempting food items.

Diet/ Healthy perceived items		Tempting perceived items	
Sweet	Savoury	Sweet	Savoury
Banana	Carrots	Biscuits	Cheese straws
Grapefruit	Peppers	Cereal bars	Crisps
Oranges	Rice cakes	Chocolate bar	Garlic bread
Strawberries	Salad	Chocolate cake	Pizza
Coca-Cola	Tomatoes	Cupcakes	Sausage roll
Coke Zero		Ice cream	
Diet-beverages		Chocolate orange	
Diet-coke			
Smoothie			
Sprite			

4.4.1.3 Demographics and screening

Participants were requested to provide details of their age, gender, student status, history of eating disorders and food allergies.

4.4.1.4 Individual differences in eating behaviour

Restraint and disinhibition were measured using the TFEQ (Stunkard & Messick, 1985). Current diet status was also recorded (see Chapter 2) and participants were asked to report their height and weight.

4.4.1.5 Procedure

The survey was advertised via email distribution lists, social network sites (Facebook), the University of Leeds participant pool database and online forums. Interested volunteers were prompted to follow the link provided in the advert which directed participants to the survey website. Participants were screened and provided demographic information. Participants were shown all of the foods and were asked to select three foods most associated with dieting to lose weight and temptation (for an example see Appendix C). Next, participants were shown each food item and were asked whether they associated the food with dieting to lose weight and temptation (yes, no, not sure) (see Appendix D). Subsequently, participants were asked to suggest any food items not included in the survey that they strongly associate with a) dieting to lose weight and b) temptation. Finally, participants completed psychometric questionnaires, indicated current diet status and self-reported height and weight.

4.4.1.6 Data analysis

To compare sample characteristics between dieters and non-dieters a series of independent t-tests were conducted. For the selection task, the frequency participants selected each food item as part of their top 3 foods was summed and converted to percentage scores. For the food suggestion task, responses for the same food items were summed together and frequencies are reported. For the association task frequency scores for participants associating each food with dieting to lose weight and temptation were converted to percentage scores.

4.4.2 Results

4.4.2.1 Participant characteristics

Dieters scored higher in TFEQ-restrained eating, TFEQ-disinhibited eating, were a higher weight and had a higher BMI compared to non-dieters (TFEQ-restrained: $t(126) = 10.39$, $p < .001$; TFEQ-disinhibition: $t(126) = 4.59$, $p < .001$; weight: $t(120) = 4.45$, $p < .001$; BMI: $t(120) = 4.56$, $p < .001$) (see Table 4.2). Thus, participants who indicated they were dieting to lose weight scored higher in psychometric traits of eating behaviour which are associated with restricting food intake.

Table 4.2. Participant characteristics (mean ± SEM).

Trait	Dieters (n =48)	Non-dieters (n = 82)
Height (m)	1.7 ± 0.1[b]	1.7 ± 0.1
Weight (kg)	73.4 ± 1.6[a]	62.6 ± 1.9[c]***
BMI (kg/m²)	27.0 ± 0.6	22.9 ± 0.6[c]***
TFEQ-restraint	12.4 ± 0.5	5.5 ± 0.4[d]***
TFEQ-disinhibition	8.6 ± 0.5	5.8 ± 0.4[d]***

Note. TFEQ = Three Factor Eating Questionnaire (Stunkard & Messick, 1985)
[a]n= 44; [b]n = 47; [c]n = 78; [d]n = 80.
****p* <.001 between groups.

4.4.2.2 Ratings and selection of items

Across the sample there was high consensus that salad vegetables, rice cakes, carrots, grapefruit, and tomatoes and oranges were associated with dieting. In the selection task, the items most selected by participants as being associated with dieting to lose weight were salad vegetables, carrots, rice cakes, grapefruit and banana (see Table 4.3).

The majority of participants rated chocolate bars, cupcakes, biscuits, cake, ice cream, pizza and chocolate orange as foods associated with temptation. Female dieters within this sample also rated biscuits, cake, ice cream and chocolate orange as tempting foods (see Table 4.3). Furthermore, when selecting the top three items most associated with temptation, chocolate cake was selected most frequently, followed by chocolate bars, cupcakes, pizza and Terry’s chocolate orange (see Table 4.3).

4.4.2.3 Food Suggestions

When asked to name foods associated with dieting that were not present in the survey dieters suggested water (n = 16), vegetables (n = 8), fruit (n = 8), fish (n = 6), soup (n = 6), and celery (n = 6). Food suggestions for tempting foods by dieters were cheese (n = 8), sweets (n = 7), take away (n = 7), curry (n = 5), chips (n =5), and fish and chips (n = 5).

Table 4.3. Ratings and selection of diet-congruent and tempting foods (n = 157).

	Association Task				Selected in top 3			
	Lose weight (%)		Tempting (%)		Lose weight		Tempting	
Food	Full sample	Female dieters	Full sample	Female dieters	Full sample	Female dieters	Full sample	Female dieters
Salad	87	98	14	17	79	75	0	0
Rice cakes	80	79	6	4	47	38	0	0
Carrots	71	79	12	11	49	38	0	0
Grapefruit	69	69	4	2	33	33	0	0
Tomatoes	65	77	18	26	13	19	0	0
Oranges	60	77	20	19	10	18	0	0
Peppers	54	60	14	15	12	22	0	0
Diet beverages	53	66	20	32	7	2.1	0	0
Diet Coke	49	64	34	43	18	14	2	2
Banana	47	60	18	25	19	29	0	0
Strawberries	46	60	59	65	8	10	8	10
Coke Zero	47	63	16	0	6	10	1	0
Smoothie	36	30	41	35	1	0	1	0
Cereal bars	31	27	16	15	6.	2	1	0
Sprite	5	7	29	27	0	0	0	0
Coca-Cola	2	4	39	39	1	2	8	6
Cheese straws	2	0	41	47	0	0	2	4
Sausage rolls	1	0	42	34	1	2	7	13
Crisps	1	0	68	69	1	0	21	10
Garlic bread	2	2	71	66	1	0	9	4
Chocolate Orange	0	0	76	85	0	0	28	35
Pizza	2	2	82	83	1	2	32	40
Ice cream	2	2	83	94	0	0	24	17
Cake	1	0	87	91	0	0	63	67
Biscuits	1	0	89	92	0	0	18	19
Cupcakes	1	0	93	96	0	0	39	33
Chocolate bars	1	0	96	98	0	0	41	40

4.4.3 Summary and discussion

In summary, the online survey identified diet-congruent and tempting foods within a general population. Diet-congruent foods were salad vegetables, carrots, rice cakes, grapefruit, tomatoes, oranges and banana. The foods associated with temptation were cake, chocolate bars, cupcakes, biscuits, pizza, ice cream and Terry's chocolate orange.

The findings from the pre-study survey reflect previous research which showed that a range of foods differ in the extent they are associated with dieting to lose weight and temptation constructs (Sobal, 1987; 1990; Carels at al. 2007). This provides support for the salient categorisation of foods as diet-congruent and tempting, a key assumption underlying the current thesis. The results from the online survey will be used to inform the selection of diet-congruent and tempting foods for laboratory studies.

There are some limitations to the online survey. Firstly, to maximise the number of completed responses, only 27 foods were included in the survey. This was not an exhaustive list of foods and it may be that there are other foods also associated with dieting to lose weight and temptation that the survey did not identify. However, many of the foods used in the survey represented generic foods; for instance, it was assumed that fresh oranges represented fruit and can be generalised to other subordinate examples of fruit such as apples and pears. This method has been adopted by previous research examining food perceptions (King et al., 1987). Furthermore, to minimise the narrow selection of foods used in the survey, participants were provided with an opportunity to name food items associated with dieting to lose weight and temptation that were not presented in the survey. Therefore, the results of the survey likely reflect an evaluation of a wide range of foods and provide an accurate indication of diet-congruent and tempting foods.

4.5 Laboratory Study

4.5.1 Method

4.5.1.1 Participants

Participants were staff and students of the University of Leeds who fulfilled participation criteria detailed in Chapter 2 (see Figure 4.1). Participants were compensated for their time with either course credits or £5.

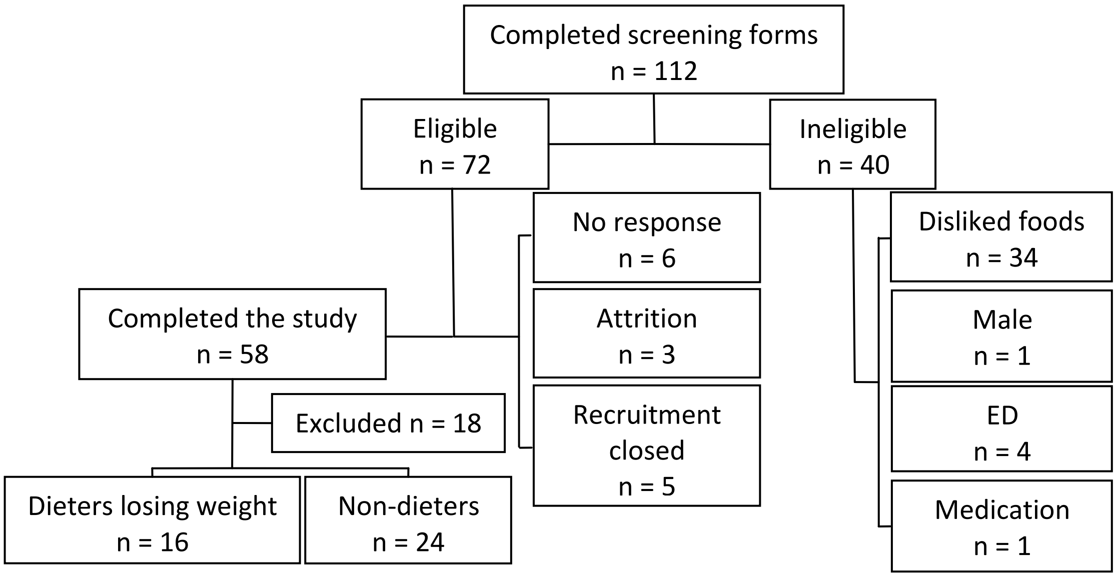

Figure 4.1 Process of recruitment

4.5.1.2 Design

The study used a 2 (condition: diet-congruent, tempting) x 2 (diet status: dieting to lose weight v non-dieters) mixed design with diet status as between-subjects factor and condition as a within-subjects factor. Each session was separated by at least 7 days with the order of cue counterbalanced across participants. To prevent participants guessing the purpose of the study, participants were initially informed that the aim of the study was to investigate the effect of food odours on memories.

4.5.1.3 Materials

4.5.1.3.1 Food cues

The diet-congruent and tempting foods were selected based on the results of the pre-study survey and previous research reporting that fruit is associated with dieting to lose weight. (Carels, et al., 2007; Sobal & Cassidy, 1987, 1990). Fresh orange (Tesco PLC) was selected for the diet-congruent food and a chocolate orange (Kraft Foods Group, Inc.) was selected as the tempting food. These were selected as they match on shape, flavour and odour. The fresh orange was presented to participants as a whole unpeeled orange, and the chocolate orange was given to participants in its foil packaging (sealed) on a plate.

4.5.1.3.2 Cue exposure task

To ensure participants engaged with the food cue, participants completed a sensory assessment of the odour and completed a memory task. The sensory assessment involved participants evaluating the odour of the food without tasting the food. Participants rated the degree to which the odour was pleasant, intense, enticing and refreshing on VAS. Participants also used VAS to rate the odour based on expected taste properties for example, "Based on the odour of the food, how bitter do you expect the food to taste?" For the bogus memory task participants completed a free recall exercise in which they were asked to write down the first word and thought that was evoked by the smell of the food. Participants then described a specific memory triggered by the smell of the food and rated the vividness, the emotional content of the memory (e.g. how emotional did you feel at the time of the memory?) and how emotional they felt recalling the memory (e.g. how do you feel emotionally now as you are recalling the experience?) on VAS. The frequency that the memory was recalled was also recorded on a 5-point scale (1 = never; 5 = very often, e.g. monthly).

4.5.1.4 Measures

4.5.1.4.1 Snack intake

Participants were offered *ad libitum* access to a diet-congruent food (fresh oranges; 210g, 39 kcal/100g), a tempting food (chocolate orange; 175g, 530 kcal/100g) and an intermediate food (cereal bar; 58g, 416kcal/100g) that was rated as neither diet-congruent nor tempting in the pre-study survey. The intermediate food was used to reduce the explicit contrast between the tempting and diet-congruent food. This selection of foods was chosen because in Chapter 3 the snack test consisted only of tempting foods and the effect of diet-congruent exposure could be stronger with the presence of a diet-congruent food in the snack test. In total 1251 kcal were offered. The snack foods were presented in bite size pieces to prevent monitored intake. Food was presented on a tray with a jug of 350g chilled water.

4.5.1.4.2 VAS

Appetite sensations and mood were recorded on VAS pre-lunch, post-lunch, pre-cue exposure, pre-snack and post-snack to examine whether they differed as a function of condition or group. See Chapter 2 for more detail on the use of VAS.

4.5.1.4.3 Individual differences in eating behaviour

The TFEQ (Stunkard & Messick, 1985) was used to measure restraint, disinhibition and hunger. All subscales showed good internal reliability (Cronbach's α restraint = .89; disinhibition = .70; hunger = .78).[5] Diet status, weight suppression, nature of diet and history of dieting were recorded (see Chapter 2 for details). To compare perceived success at dieting participants completed the PSRS (Cronbach's α = .60) (Fishbach, et al., 2003). These scales were administered in paper and pen form and are discussed in more detail in chapter 2.

4.5.1.5 Study Procedure

Participants attended two study sessions at the Human Appetite Research Unit (between 1030 and 1700 hours). Participants initially completed VAS 1 followed by the cue exposure task. In the diet condition participants were instructed to divide the fresh orange in to segments using a knife and to inhale and smell the food odour three times. In the tempting food condition, participants were instructed to remove the packaging from the chocolate, segment the chocolate and, inhale the smell of the food three times before participants completed the sensory assessment and memory task. Once complete, the food was removed from the room by the experimenter and VAS 2 was completed. Next participants completed the snack test. Participants were instructed to help themselves to as much or as little of the foods as they liked but to make sure they tried some of each snack food to complete the ratings. While participants tasted the food they rated how strong their desire was to eat the food and how pleasant the food tasted on VAS. There were no set time limits for this task and participants were requested to inform the experimenter when they had finished eating. Next, participants completed the post-snack appetite and mood ratings (VAS 3). In the first session this was the end of testing. In the second session participants subsequently completed the psychometric questionnaires. Next participants rated the cued and test foods association with health on 5-point scale ranging from 1 (extremely unhealthy) to 5 (extremely healthy). Although "health" is not synonymous with dieting to lose weight there is large overlap in the foods associated with health and dieting (Carels et al. 2007). Finally, height and weight were recorded (see Chapter 2). For a summary of the procedure please see Figure 4.2.

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[5] The DEBQ and PFS were also administered to examine group differences. However, these did not enhance study findings and shall not be reported.

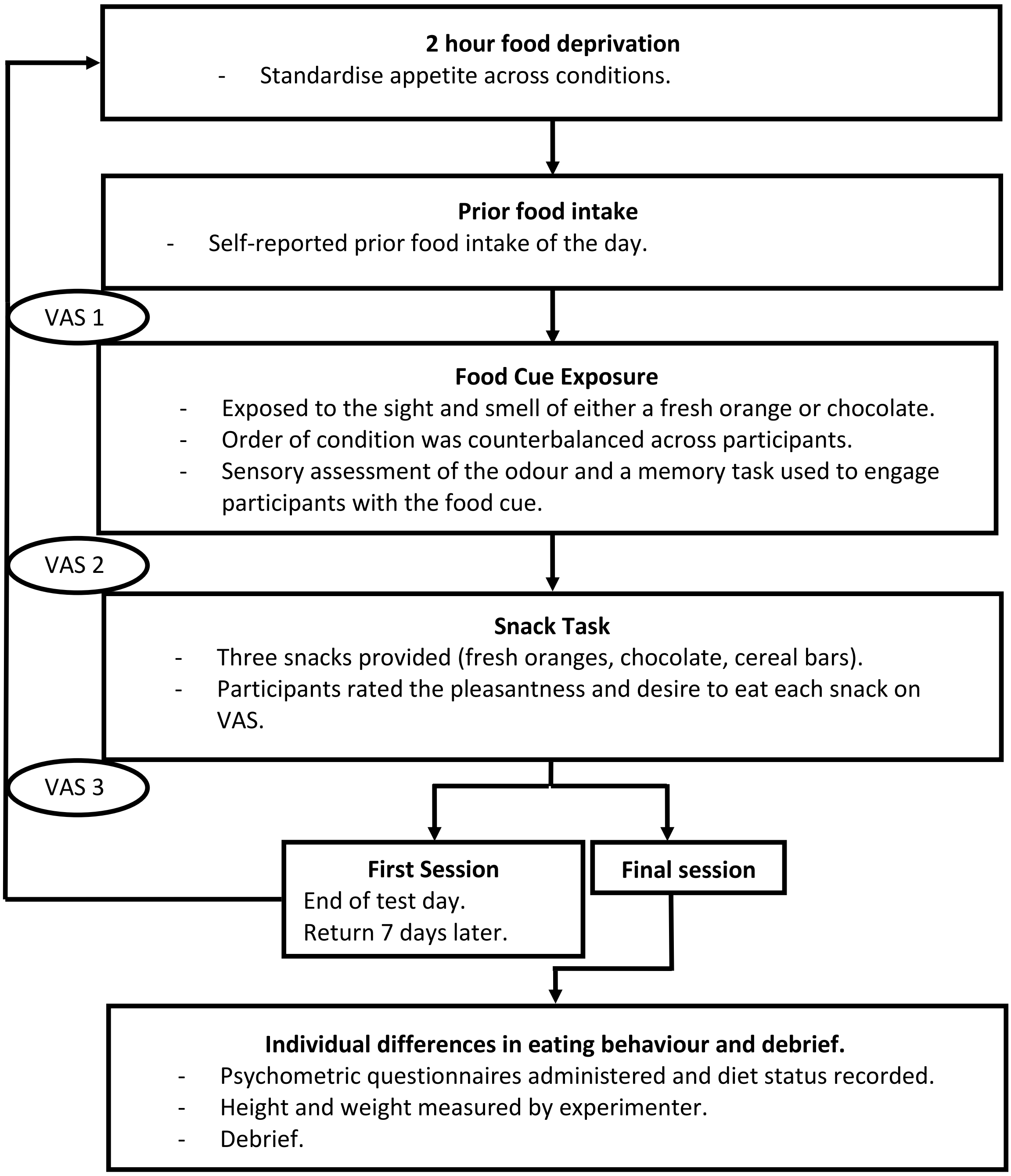

Figure 4.2. Study Procedure.

4.5.1.6 Data analysis

A series of independent t-tests were conducted to compare age, BMI, and psychometric scores between dieters and non-dieters. Bivariate correlations were used to identify relationships between BMI and psychometric scores with energy intake across conditions for dieters and non-dieters separately. A mixed ANOVA examined the effect of diet status and condition on energy intake with condition as a repeated measures factor and diet status as a between-subjects factor. The effect of condition and diet status on appetite was explored with a mixed ANOVA with condition and time as repeated measures factors and diet status as a between-subjects factor. To compare evaluations of the snacks a mixed ANOVA was conducted with snack type and condition as repeated measures factors and diet status as between-subjects factor. To examine the role of restraint disinhibition subtypes, participants were divided in to high and low TFEQ-restraint (low ≤ 11 and high > 11) and TFEQ-disinhibition (low ≤ 8 and high > 8) using a median split on the full dataset. The classification provided 4 groups: high restrained high disinhibition (HRHD) (n = 10), high restrained low disinhibition (HRLD) (n = 6), low restrained high disinhibition (LRHD) (n = 5) and low restrained and high disinhibition (LRLD) (n = 19). The combination subtype was entered as a between-subjects factor in a mixed ANOVA with condition as a repeated measures factor. This approach has been adopted in other repeated measures designs (Yeomans, et al., 2004). Bonferroni adjustment was applied for post hoc analyses. Any significant interactions were explored with paired samples t-tests and one-way ANOVAs. To correct for multiple comparisons alpha was set at $p < .025$ with the exception of one tailed hypotheses where alpha was set at $p < .05$. When the assumption of sphericity was violated Greenhouse-Geisser correction was applied.

For manipulation checks, comparisons of health ratings for the snack foods used the non-parametric Wilcoxon Signed rank test. To check the emotional content of the memories in each condition were similar, a mixed ANOVA compared ratings with diet status as a between-subjects factor.

All data is presented as mean ± SEM. Partial eta squared (ηp^2) was used for effect size with 0.01 = small, 0.09 = medium and 0.25 = large effects.

4.5.2 Results

4.5.2.1 Manipulation check

In support of the study's manipulation, participants rated the fresh oranges (4.7 ± 0.1) as the healthiest snack compared to the cereal bars (3.2 ± 0.1) (Z = 5.5, p < .001) and chocolate (3.0 ± 0.1) (Z = 5.6, p < .001). The chocolate was perceived as least healthy compared to the cereal bars (Z = 5.3, p < .001). Health ratings of cued foods were unaffected by diet status [$F(1, 38) = 1.55$, p = *ns*, $\eta p^2 = .04$].

4.5.2.1.1 Memories recalled

All participants recalled a memory associated with each cue. Importantly, none of the memories were reported with a particular positive or negative affect. For example, holidays in the sun or being outside were recalled most frequently for fresh oranges (n = 18) and memories of Christmas were recalled most frequently for the chocolate orange (n = 23).

4.5.2.2 Participant Characteristics

In total 58 participants completed the study however 10 reported they were dieting to maintain weight and were excluded[6]. Of the remaining 48 participants, 8 were excluded for high intake (n = 5), reporting a desire to gain weight (n = 1), starting a diet during the interval between the two sessions (n = 1) and being underweight (17.5kg/m^2) (n = 1). The remaining sample consisted of 16 dieters losing weight and 24 non-dieters (73% were students).

Dieters reported the following diet strategies: exercising (n = 6), eating healthily (n = 6) eating less food (n = 4), reducing calorie intake (n = 4), adopting a low carbohydrate diet (n = 2), or low fat diet (n = 2), commercial weight-loss program (n = 1), avoiding baked foods (n = 1), avoiding junk food (n = 1), avoiding alcohol (n = 1) and practical and sensible diets (n = 1). Thus dieting to lose weight corresponded with reported weight loss strategies. For dieters, 63% reported previous efforts of dieting, of which 80% reported dieting more than once a year. For non-dieters, 38% reported previous diet attempts and of those, 11% reported dieting more than once a year.

[6] Psychometric scores revealed differences between dieters losing and maintaining weight. Dieters maintaining weight scored significantly lower in PFS-available compared to dieters' losing weight, $t(20.95) = 3.03$, p = .006. These differences supported the decision to exclude dieters maintaining weight from the analysis.

Dieters desired a greater weight loss than non-dieters, t(33) = 4.71, $p < .001$. Additionally, dieters scored higher than non-dieters in BMI, TFEQ-restrained eating, flexible control, rigid control, TFEQ-disinhibition, internal disinhibition, DEBQ-restrained eating, DEBQ-external eating, DEBQ-emotional eating, PFS-available, and PFS-tasted and scored lower in PSRS, indicating lower perceived self-regulatory success compared to non-dieters [BMI: t(38) = 2.19, $p = .03$; TFEQ-restrained: t(38) = 5.51 $p < .001$; flexible control: t(38) = 4.81, $p < .001$; rigid control: t(38) 5.09, $p <.001$; TFEQ-disinhibition: t(38) = 3.65, $p = .001$; DBEQ-restrained eating: t(38) = 3.20, $p = .003$; DEBQ-external: t(38) = 4.37, $p < .001$; DEBQ-emotional: t(38) = 4.53, $p < .001$; PFS-available: t(38) = 2.7, $p < .01$; PFS-tasted: t(38) = 2.4, $p = .02$] and lower in PSRS [PSRS: t(38) = 2.24, $p = .04$]. Thus, dieters scored higher in psychometric traits associated with overconsumption compared to non-dieters (see Table 4.4).

4.5.2.3 Study Compliance

All participants complied with the instruction to fast for 2 hours prior to each study session. Time since participants last ate did not differ between conditions or groups [condition: F(1, 27) = 0.17, $p = ns$, $\eta p^2 = .005$; group: F(1, 27) = 0.01, $p = ns$, $\eta p^2 = 0$]. There were no order effects of cue exposure on total energy intake, F(1, 38) = 1.31, $p = ns$, $\eta p^2 = .03$.

Table 4.4. Participant characteristics (mean ± SEM).

Characteristic	Dieters (n = 16)	Non-dieters (n = 24)
Age (years)	23.4 ± 2.0	28.4 ± 1.9
Height (m)	1.7 ± 0.1	1.7 ± 0.1
Weight (kg)	67.7 ± 2.3	61.6 ± 1.8*
BMI (kg/m²)	24.8 ± 0.8	22.6 ± 0.6*
Desired weight loss	8.9 ± 1.2[a]	2.6 ± 0.7[b]***
TFEQ-re	15.4 ± 1.1	7.3 ± 1.0***
Flexible	5.1 ± 0.4	2.4 ± 0.4***
Rigid	5.3 ± 0.4	2.4 ± 0.4***
Internal disinhibition	4.4 ± 0.5	2.1 ± 0.4**
External disinhibition	3.3 ± 0.4	2.8 ± 0.4
TFEQ-d	9.4 ± 0.9	6.1 ± 0.7**
TFEQ-Hunger	6.4 ± 0.9	5.8 ± 0.6
DEBQ-re	3.7 ± 0.2	3.0 ± 0.2**
DEBQ-em	3.6 ± 0.2	2.7 ± 0.1***
DEBQ-ex	3.0 ± 0.1	2.3 ± 0.1***
PFS-available	18.7 ± 1.7	13.3 ± 1.2*
PFS-present	12.0 ± 1.5	12.3 ± 0.8
PFS-tasted	16.7 ± 1.2	13.7 ± 0.6*
PFS-total	46.3 ± 4.6	39.3 ± 2.2
PSRS	3.7 ± 0.4[c]	4.7 ± 0.3[c*]
WS	2.0 ± 2.1[a]	2.7 ±1.0[b]

Note. TFEQ = Three Factor Eating Questionnaire (Stunkard & Messick, 1985); TFEQ-re = TFEQ-restraint; TFEQ-d = TFEQ-disinhibition; Internal-d = Internal disinhibition; External-d = External disinhibition; DEBQ = Dutch Eating Behavior Questionnaire (van Strien, et al., 1986); DEBQ-re = DEBQ restraint; DEBQ-em = DEBQ-emotional; DEBQ-ex = DEBQ-external; PFS = Power of Food Scale (Lowe, et al., 2009); PSRS = Perceived Self-Regulatory Success (Fishbach et al. 2003); WS = Weight suppression.
[a] n = 15. [b] n = 20. [C] n = 9
**p* < .05 between groups.
***p* < .01 between groups.
****p* < .001 between groups.

4.5.2.4 Correlations between energy intake and eating behaviour traits across conditions

Examination of correlations between intake in each condition and individual characteristics for dieters and non-dieters showed that in the diet condition dieters' energy intake negatively correlated with BMI and TFEQ-restraint, as BMI and TFEQ-restraint increased consumption declined. In the tempting food condition, higher scores for disinhibition, internal disinhibition, hunger, PFS-available, PFS-present, PFS-tasted and PFS-total were associated with increases in energy intake for dieters. For non-dieters, weight suppression was positively associated with energy intake in the diet condition. In the tempting food condition increases in flexible eating was associated with decreases in energy intake for non-dieters. Higher scores in external disinhibition, DEBQ-external and PFS-present were associated with increased intake by non-dieters (see Table 4.5).

Table 4.5. Correlations between dieters' and non-dieters' characteristics and energy intake across conditions.

	Dieters		Non-dieters	
	Diet-congruent	Tempting condition	Diet-congruent	Tempting condition
Age (years)	-.23	-.26	-.08	-.08
BMI (kg/m²)	-.51*	-.13	-.17	.02
TFEQ-re	-.53*	.07	-.17	-.34
Flexible	-.39	-.06	-.14	-.50*
Rigid	-.44	.09	-.25	-.26
TFEQ-d	.15	.60*	.28	.29
Internal-d	.25	.54*	.27	.10
External-d	-.03	.46	.28	.44*
TFEQ-Hunger	.06	.55*	-.05	-.12
DEBQ-re	.11	.46	-.02	.12
DEBQ-re	-.10	.47	.11	.16
DEBQ-ex	.09	.38	.28	.44*
PFS-available	.00	.52*	.17	.29
PFS-present	.28	.66**	.33	.44*
PFS-tasted	.13	.55*	.22	.11
PFS-total	.20	.66**	.27	.34
WS	-.01	.20	.47*	.09

Note. TFEQ = Three Factor Eating Questionnaire (Stunkard & Messick, 1985); TFEQ-re = TFEQ-restraint; TFEQ-d = TFEQ-disinhibition; Internal-d = Internal disinhibition; External-d = External disinhibition; DEBQ = Dutch Eating Behavior Questionnaire (van Strien, et al., 1986); DEBQ-re = DEBQ restraint; DEBQ-em = DEBQ-emotional; DEBQ-ex = DEBQ-external; PFS = Power of Food Scale (Lowe, et al., 2009); WS = Weight suppression.
**p* < .05.
***p* < .01.

4.5.2.5 Impact of condition and diet status on energy intake

There were no main effects of food condition or diet status on energy intake, [condition: $F(1, 38) = 0.57$, $p = ns$, $\eta p^2 = .02$; diet status: $F(1, 38) = 0.18$, $p =$ ns, $\eta p^2 = .01$]. However the condition x diet status interaction approached significance, $F(1, 38) = 3.25$, $p = .08$, $\eta p^2 = .08$. There was a trend for dieters to consume less after exposure to the fresh oranges compared to chocolate yet this difference failed to reach significance, $t(15) = 1.62$, $p = .13$ (diet condition: 283 ± 49 kcal; tempting condition: 375 ± 54 kcal). Non-dieters consumed similar energy intake across conditions (diet condition: 323 ± 49 kcal; tempting condition: 286 ± 34 kcal) (see Figure 4.3).

4.5.2.6 Impact of condition and diet status on type of snack food consumed

There was a main effect of snack type consumed on energy intake, $F(1.44, 38) = 34.19$, $p < .001$, $\eta p^2 = .47$. Participants consumed more of the tempting food compared to the diet-congruent ($p < .001$) and intermediate food ($p = .009$). The diet-congruent food showed the lowest intake compared to chocolate and the intermediate food ($p < .001$). Intake of snack types did not vary by diet status, $F(1, 38) = 0.19$, $p = ns$, $\eta p^2 = .005$. A significant condition x group x snack type interaction emerged, $F(1.14, 43.43) = 4.03$, $p = .02$, $\eta p^2 = .10$. Exploration of the means showed that dieters consumed 40% (90 ± 50 kcal) less chocolate intake in the diet condition compared to the tempting condition, this difference approached significance ($p = .09$). Non-dieters did not change between conditions ($p = ns$) (see Figure 4.3).

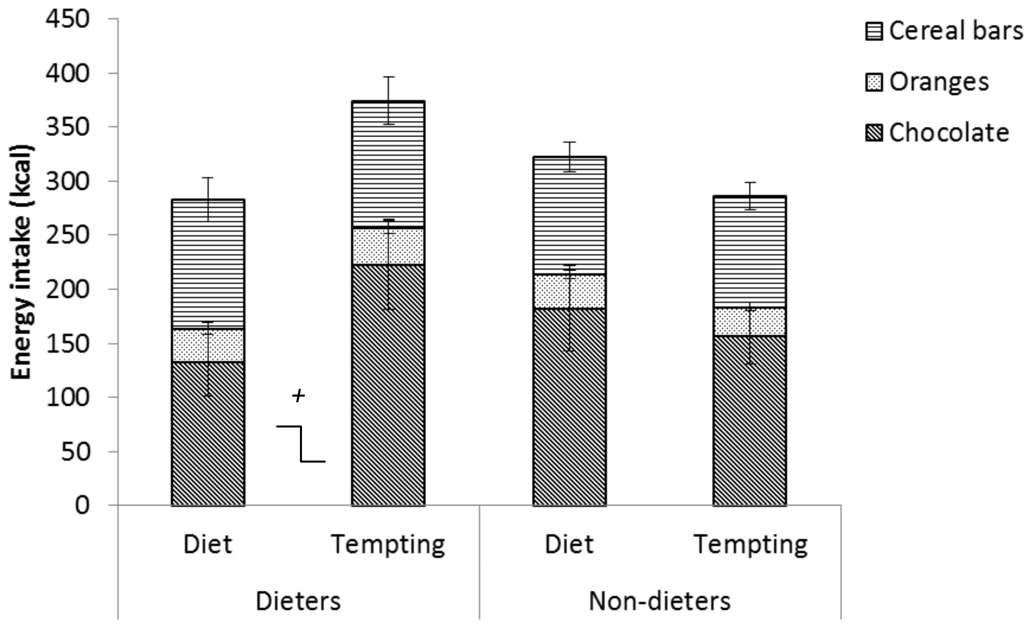

Figure 4.3. Dieters' and non-dieters' mean energy intake (± SEM) for snacks across conditions.

+ = .09 between conditions

4.5.2.7 Ratings of snack foods

Participants' pleasantness and desire to eat the snack foods did not differ between conditions[7] [pleasantness: $F(1, 37) = 0.22$, $p =$ ns, $\eta p^2 = .01$; desire to eat: $F(1, 37) = 0.64$, $p =$

[7] One non-dieter did not complete the taste ratings.

ns, ηp^2 = .02]. Pleasantness and desire to eat ratings did not differ by diet status [pleasantness: F(1, 37) = 3.53, p = .07, ηp^2 = .09; desire to eat: F(1, 37) = 1.87, p = *ns*, ηp^2 = .05].

The snack foods were rated differently for pleasantness and desire to eat [pleasantness: F(2, 37) = 8.35, p = .001, ηp^2 =.18; desire to eat: F(2, 37) = 7.66, p = .001, ηp^2 = 0.17]. Evaluations of fresh orange and chocolate were similar (pleasantness: fresh orange: 85.4 ± 2.0 mm; chocolate: 84 ± 2.6 mm; desire to eat: fresh orange: 76.4 ± 2.9mm; chocolate: 76.9 ± 3.0 mm) but were more pleasant and more desirable than the cereal bars (cereal bars: pleasantness: 73 ± 3.1 mm; desire to eat: 61.2 ± 4.1 mm) (pleasantness p = .006; desire to eat p < .05).

4.5.2.8 Impact of cue and diet status on appetite sensations

Hunger, desire to eat and fullness changed over the course of each session [hunger: F(1.54, 58.66) = 49.33, p < .001, ηp^2 =.57; desire to eat: F(1.58, 60.14) = 30.17, p < .001, ηp^2 =.40; fullness: F(1.53, 58.3) = 77.8, p < .001, ηp^2 = 0.70]. Hunger and desire to eat increased from pre-cue exposure (hunger: 56.28 ± 2.9 mm; desire to eat: 57.2 ± 3.0 mm) to post-cue exposure (hunger: 65.79 ± 3.0 mm; desire to eat: 70.56 ± 3.0 mm) and decreased after snack intake (hunger: 34.4 ± 3.5 mm; desire to eat: 39.3 ± 4.0 mm). Fullness ratings did not change from pre-cue exposure (29.8 ± 2.5 mm) to post-cue exposure (28.6 ± 2.5 mm) (p = *ns*) but did significantly increase from post-cue to post-snack (62 ± 3.5 mm).

Hunger, desire to eat and fullness did not differ between conditions or diet status [condition: hunger: F(1, 38) = 0, p = *ns*, ηp^2 = 0; desire to eat: F(1, 38) = 0.13, p = *ns*, ηp^2 = .004; fullness: F(1, 38) = 3.57, p = .07, ηp^2 = .09; diet status: hunger: F(1, 38) = 2.21, p = *ns*, ηp^2 =.06 ; desire to eat: F(1, 38) = 0.76, p = ns, ηp^2 = .02; fullness: F(1, 38) = 0.001, p = *ns*, ηp^2 = 0].There were no time x diet status nor condition x time x diet status interactions on hunger, desire to eat or fullness ratings, [two way interactions: hunger: F(2, 76) = 0.84, p = *ns*, ηp^2 =.02; desire to eat: F(2, 76) = 0.11, p = *ns*, ηp^2 = .003; fullness: F(2, 76) = 2.76, p = *ns*, ηp^2 = .001; three-way interactions: hunger: F(4, 86) = 0.94, p = *ns*, ηp^2 = .04; desire to eat: F(2, 76) = 0.57, p = *ns*, ηp^2 = .02; fullness: F(2, 76) = 0.12, p = *ns*, ηp^2 = .003].

Thus, appetite changed over time, however, the diet-congruent food cue did not influence appetite sensations differently to the tempting food cue.

4.5.2.9 Impact of condition and restraint disinhibition subtypes on energy intake

Restraint and disinhibition scores differed across the restraint disinhibition subtypes [restraint: $F(3, 39) = 36.03$, $p < .001$; disinhibition: $F(3, 39) = 23.28$, $p = < .001$]. HRHD and HRLD scored greater in restraint compared to LRHD and LRLD. HRHD and LRHD scored higher in disinhibition compared to HRLD and LRLD (see Table 4.6). There were no differences in intake between conditions, $F(1, 36) = 0.03$, $p = ns$, $\eta p^2 = .001$. There was a main effect of restraint disinhibition subtype, $F(1, 36) = 3.06$, $p = .04$, $\eta p^2 = .20$. HRHD consumed 230 ± 83 kcal more compared to HRLD. There was a significant condition x group interaction on energy intake, $F(3, 36) = 3.57$, $p = .02$, $\eta p^2 = .23$. Of the subtypes, HRHD consumed 176 ± 67 kcal less after exposure to the diet-congruent food odour compared to the tempting food odour ($p = .03$) (see Figure 4.4).

Table 4.6. Restraint and disinhibition scores for the restraint disinhibition subtypes (mean ± SEM).

	HRHD (n = 10)	HRLD (n = 6)	LRHD (n = 5)	LRLD (n = 19)
TFEQ-re	16.5 ± 0.9[a]	17.2 ± 1.1[a]	9.2 ± 0.8[b]	5.7 ± 0.8[b]
TFEQ-d	11.7 ± 0.2[a]	6.2 ± 0.7[b]	10.6 ±0.7[a]	4.7 ± 0.6[b]
Dieters (n)	8	5	1	2

*Note.*TFEQ = Three Factor Eating Questionnaire (Stunkard & Messick, 1985); TFEQ-re = TFEQ-restraint; TFEQ-d = TFEQ-disinhibition.
Different letters denote significant differences between groups.

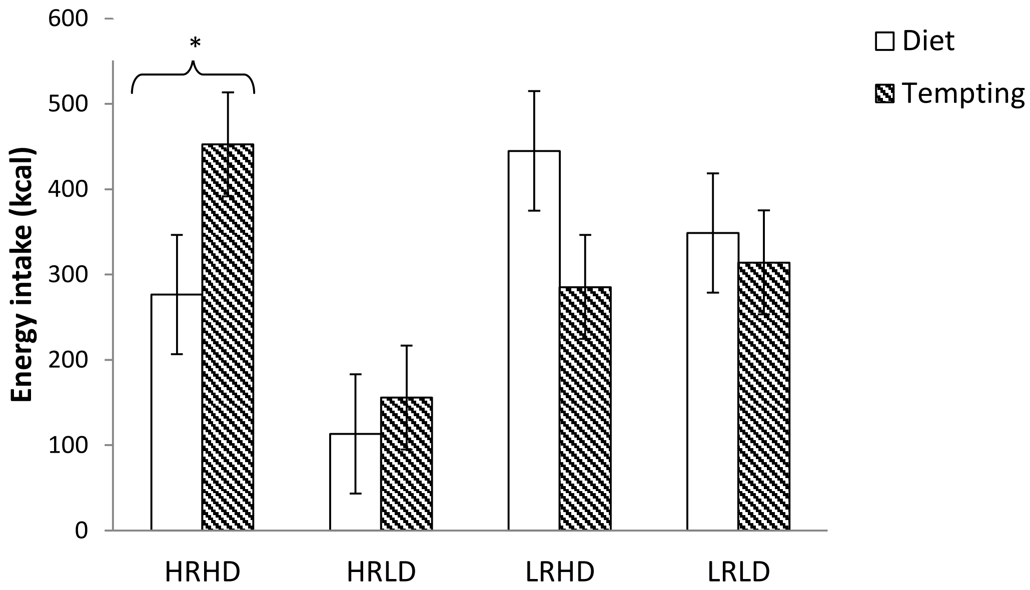

Figure 4.4. Mean energy intake (± SEM) for restraint disinhibition subtypes across conditions.

H = high; L = low; R = restraint; D = disinhibition.

*$p < .05$ between conditions.

4.5.2.10 Mood.

Happiness did not differ between conditions or diet status [conditions: $F(1, 38) = 0.12$, $p =$ ns, $\eta p^2 = .003$; diet status: $F(1, 38) = 0.35$, $p =$ ns, $\eta p^2 = .009$]. There was a time x diet status interaction on happiness, $F(2, 76) = 8.01$, $p = .001$, $\eta p^2 = .17$. Exploration of the interaction showed that in the tempting food cue condition, dieters were happier than non-dieters at post-cue exposure (VAS 2) (dieters: 78.5 ± 3.2 mm; non-dieters: 67.4 ± 3.9 mm). All other subjective states (sadness, relaxed, alert, tired, anxious) showed no differences between condition and groups at post-cue exposure.

4.5.2.11 Emotional content of memories

There were no differences in how emotional participants felt whilst recalling memories between conditions, or group [condition: $F(1, 38) = 1.68$, $p = ns$, $\eta p^2 = .04$; diet status: $F(1, 38) = 0.02$, $p =$ ns, $\eta p^2 = .001$]. Thus, dieters and non-dieters felt equally emotional between conditions.

4.5.2.12 Awareness of the study purpose

Of the sample 5 participants suspected that appetite or food intake was the main variable of interest. Exclusion of these participants made no difference to the significance of the condition x diet status interactions on energy intake for the analysis on the full sample [$F(1, 31) = 3.64$, $p = .07$], the analysis on restrained and unrestrained dieters [$F(1, 26) = 6.34$, $p = .02$] and the analysis on the restraint disinhibition subtypes [$F(3, 29) = 4.51$, $p = .01$].

4.5.3 Discussion

The current study found that exposure to a diet-congruent food odour reduced dieters' snack intake compared to exposure to a tempting food odour. This reduced snack intake was accounted for by a 40% reduction in dieters' chocolate intake in the diet condition compared to the tempting condition, whereas intake of fresh oranges and cereal bars did not differ between conditions. Unlike dieters, non-dieters' energy intake did not differ between conditions. An exploratory analysis also showed that HRHD eaters reduced snack intake in the diet condition compared to the tempting condition, whereas HRLD, LRHD and LRLD eaters' intake did not differ between conditions.

Due to the specific effect of diet-congruent cues on dieters' and not non-dieters' food intake, the findings are consistent with the goal conflict theory which predicts that diet-congruent cues will only affect those individuals holding relevant goals – namely dieters (Stroebe, et al., 2008; Stroebe, et al., 2013). However, the goal conflict theory specifically proposes that exposure to diet-congruent cues should increase the salience of diet thoughts compared to exposure to tempting cues (Stroebe, et al., 2008; Stroebe, et al., 2013).To further support this mechanism, subsequent studies would need to incorporate a lexical decision task to measure diet goal salience (Forster, et al., 2007). In the current study a lexical decision task was not included so that the effects of diet-congruent food odours on food intake could be examined without the potential interference from diet and tempting words in the task. However, it would be valuable for subsequent studies to confirm the underlying mechanism of diet-congruent food odours by testing the effects of diet-congruent cues on the salience of diet thoughts and food intake. Importantly, in the current study effects due to differences in subjective appetite, mood and emotion can be ruled out as an explanation for the current findings as there were no differences observed in these measures.

The finding that diet-congruent food odours reduced dieters' and HRHD eaters' snack intake is important because previous research has only examined the effects of diet-congruent cues in restrained eaters (Anschutz, et al., 2008; Harris, et al., 2009; Papies & Hamstra, 2010) and general samples (Brunner, 2010; Brunner & Siegrist, 2012; Mann & Ward, 2004). Yet, dieters and HRHD eaters are prone to overconsumption and could also benefit from diet-congruent cues. Specifically, dieters tend to regain previously lost weight (Mann, et al., 2007; Thomas, 1995), possibly due to food being more rewarding after restricting food intake (Cameron, et al., 2008; Epstein, Truesdale, et al., 2003; Raynor & Epstein, 2003). Similarly, HRHD eaters have been shown to overeat in response to a variety of cues and disinhibitors (Haynes, et al., 2003; Soetens, et al., 2008; Westenhoefer, et al., 1994). Therefore, the current findings indicate that diet-congruent cues could be an effective strategy to assist those trying to restrict food intake. However, caution is needed when interpreting the effect of diet-congruent cues on restraint and disinhibition subtypes as the number of LRHD eaters was low and replication in larger studies is necessary.

Nevertheless, the efficacy of diet-congruent cues to reduce dieters' chocolate intake might reflect the potency of diet-congruent odours to reduce intake of a highly desired snack food. Chocolate is a commonly craved food among females and especially dieters (Pelchat, 1997) and the study findings suggest that diet-congruent food cues can help dieters to resist intake of foods likely to tempt them most. The current findings extend those presented in Chapter 3 on diet-congruent images, by demonstrating the role of diet-congruent food odours on dieters' intake. It has been suggested that diet-congruent food odours are more potent cues compared to diet-congruent image cues (Jansen & van den Hout, 1991). Indeed, the current findings showed diet-congruent food odours reduced intake of highly desired and diet-forbidden food (chocolate), whereas, diet-congruent images only reduced intake of a low fat sweet food.

However, there are differences between the current study and Chapter 3 which might explain why the current study showed a suppression of tempting food and Chapter 3 did not. Firstly, the types of foods offered differed between studies. The type of snack foods provided in Chapter 3 were all tempting, whereas in the current study participants were provided with a selection of diet-congruent, tempting and intermediate snacks. In the current study, the presence of diet-congruent food with a tempting food in the snack test might have reminded dieters of the preceding diet-congruent cue in the diet condition and encouraged regulated intake. Indeed, the order that participants encounter foods can affect evaluations of subsequent foods. Thus, exposure to a diet-congruent food might lead to an assimilation effect, in which foods subsequently encountered are judged as more diet-congruent compared to if the food had been presented alone (Chernov, 2011; Ahern, 2013). Thus, in the diet-congruent condition, the diet-congruent food presented in the snack test might have been judged as more diet-congruent compared to the tempting condition and this salient diet-congruent cue might have facilitated dieters to control snack intake more so than in the tempting condition.

Secondly, in the current study the foods used as cues and the subsequent snack test were all orange flavoured. Sensory specific satiety can occur with exposure to food odours such as banana (Rolls & Rolls, 1997). It is possible that the fresh orange was more sensitive to sensory specific satiety (SSS) compared to the chocolate orange such that pleasantness of orange flavoured foods declined and terminated snack intake quicker in the diet condition compared to the tempting condition. However, it is difficult to tell which property of fresh oranges might make a fresh orange odour more sensitive to SSS compared to a chocolate orange odour. Intensity of flavour does not affect SSS (Havermans, Geschwind, Filla, Nederkoorn, & Jansen, 2009) therefore this is an unlikely explanation for the finding. Furthermore, this explanation would also require dieters to be more sensitive to olfactory sensory specific satiety than non-dieters, however, to date research suggests that individual differences such as restraint (Brunstrom & Mitchell, 2006; Hetherington, Foster, Newman, Anderson, & Norton, 2006; Tepper, 1992) and BMI do not moderate SSS (Brondel, Lauraine, Van Wymelbeke, Romer, & Schaal, 2009). Nevertheless to rule out this explanation future studies might benefit by testing whether the suppressant effects of diet-congruent cues extend to snack foods that are different to the cued food.

A limitation of the current study is the absence of a non-food control condition which constrains the interpretation of these findings. In the absence of a non-food condition it is unclear whether the differences in energy intake between conditions reflected the suppression of energy intake in the diet-congruent condition, or reflected a stimulation of intake in the tempting food condition. In support that diet-congruent food odours reduced energy intake, the ratings (appeal and pleasantness) of the snack test foods did not differ between conditions, whereas cue reactivity involves heightened hedonic snack ratings (Fedoroff, et al., 1997). Nevertheless, to resolve this issue subsequent studies would need to include a non-food control condition to illustrate whether intake in the diet condition is suppressed compared to the control and intake in the tempting condition is increased compared to the control.

4.6 Directions for future research:

To extend the current findings, subsequent studies could amend the design of this study in several ways. Firstly, a control non-food condition would confirm the effects of diet-congruent food odours to reduce dieters' snack intake. Secondly, to substantiate goal priming as a mechanism, a lexical decision task could be incorporated to assess the salience of diet and tempting thoughts in response to diet-congruent food odours. Thirdly, a more tempting snack test could be used to examine whether the effects of diet-congruent food odours extend to situations where no diet-congruent foods are available. Finally, to test whether the effect of diet-congruent food odours on energy intake is a general effect that extends to snack foods that participants have not been previously exposed to (non-cued foods), thus the food cues could differ from the foods offered in the snack test.

4.7 Key findings

- The online survey provided a database of foods associated with dieting to lose weight and temptation. These findings informed the selection of diet-congruent and tempting foods in subsequent laboratory studies.

- Dieters exposed to a diet-congruent food odour reduced energy intake compared to a tempting food odour. In contrast, non-dieters consumed a similar amount between conditions.

- Dieters' lower energy intake in the diet condition was driven by a 40% suppression of chocolate intake, a diet-forbidden food (Pelchat et al. 1997) relative to the tempting condition.

- The reduction in dieters' energy intake occurred independent of appetite and mood. Neither dieters' nor non-dieters' appetite or mood differed between conditions.

- HRHD eaters were responsive to the diet-congruent food odour and reduced intake relative to the tempting odour. Caution is needed with the interpretation of this finding as sample size was low for LRHD eaters.

Chapter 5

Are diet-congruent odour cues always fruitful?: Effects of diet-congruent food odours on snack intake.

5.1 Abstract

To extend findings on diet-congruent food odours (Chapter 4) the current study exposed dieters (n = 11) and non-dieters (n = 19) to either the smell of fresh oranges, chocolate orange or soap, and the salience of diet, tempting and neutral thoughts were measured with a lexical decision task. Subsequent snack intake was measured. Results showed similar intakes across conditions. Results from the lexical decision task were not influenced by condition but by word type. Motivational state appeared to moderate effects since participants were less hungry, had less desire to eat and were fuller than those in the previous study (Chapter 4).

5.2 Introduction

Exposure to the sight and smell of diet-congruent food reduced dieters' chocolate intake compared to exposure to a tempting food. This may be explained in part by the effect of seeing and smelling food linked to weight loss by bringing diet-related thoughts to the fore when faced with tempting food cues. This explanation fits previous research (Brunner, 2010; Brunner & Siegrist, 2012; Papies & Hamstra, 2010). However, to test this assumption, diet goal salience following diet-congruent cue exposure is necessary to assess the goal priming explanation (Forster, et al., 2007). As of yet, only one study has examined the effects of diet-congruent cues on both snack intake and the salience of diet and tempting thoughts (Pelaez-Fernandez & Extremera, 2011).

The salience of diet thoughts after diet-congruent exposure was measured previously (Chapter 3), but there was a floor effect to the 4 diet words used in the lexical decision task. Priming research generally involves more than 4 words to assess goal salience. For instance, research measuring the salience of aggressive thoughts (Bushman, 1998; Denzler, Foerster, & Liberman, 2009; Gollwitzer & Denzler, 2009) and the effects of perceived power (Slabu & Guinote, 2010) have included 7 to 24 aggressive or power words to assess the prominence of these constructs. Thus an improvement to the previous study's lexical decision task (Chapter 3) is to increase the words used within the task. Secondly, the previous lexical decision task selected diet and tempting words derived from previous research, however, there is no evidence that the diet words selected were associated with dieting concepts. To measure the salience of diet thoughts it is pertinent that the words selected are closely linked with dieting concepts. Research in non-appetite areas have validated critical words to enable selection of items most closely associated with the target construct (Denzler, et al., 2009). Thus, evidence that individuals do strongly associate particular words with dieting concepts is currently needed.

Importantly another improvement to the previous study is to include a control group. It is unclear whether suppressed energy intake in the diet-congruent condition reflected inhibited intake, or whether the difference between conditions is explained by responsiveness to a tempting food cue. Other studies examining food cue exposure on subsequent intake have typically used either a non-food stimulus such as soap (Jansen & Nederkoorn, 2002), or a no stimulus control condition (Fedoroff et al. 1997) to compare intake between conditions. Integrating a non-food exposure condition is needed to confirm the suppressant effects of diet-congruent food odours on dieters' snack intake.

5.3 Aims

Therefore there were two main aims of the current study. Firstly, to replicate the effect of the sight and smell of diet-congruent food to reduce dieters' intake of a tempting snack compared to control and tempting cues. Secondly, to measure the salience of diet and tempting thoughts after exposure to diet-congruent cues compared to tempting and non-food cues by using a lexical decision task.

5.4 Pre-study survey – identification of diet-congruent and tempting food words

5.4.1 Method

5.4.1.1 Participants

In total 154 female participants aged 20 – 55 years (*M*: 32.0 ± 0.2 years) completed the survey. The sample comprised of 42 dieters losing weight, 17 dieters maintaining weight and 95 non-dieters. Of the sample 48.7% were students. There were an additional 27 participants who indicated a history of eating disorders and 2 males who were excluded from participating in the study. Only responses from women were collected to obtain ratings from a sample similar to the laboratory studies and participants with a history of eating disorders were excluded to abide with ethical approval. Participants were recruited by email (71.4%), online forums (11%), the social network site Facebook (6.5%), the

University of Leeds participant pool (6.5%) and word of mouth (3.5%). Upon completion participants were entered in to a prize draw to win £75.

5.4.1.2 Materials

The survey was designed using Qualtrics software version 12018 (Provo, Utah, 2009).

5.4.1.2.1 Words

The words used in the survey were generated by a group of researchers (n = 6) who were asked to list words that were triggered when thinking about the construct “dieting to lose weight” and “temptation.” Words were also selected from a previous study which asked participants to generate weight-related words (Greenleaf, Starks, Gomez, Chambliss, & Martin, 2004). All words generated from these two methods were then entered into an online thesaurus and any additional words deemed relevant by the researcher were selected for the survey. In total there were 40 diet candidate words, 40 temptation candidate words and 40 neutral words used in the survey (see Appendix E). Neutral words were included to reduce the contrast between diet and temptation words and to validate words that hold no association with dieting to lose weight and temptation.

5.4.1.3 Procedure

The advert for the online survey presented a direct link to the website. Participants were asked to indicate their age, gender and whether they had a history of eating disorders. All excluded participants were shown a page informing them about ineligibility and were thanked for their time. Eligible participants completed the word rating task. For the word rating task, a word appeared at the top of the screen with the question “How strongly do you associate the word ***slimming*** with dieting to lose weight?” Participants responded on a 10-point scale ranging from 1 (not at all associated) to 10 (extremely associated). A 10-point scale was used based on previous research which validated words for a lexical decision task (Denzler, et al., 2009). To prevent ratings being contaminated by previously seen words participants were instructed to rate each word in isolation to previously seen words. To encourage uninhibited responses participants were informed that there were no right or wrong responses. The task commenced with 1 practice trial. The words appeared in a random order for each participant. Once participants had rated the diet-congruency of all words, participants repeated the rating task but rated each word for its association with eating purely for pleasure or temptation. Next, participants indicated their student status, diet status (see Chapter 2) and how they became aware of the survey.

5.4.1.4 Data analysis

Mean rating scores were calculated for each word based on how strongly the word was associated with dieting to lose weight and eating purely for pleasure (temptation). The 15 words with the highest mean rating for dieting to lose weight and temptation were selected. The 15 neutral candidate words least associated with dieting to lose weight and temptation and those that were a similar length to the diet and temptation words were selected for neutral words.

5.4.2 Results

Mean scores for the 40 diet-candidate words ranged from 5.4 ± 0.2 to 9.4 ± 0.1 (*M*: 7.2 ± 0.2). The ratings for the temptation candidate words ranged from 2.9 ± 0.2 to 8.7 ± 0.1 (*M*: 7.0 ± 0.3). The neutral words diet scores ranged from 1.2 ± 0.1 to 4.2 ± 0.2 (M: 1.8 ± 0.1) and temptation scores ranged from 1.1 ± 0.1 to 2.5 ± 0.2 (*M*: 1.5 ± 0.1). Table 5.1 shows the 15 words most associated with dieting to lose weight, temptation and neutral concepts.

Table 5.1. Words most associated with dieting to lose weight, temptation and neutral (mean ± SEM) (responses on a 10-point scale, higher scores indicate a higher association).

Type of word and rating score					
Lose weight	Rating	Tempting	Rating	Neutral	Rating
Dieting	9.4 ± 0.1	Delicious	8.7 ± 0.1	Brick	1.2 ± 0.6
Slimming	8.7 ± 0.1	Tasty	8.6 ± 0.1	Contacted	1.3 ± 0.7
Calories	8.6 ± 0.2	Dessert	8.6 ± 0.2	Dust	1.7 ± 0.2
Weigh	8.5 ± 0.2	Indulge	8.4 ± 0.2	Herds	1.2 ± 0.7
Thinner	8.5 ± 0.2	Cake	8.2 ± 0.2	Holes	1.3 ± 0.1
Willpower	8.4 ± 0.2	Eat	8.2 ± 0.2	Husks	1.6 ± 0.2
Healthy	8.1 ± 0.2	Feast	8.1 ± 0.2	Molar	1.3 ± 0.1
Scales	7.9 ± 0.2	Food	8.1 ± 0.2	Molecule	1.4 ± 0.1
Size	7.9 ± 0.2	Cheese Cake	7.9 ± 0.2	Parked	1.2 ± 0.1
Pounds	7.9 ± 0.2	Restaurant	7.9 ± 2.0	Placed	1.4 ± 0.1
Salad	7.8 ± 0.2	Satisfaction	7.8 ± 0.2	Sharpener	1.4 ± 0.1
Body	7.7 ± 0.2	Tempting	7.7 ± 0.2	Sped	1.3 ± 0.1
Fitness	7.7 ± 0.2	Scrumptious	7.7 ± 0.2	Taxed	1.5 ± 0.1
Figure	7.7 ± 0.2	Sweet	7.6 ± 0.2	Triangle	1.2 ± 0.1
Skinny	7.7 ± 0.2	Baking	7.6 ± 0.2	Whistling	1.2 ± 0.1

5.4.2.1 Frequency and length of the diet, temptation and neutral words

The frequency and length of words in the diet, temptation and neutral groups were compared to identify if any of the word lists differed in frequency of use in the English language and length. The frequency of each word was identified using CELEX database. A one-way ANOVA showed that frequency and word length did not differ between the diet, tempting and neutral words [length: $F(2, 42) = 0.59$, $p = ns$; frequency: $F(2, 42) = 1.85$, $p = ns$].

5.4.3 Summary

The online survey identified words associated with dieting to lose weight, temptation and words not associated with either of these constructs. Importantly, the ratings obtained were from a sample of women with an age range that reflects the sample used in the subsequent laboratory study. This survey was important to inform the selection of words for lexical decision task in the laboratory study.

5.5 Laboratory study

5.5.1 Method

5.5.1.1 Participants

Participants were staff, students and members of the local community. In extension to the eligibility requirements listed in Chapter 2 participants who had previously taken part in Chapter 4 were excluded from recruitment. All participants who completed the study were given £15. Based on the large effect size found in Chapter 4, calculations in G*power estimated that a sample size of 50 would allow a difference in snack intake to be detected with 80% power and with a significance level at 0.05. For a summary of the recruitment process see Figure 5.1.

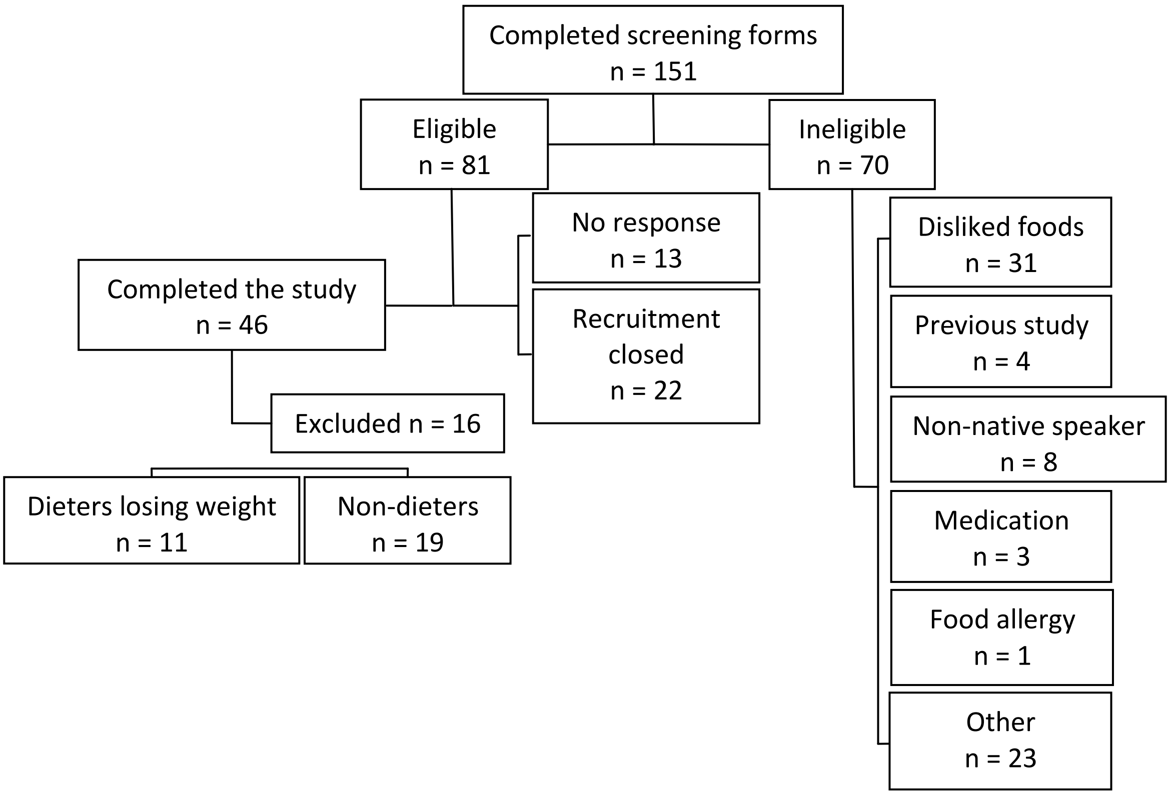

Figure 5.1. Process of recruitment

5.5.1.2 Design

The study used a 3 (condition: diet-congruent, tempting, control) x 2 (diet status: dieting to lose weight, non-dieting) mixed design with diet status as a between-subjects factor and condition as a repeated measures factor. Participants were exposed to one of the cues on 3 separate test days with the order counterbalanced across participants. Each test day was separated by a wash out period of at least 7 days. To prevent participants being aware of the purpose of the study a cover story informed participants the study the effects of different food odours on taste perception.

5.5.1.3 Materials

5.5.1.3.1 Food cues

Using the database of diet-congruent foods established in Chapter 4, fresh oranges (Tesco PLC) were used for a diet-congruent food cue and a chocolate flavoured orange (Kraft Foods Group, Inc) was used as a tempting food cue. These foods were selected due to their matched orange flavour, similarity in presentation (both spheres with segments), and due to having strong odours. As foods tend to be categorised as either healthy or unhealthy (Rozin, Ashmore, & Markwith, 1996) and as “diet” or “fattening” (Sobal & Cassidy, 1987, 1990) a non-food object was selected as a non-food control cue. Soap (Imperial Leather, Cussons) was selected due to its strong odour and because previous studies have used cues similar to soap as an appropriate control (Nederkoorn & Jansen, 2002). The fresh orange was presented as a whole unpeeled orange and the chocolate and soap were presented in their packaging sealed.

5.5.1.3.2 Cue exposure task

Similar to the procedure in Chapter 4, participants completed a sensory assessment of the cue and a memory task related to the cue’s odour to ensure engaged attention to the cue. In each condition, participants rated the extent the cue’s odour was pleasant, refreshing, had a strong intensity, and how sweet they expected the cued food to taste (in the control condition this question was changed to “how moist do you expect the soap to feel?”) on a 9 point scale ranging from 1 (not at all) to 9 (extremely). Participants also rated the food cues (fresh oranges and chocolate) on temptation and health on a 7-point scale ranging from 1 (not at all) to 7 (extremely associated) to obtain an online measure of diet-congruency. For the memory task, participants were asked to report the first word they thought of when they saw the cue, to briefly describe a memory triggered by the cue and to report the vividness of the memory.

5.5.1.4 Measures

5.5.1.4.1 Snack intake

Participants were provided with *ad libitum* access to LFSW, LFSA, HFSW, and HFSA snacks. The snacks were chosen to provide choice and to provide variety. The LFSA snack was cheese flavoured bite size crackers (Oddities by Jacobs, United Biscuits Ltd.; 40g, 455 kcal/100g), the LFSW snack was toffee flavoured popcorn (Butterkist, Tangerine Confectionery Ltd.; 165g, 365kcal/100g), the HFSW snack was chocolate chip cookies (Fox's Biscuits Ltd.; 95g, 545 kcal/100g) and the HFSA snack was salted crisps (Walkers Snack Foods Ltd.; 40g, 502 kcal/100g). In total 1503 kcal were offered. All of the foods were presented in bite size pieces to prevent monitored intake. All foods were served on a tray with 350g of chilled water.

5.5.1.4.2 Salience of diet, tempting and neutral thoughts

The lexical decision task used 15 diet-congruent words, 15 tempting words, 15 neutral words and 15 non-words. The diet, tempting and neutral words were selected from the pre-study validation survey which showed these words are associated with dieting to lose weight, eating purely for pleasure and neutral. For more detail on the lexical decision task see Chapter 2.

5.5.1.4.3 VAS

To assess appetite throughout the study participants rated sensations of hunger, desire to eat and fullness on 100 mm VAS (see Chapter 2). To control for mood, participants rated the extent they felt happy, relaxed, tired and stressed on VAS throughout the study.

5.5.1.4.4 Individual differences in eating behaviour

The TFEQ (Stunkard & Messick, 1985) was used to measure restraint, disinhibition and hunger. All subscales showed good internal reliability (Cronbach's α restraint = .90; disinhibition = .80; hunger = .77).[8] Diet status, weight suppression, nature of diet and history of dieting were recorded. To compare perceived success at dieting participants

[8] The DEBQ and PFS were also administered to examine group differences. However, these did not enhance study findings and shall not be reported.

completed the PSRS (Cronbach's α = .5.32) (Fishbach, et al., 2003). These questions were administered using an online survey (Qualtrics software version 12018 Provo, Utah, 2009).

5.5.1.5 Study Procedure

Participants attended the Human Appetite Research Unit (HARU) on three days between 1200 and 1430 hours to complete VAS 1 and eat a fixed lunch of cheese sandwich (buttered wholemeal bread, cheese, mayonnaise and lettuce) and cherry flavoured yoghurt (598 kcal). After lunch participants completed VAS 2 and left the laboratory with instructions to fast. Two hours later participants returned to the HARU to complete VAS 3 and the cue exposure task. Participants completed the sensory assessment and memory task timed to 10 minutes. Participants were instructed to remove the cue's packaging (in the diet-congruent condition participants were provided with a knife and were requested to divide the orange into quarters) and to inhale deeply through their nose three times to take in the smell of the cue. Once complete, the food remained in the test room on the desk to remind participants of the food cue throughout the remains of the study. Then another set of ratings (VAS 4) was completed followed by the lexical decision task and VAS 5. Next, participants completed the snack test by rating the visual (appeal and tempting), tactile (crunchy, smooth, crumbly, soft) and taste (sweet, moist, salty and bitter) properties of the foods on a 10-point scale ranging from 1 (not at all) to 10 (extremely). Participants were verbally reminded of the food cue they had been exposed to and were instructed to smell the cue throughout the taste task if they needed to be reminded about the smell of the cue. This was done to remind participants of the food cue to bolster the durability of the cue and to minimise interference from the lexical decision task. Participants were left in the room for 10 minutes. When participants completed all ratings they were prompted to help themselves to as much or as little of the food as they wished until the experimenter returned. After the snack task, participants rated VAS 6. For the first and second session this was the end of the test day. On the third session, participants reported what they thought the study purpose was, rated the extent the cued and snack test foods were tempting and health related on a 7-point scale, and completed questionnaires on individual differences in eating behaviour (see Chapter 2). Finally height and weight was recorded (see Chapter 2) and participants were thanked and debriefed. For a summary of the procedure see Figure 5.2.

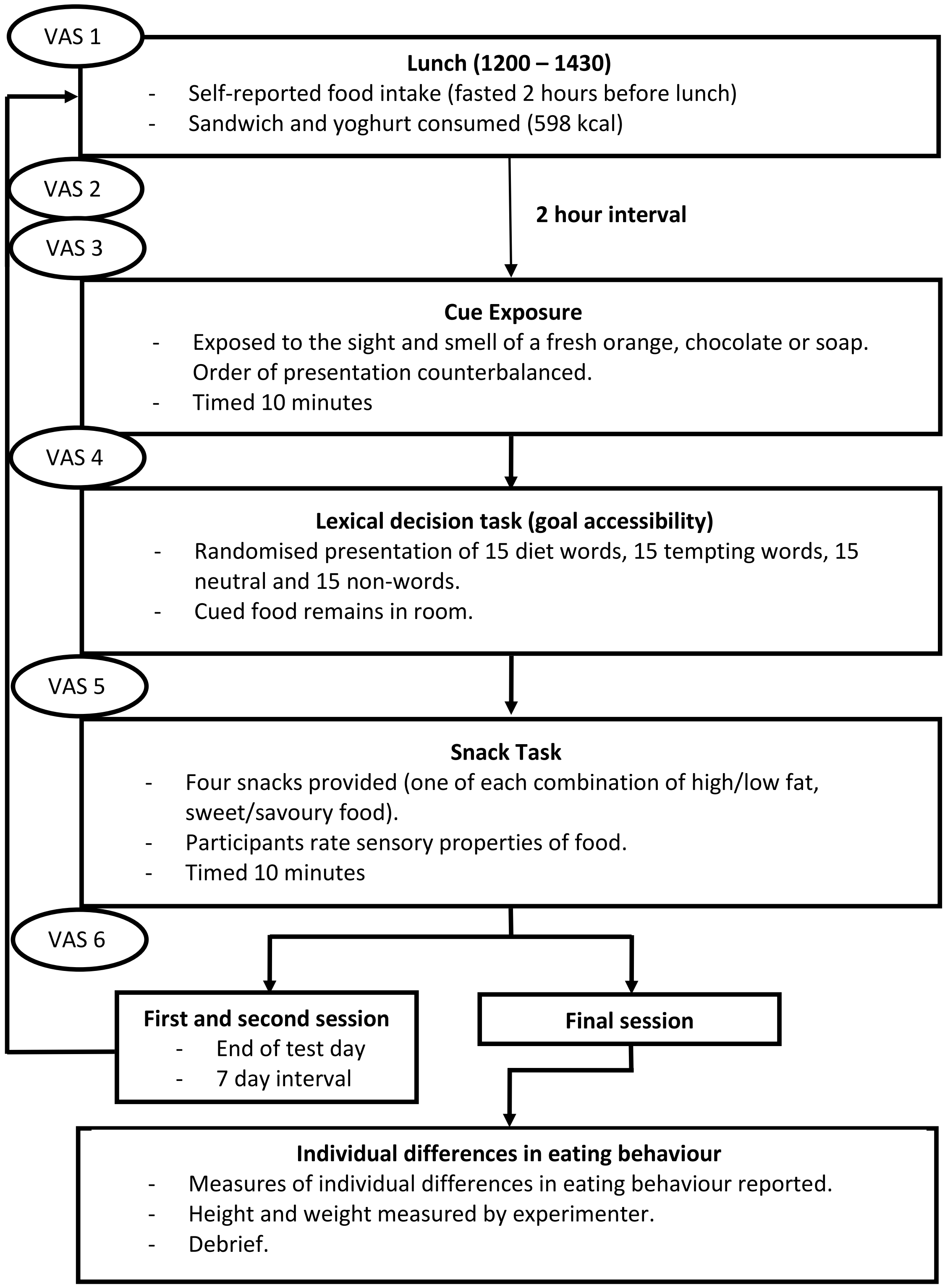

Figure 5.2. Study Procedure.

5.5.1.6 Data analysis

To compare group differences in age, BMI and questionnaire scores a series of independent t-tests were conducted. Bivariate correlations were conducted to examine relationships between energy intake and psychometric scores separately for dieters and non-dieters. To examine the effect of condition and diet status on energy intake a mixed ANOVA was conducted with condition as repeated measures factors and diet status as a between-subjects factor. To assess the influence of condition and diet status on appetite ratings a mixed ANOVA was conducted with condition and time as repeated measures and diet status as a between-subjects factor. To compare evaluations and intake of the snack types across conditions by group a mixed ANOVA was conducted with condition and snack type as repeated measures factors and diet status as a between-subjects factor.

To assess the impact of individual differences, participants with high restraint and high disinhibition scores were grouped using median splits on the TFEQ-restraint subscale (low < 11 and high ≥ 11) and low or high on the TFEQ-disinhibition subscale (low < 9 and high ≥ 9). This yielded 4 subtypes (HRHD, HRLD, LRHD, LRLD). Due to a low number of participants being classified as HRLD (n = 1) this subtype was removed from the analysis. A two-way ANOVA with subtypes as a between-subjects factor and condition as a repeated measures factor was conducted. For the lexical decision task, all incorrect responses were excluded and extreme reaction times (> 3 SDs) were removed from analysis. There was a technical error in data collection for neutral words, therefore only reaction times to diet and tempting words were included in the analysis. A mixed ANOVA with word type and condition as a repeated measures factor and diet status as a between-subjects factor were entered in to the model. Bonferroni correction was applied for post hoc comparisons. When the assumption of sphericity was violated Greenhouse-Geisser correction was applied.

For manipulation checks that the food cues were associated with health and temptation and to check the perceived temptation of the snack foods, the non-parametric Wicoxon Signed Rank test was applied to analyse responses to 7-point Likert scale. To assess group effects on ratings several mixed ANOVAs were conducted.

To compare differences between the current study and Chapter 4 a series of univariate ANOVAs were conducted on age, BMI, psychometric scores, and appetite ratings with study type and diet status entered as between-subject factors. Bonferroni correction was applied to multiple comparisons. Significant interactions were explored with independent t-tests.

To correct for multiple comparisons alpha was set at $p < .025$. Results are presented as mean ± SEM. Partial eta squared (ηp^2) is reported for effect sizes and interpreted as: .01 = small, .09 = medium and .25 as large effects.

5.5.2 Results

5.5.2.1 Manipulation check

Participants rated fresh oranges as healthier than chocolate orange [6.9 ± 0.1; vs. 1.5 ± 1.5, $Z = 4.89$, $p < .001$; respectively]. Conversely, chocolate orange was rated as more tempting than fresh oranges [6.5 ± 0.1; vs. 4.9 ± 0.4, $Z = 3.49$, $p < .001$ respectively]. Ratings of food did not differ between groups (largest F: $F(1, 28) = 0.20$, $p = ns$, $\eta p^2 = .01$). This supports the use of fresh oranges as diet-congruent foods and chocolate as a tempting food cue.

5.5.2.2 Memories recalled

All participants reported a memory associated with each preload. The memories did not describe intense positive or negative moments, for example, in the diet condition memories comprised of the convenience of eating oranges such as being messy and effort peeling (n = 8), the last time oranges were eaten (n = 5) and eating oranges while dieting (n = 2). In the tempting condition most participants recalled memories of Christmas (n = 21) or the last time they ate a chocolate orange (n = 3). In the control condition recalling other people associated with a soap odour (n = 9) and cleaning hands (n = 4) were the most frequently recalled memories.

5.5.2.3 Participant characteristics

In total 46 participants took part in the study. Data from one participant who did not complete all sessions and one participant who received part of the procedure in the wrong order were not included in the analysis. Of the remaining sample there were 19 non-dieters, 11 dieters and 14 maintainers (57% were students). To promote the homogeneity of the sample and to mirror Chapter 4, the subsequent analysis included only dieters losing weight and non-dieters.[9]

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[9] Scores on psychometric scales suggested dieters maintaining weight were less susceptible to overeating compared to dieters losing weight. Dieters maintaining weight had lower BMI scores, lower TFEQ-disinhibition, lower disinhibition-internal scores and were younger than dieters losing weight [BMI: $t(23) = 2.18$, $p = .04$; TFEQ-disinhibition $t(23) = 1.99$, $p = .06$; internal disinhibition: $t(23) = 2.42$, $p = .02$; age: $t(23) = 2.63$, $p = .03$]. These differences supported the decision to exclude dieters maintaining weight from the analysis.

Dieters reported multiple strategies for weight loss including healthy eating (n = 6), commercial weight loss program (n = 2), avoiding snacks (n = 2), low calorie diet (n = 2), eating less (n = 1) and exercising (n = 1). For dieters, 91% reported previous attempts to diet and of those 70% reported dieting more than once a year. For non-dieters, 37% reported previously dieting and of those 43% reported dieting more than once a year.

Dieters scored significantly higher in restrained eating [TFEQ-restrained: $t(28) = 3.7$, $p = .001$; DEBQ-restrained: $t(28) = 2.36$, $p = .03$], flexible control [$t(28) = 2.6$, $p = .02$] and rigid control [$t(28) = 2.89$, $p = .007$] compared to non-dieters (see Table 5.2). All other traits did not differ between groups (largest t: $t(28) = 1.71$, $p = ns$). Thus, dieters scored higher in psychometric traits associated with restricting food intake compared to non-dieters.

Table 5.2. Participant characteristics (mean ± SEM).

Characteristic	Dieters (n = 11)	Non-dieters (n = 19)
Age (years)	29.7 ± 3.7	26.5 ± 2.6
Height (m)	1.7 ± 0.1	1.6 ± 0.0
Weight (kg)	73.0 ± 4.8	64.7 ± 2.5
BMI (kg/m²)	26.4 ± 1.4	24.1 ± 0.8
TFEQ-re	12.1 ± 1.1	6.0 ± 1.1***
Flexible	3.3 ± 0.5	1.8 ± 0.3*
Rigid	4.2 ± 0.6	2.0 ± 0.5**
TFEQ-d	10.5 ± 1.1	8.7 ± 0.9
Internal-d	4.5 ± 0.6	3.5 ± 0.6
External-d	4.1 ± 0.6	3.8 ± 0.3
TFEQ-hunger	7.2 ± 1.1	6.9 ± 0.9
DEBQ-re	3.2 ± .2	2.4 ± 0.2*
DEBQ-em	2.9 ± 0.2	2.8 ± 0.9
DEBQ-ex	2.9 ± 0.2	3.0 ± 0.1
PFS-available	20.1 ± 1.9	15.7 ± 1.5
PFS-present	14.1 ± 1.3	14.0 ± 1.0
PFS-tasted	14.4 ± 1.3	14.5 ± 0.9
PFS-total	48.6 ± 4.0	43.6 ± 3.0
PSRS	3.9 ± 0.4	4.0 ± 0.3
WS	5.2 ± 2.3	2.6 ± 1.1

Note. TFEQ = Three Factor Eating Questionnaire (Stunkard & Messick, 1985); TFEQ-re = TFEQ-restraint; TFEQ-d = TFEQ-disinhibition; Internal-d = Internal disinhibition; External-d = External disinhibition; DEBQ = Dutch Eating Behaviour Questionnaire (van Strien, et al., 1986); DEBQ-re = DEBQ restraint; DEBQ-em = DEBQ-emotional; DEBQ-ex = DEBQ-external; PFS = Power of Food Scale (Lowe, et al., 2009); PSRS = Perceived Self-Regulatory Success (Fishbach et al. 2003); WS = Weight suppression.
*$p < .05$ between groups.
***$p \le .001$ between groups.

5.5.2.4 Participant compliance

Order of condition did not influence energy intake across conditions, $F(5, 24) = 1.57$, $p = ns$, $\eta p^2 = .25$. There were no differences between conditions for fasting time before each session (diet: 172.5 ± 17.5 minutes; tempting: 143.33 ± 21.8 minutes; control: 171.8 ± 16.9 minutes, $F(2, 56) = 1.13$, $p = ns$, $\eta p^2 = .04$).

5.5.2.5 Correlations between energy intake and eating behaviour traits across conditions.

There were no correlations between dieters' energy intake in the diet condition and eating behaviour traits or age and BMI. In the tempting condition, increased energy intake in dieters was associated with increases in BMI and lower scores on restraint (TFEQ and DEBQ) and flexible control. In the control condition higher energy intake was associated with higher BMI and weight suppression scores in dieters. For non-dieters, in the diet condition greater BMI, rigid control, external disinhibition, DEBQ-external, PSRS and weight suppression scores were associated with increases in energy intake. Non-dieters' energy intake in the tempting and non-food control conditions positively correlated with weight suppression (see Table 5.3).

Table 5.3. Correlations between dieters' and non-dieters' characteristics and energy intake across conditions.

	Dieters			Non-dieters		
	Diet	Tempting	Non-food	Diet	Tempting	Non-food
Age (years)	.50	.59	.47	-.04	-.01	-.03
BMI (kg/m²)	.54	.61*	.75**	.60**	.32	.23
TFEQ-re	-.46	-.75**	-.57	.23	-.10	-.20
Flexible	-.56	-.74**	-.54	-.04	-.28	-.20
Rigid	-.04	-.41	-.21	.47*	.14	-.03
TFEQ-d	.21	.02	.11	.26	.12	-.20
Internal-d	.18	.03	.09	.12	-.07	-.27
External-d	.15	.05	.07	.46*	.43	.07
TFEQ Hunger	-.08	.34	-.19	.19	.23	.19
DEBQ-re	-.40	-.65*	-.36	.19	-.03	-.18
DEBQ-em	-.17	-.09	-.24	.19	-.13	-.43
DEBQ-ex	-.23	-.29	-.20	.46*	-.12	-.39
PFS-available	.40	-.25	.19	.06	.18	.19
PFS-present	-.06	.06	-.22	-.17	-.23	-.17
PFS-tasted	-.28	.14	-.29	.08	.01	-.09
PFS-total	.09	.05	-.07	-.01	.05	-.08
PSRS	.32	.17	.34	.46*	-.01	.02
WS	.53	.60	.70*	.88**	.76*	.86*

Note. TFEQ = Three Factor Eating Questionnaire (Stunkard & Messick, 1985); TFEQ-re = TFEQ-restraint; TFEQ-d = TFEQ-disinhibition; Internal-d = Internal disinhibition; External-d = External disinhibition; DEBQ = Dutch Eating Behavior Questionnaire (van Strien, et al., 1986); DEBQ-re = DEBQ restraint; DEBQ-em = DEBQ-emotional; DEBQ-ex = DEBQ-external; PFS = Power of Food Scale (Lowe, et al., 2009); PSRS = Perceived Self-Regulatory Success (Fishbach et al. 2003); WS = Weight suppression.
*$p < .05$
**$p < .01$.

5.5.2.6 Impact of condition and group on energy intake

There were no main effects of condition or diet status on energy intake [condition: $F(2, 56) = 0.07$, $p = ns$, $\eta p^2 = .003$; diet status: $F(1, 28) = 2.03$, $p = ns$, $\eta p^2 = .07$]. The condition x diet status interaction on energy intake was non-significant, $F(2, 56) = 0.01$, $p = ns$, $\eta p^2 = 0$. Dieters and non-dieters consumed similar amounts across conditions (dieters: diet-congruent: 322 ± 42 kcal; tempting: 331 ± 58 kcal, non-food: 326 ± 56 kcal; non-dieters: diet-congruent: 394 ± 32 kcal, tempting: 407 ± 44 kcal, non-food: 408 ± 40 kcal) (see Figure 5.3).

5.5.2.7 Impact of condition and diet status on type of snack food consumed

There was a main effect of snack type on energy intake, $F(1.45, 48.67) = 49.72$, $p < .001$, $\eta p^2 = .64$. Energy intake of the HFSW snack was greater than the LFSW, LFSA and HFSA snacks ($p < .001$). Intake of the HFSA snack was greater than the LFSW snack ($p = .002$). Energy intake of the LFSW snack was the lowest compared to HFSW snack (p = .04) and HFSA snack (p < .001). Intake of the snack types did not vary by diet status, F(1, 28) = 2.03, p = ns, ηp^2 = .07. There was no snack type x condition nor snack type x condition x diet status interaction on energy intake [two-way interaction: F(2.59, 72.49) = 0.54, p = ns, ηp^2 = .02; three way interaction: F(6, 168) = 0.08, p = ns, ηp^2 = .003]. Thus, there were no differences between groups in intake of each of the four snack types across conditions (see Figure 5.3).

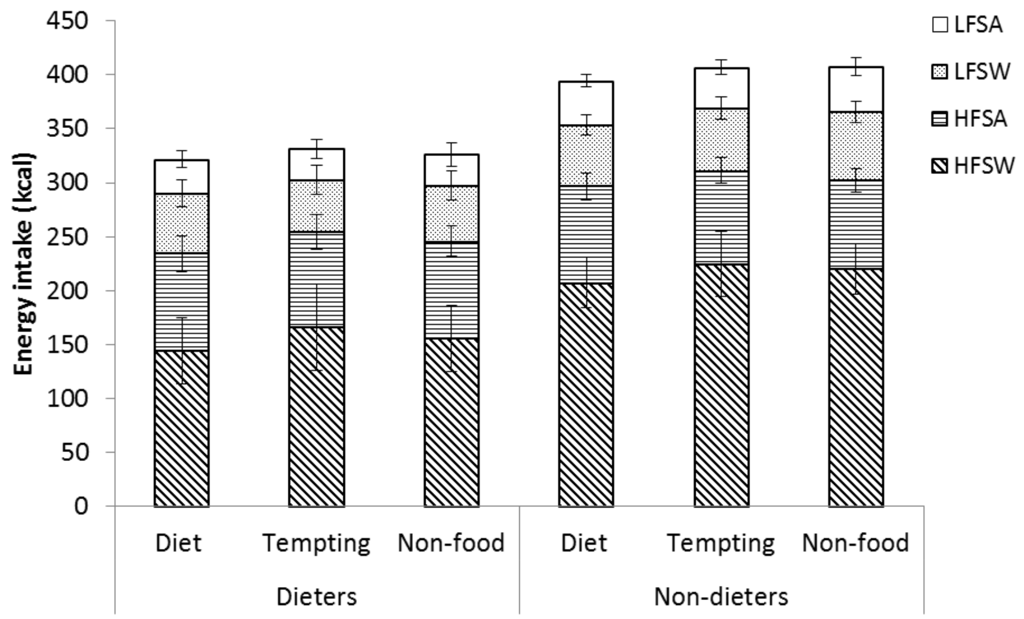

Figure 5.3. Dieters' and non-dieters' mean energy intake (± SEM) for snacks across conditions.

5.5.2.8 Impact of condition and diet status on appetite sensations

Hunger, desire to eat and fullness changed with time [hunger: F(2.59, 67.42) = 65.40, p < .001, ηp^2 = 0.72; desire to eat: F(2.63, 68.33) = 39.39, p < .001, ηp^2 = .60; fullness: F(2.76, 71.92) = 80.38, p < .001, ηp^2 = 0.76.]. Hunger and desire to eat declined after lunch and fullness increased compared to pre-lunch (all p < .001). Hunger and desire to eat increased after cue exposure compared to pre-cue exposure (hunger: p = .03; desire to eat: p < .001) and declined after snack intake (both p < .01). Fullness increased after snack intake compared to pre-snack (p < .001) (see Table 5.4).

Hunger and fullness sensations did not vary as a function of condition or diet status [largest F: F(2, 52) = 1.36, p = ns, ηp^2 = .05]. There were no group effects on desire to eat ratings, F(1, 26) = 0.95, p = ns, ηp^2 =.04. However, there was a main effect of condition on desire to eat ratings [$F(2, 52) = 4.16$, $p = .02$, $\eta p^2 = .14$] with participants reporting greater desire to eat in the temptation condition compared to the diet condition [tempting: 45.5 ± 3.2 mm; diet: 38.2 ± 3.5 mm].

Table 5.4. Dieters' and non-dieters' hunger, desire to eat and fullness sensations (mm) across conditions (mean ± SEM).

	Dieters			Non-dieters		
	Diet	Tempting	Non-food control	Diet	Tempting	Non-food control
Hunger						
Pre-lunch	54.1 ± 7.4	65.0 ± 8.1	67.7 ± 6.9	69.7 ± 5.5	67.5 ± 6.0	68.1 ± 5.1
Post-lunch	7.6 ± 4.7	10.4 ± 5.0	7.5 ± 3.8	17.4 ± 3.5	16.8 ± 3.7	16.5 ± 2.8
Pre-cue	14.5 ± 6.1	25.9 ± 7.7	33.6 ± 7.8	39.5 ± 4.6	36.7 ± 5.7	37.0 ± 5.8
Post-cue	31.5 ± 8.3	40.4 ± 9.2	38.5 ± 8.7	50.9 ± 6.2	50.6 ± 6.8	36.9 ± 6.5
Post-LDT	38.0 ± 7.8	38.5 ± 9.5	34.2 ± 7.9	47.0 ± 5.8	48.6 ± 6.8	41.3 ± 5.9
Post-snack	16.0 ± 5.3	13.3 ± 6.1	13.3 ± 5.2	22.3 ± 3.9	22.8 ± 4.5	16.9 ± 3.9
Desire to eat						
Pre-lunch	57.8 ± 9.0	66.5 ± 8.2	67.1 ± 8.0	64.9 ± 6.7	70.6 ± 6.1	68.7 ± 6.0
Post-lunch	12.8 ± 6.5	14.0 ± 6.5	13.2 ± 6.4	22.3 ± 4.9	23.5 ± 4.9	20.1 ± 4.8
Pre-cue	28.0 ± 7.9	27.6 ± 6.9	35.6 ± 8.7	40.8 ± 5.9	42.6 ± 5.1	42.1 ± 6.5
Post-cue	42.1 ± 8.8	58.4 ± 7.9	40.5 ± 9.4	55.3 ± 6.6	64.4 ± 5.9	40.1 ± 7.0
Post-LDT	41.3 ± 8.7	52.3 ± 7.7	38.2 ± 8.7	48.8 ± 6.5	54.5 ± 5.8	46.9 ± 6.5
Post-snack	17.6 ± 5.8	38.7 ± 9.2	25.3 ± 7.3	27.2 ± 4.4	32.8 ± 6.9	22.6 ± 5.4
Fullness						
Pre-lunch	32.7 ± 6.1	16.1 ± 6.4	17.4 ± 6.4	24.7 ± 4.6	19.8 ± 4.8	22.2 ± 4.7
Post-lunch	71.1 ± 5.7	76.4 ± 4.9	78.1 ± 5.1	72.7 ± 4.3	75.4 ± 3.7	74.3 ± 3.8
Pre-cue	58.9 ± 5.4	53.7 ± 6.1	46.6 ± 7.6	60.7 ± 4.0	59.4 ± 4.6	55.3 ± 5.7
Post-cue	56.0 ± 6.6	46.0 ± 7.4	53.8 ± 7.7	56.8 ± 4.9	57.6 ± 5.5	51.6 ± 5.7
Post-LDT	54.6 ± 6.6	45.2 ± 7.7	52.6 ± 8.0	52.3 ± 5.0	55.8 ± 5.7	50.4 ± 6.0
Post snack	67.2 ± 5.9	61.3 ± 7.6	66.2 ± 6.3	71.8 ± 4.4	69.0 ± 5.7	76.7 ± 4.7

Note. Participants who provided incomplete hunger and desire to eat (n = 2) and fullness (n = 1) ratings were excluded from analysis.

5.5.2.9 Impact of condition and restraint disinhibition subtypes on energy intake

Restraint and disinhibition scores differed across the subtypes. HRHD scored significantly higher in restraint compared to the LRHD and LRLD groups, $F(2, 28) = 21.64$, $p < .001$. HRHD and LRHD scored greater in disinhibition compared to the LRLD group, $F(2, 28) = 34.95$, $p < .001$ (see Table 5.5). Energy intake did not differ between condition or group [condition: $F(2, 52) = .01$, *p* = *ns*, $\eta p^2 = .04$; group: $F(2, 26) = 1.43$, *p* = *ns*, $\eta p^2 = .10$]. The condition x group interaction on energy intake was non-significant, $F(4, 52) = 0.55$, *p* = *ns*, $\eta p^2 = .04$.

Table 5.5. Restraint and disinhibition scores and diet status for the restraint disinhibition subtypes (mean ± SEM).

	HRHD (n = 7)	LRHD (n = 11)	LRLD (n = 11)
TFEQ-re	15.3 ± 0.6[a]	5.6 ± 1.3[b]	5.8 ± 1.0[b]
TFEQ-d	12.0 ± 0.3[a]	11.8 ± 0.6[a]	5.4 ± 0.8[b]
Dieters (n)	4	4	2

Note. TFEQ = Three Factor Eating Questionnaire (Stunkard & Messick, 1985); TFEQ-re = TFEQ-restraint; TFEQ-d = TFEQ-disinhibition.

Different letters denote significant differences between groups.

5.5.2.10 Impact of condition and diet status on salience of diet and tempting thoughts

There was a main effect of condition on reaction times, $F(1.58, 5.62) = 5.62$, $p = .01$, $\eta p^2 = .17$. Participants were faster to recognise words in the diet and tempting food condition compared to control (diet: 563.1 ± 13.7 ms; tempting food: 548.6 ± 13.2 ms; control: 598.1 ± 20.2 ms). There was no effect of diet status on reaction times, $F(1, 27) = 0.07$, *p* = *ns*, $\eta p^2 = .002$. There was also no condition x word type x diet status interaction on reaction times, $F(1.95, 52.56) = 0.58$, *p* = *ns*, $\eta p^2 = .02$. Thus, participants were faster to recognise diet and tempting words in the experimental conditions compared to control but this did not differ between groups.

5.5.2.11 Mood

Mood was assessed to examine whether condition affected mood states for dieters and non-dieters. None of the mood states recorded (happy, relaxed, tired and stressed) changed over the course of the study [largest F: $F(1.25, 33.76) = 2.26$, *p* = *ns*; $\eta p^2 = .08$] and did not differ between conditions (largest F: $F(1.32, 35.62) = 2.30$, *p* = ns, $\eta p^2 = .08$) or diet status (largest F: $F(1, 27) = 2.61$, *p* = *ns*, $\eta p^2 = .09$).

5.5.2.12 Awareness of study purpose

One participant dieting to lose weight and 5 participants who were not dieting guessed that food intake was the main outcome measure. However, exclusion of these participants made no difference to the energy intake results which remained non-significant (condition: $F(2, 44) = 0.24$, p = *ns*; diet status $F(1, 22) = 0.77$, p = *ns*).

5.5.3 Comparisons

To consider differences between the current and the previous study (Chapter 4) a comparative analysis on appetite measures and sample differences was conducted.

5.5.3.1 Comparing appetite between studies

The current study instructed participants to fast 2 hours prior to lunch and provided a set lunch to standardise appetite 2 hours prior to cue exposure. In contrast, in Chapter 4, participants were only instructed to fast 2 hours prior to the start of the study and were not provided with a set lunch. The consistent instruction to fast for 2 hours in both studies successfully resulted in no differences between the duration since participants last ate between studies (current study diet condition: 207 minutes; tempting condition: 224 minutes; Chapter 4 diet condition: 258 minutes; tempting: 243 minutes).

However, appetite measures at pre-cue exposure (current study VAS 3 and chapter 4: VAS 1) were significantly different between studies for hunger, desire to eat and fullness sensations across the diet-congruent and tempting conditions [diet: hunger: $F(1, 66) = 24.29$, $p < .001$, $\eta p^2 = .27$; desire to eat: $F(1, 66) = 13.27$, $p < .001$, $\eta p^2 = .17$; fullness: $F(1, 66) = 44.41$, $p < .001$, $\eta p^2 = .40$]; tempting: hunger: $F(1, 66) = 18.52$, $p < .001$, $\eta p^2 = .22$; desire to eat: $F(1, 66) = 13.72$, $p < .001$, $\eta p^2 = .17$; fullness: $F(1, 66) = 20.64$, $p < .001$, $\eta p^2 = .24$]. In the current study, participants were less hungry, had less desire to eat and were fuller across the diet-congruent and tempting conditions at pre-cue exposure compared to participants in Chapter 4 (see Table 5.6). There was also a study type x diet status interaction on hunger sensations in the diet-congruent condition, $F(1, 66) = 8.17$, $p = .006$, $\eta p^2 = .11$. Dieters in the current study were less hungry than dieters in Chapter 4 (current study dieters: 15.54 ± 3.91 mm; Chapter 4 dieters: 58.41 ±5.22 mm), whereas non-dieters did not differ between studies. Furthermore, the differences in appetite continued throughout the study with differences in hunger, desire to eat and fullness at pre-snack (current study = VAS 4; Chapter 4 = VAS 2) [diet-congruent: hunger: $F(1, 66) = 15.36$, $p < .001$, $\eta p^2 = .19$; desire to eat: $F(1, 66) = 18.16$, $p < .001$, $\eta p^2 = .22$; fullness: $F(1, 66) = 35.48$,

$p < .001$, $\eta p^2 = .35$; tempting: hunger: $F(1, 66) = 11.66$, $p = .001$, $\eta p^2 = .15$; desire to eat: $F(1, 66) = 7.20$, $p < .001$, $\eta p^2 = .09$; fullness: $F(1, 66) = 7.94$, $p = .006$, $\eta p^2 = .11$]. Thus, participants in the current study were less hungry, had lower desire to eat and were fuller compared to participants in Chapter 4.

Table 5.6 Participants' hunger, desire to eat and fullness (mean ± SEM) (mm) between studies at pre-cue exposure and pre-snack.

	Pre-cue exposure		Pre-snack	
	Chapter 4	Chapter 5	Chapter 4	Chapter 5
Diet				
Hunger	55.0 ± 3.8	31.2 ± 4.1***	65.7± 4.0	44.0 ± 4.5***
Desire to eat	57.9 ± 3.5	37.4 ± 4.6**	72.2 ± 3.8	47.1 ± 4.9***
Fullness	27.3 ± 3.1	59.5 ± 3.0***	23.6 ± 3.2	53.2 ± 3.7***
Tempting				
Hunger	56.5 ± 3.3	33.1 ± 4.4***	63.7 ± 4.0	44.3 ± 5.1**
Desire to eat	58.0 ± 3.6	36.9 ± 4.0***	67.7 ± 3.9	52.3 ± 4.4**
Fullness	31.0 ± 3.1	57.0 ± 3.5***	33.9 ± 3.8	52.1 ± 4.4**

Note. In Chapter 4 pre-cue exposure refers to VAS 1 and pre-snack refers to VAS 2. In Chapter 5 pre-cue exposure refers to VAS 3 and pre-snack refers to VAS 5.
**$p < .01$ between studies.
***$p < .001$ between studies.

5.5.3.2 Sample differences

The current sample scored higher in TFEQ-disinhibition, TFEQ-external disinhibition and DEBQ-external eating compared to the sample in Chapter 4 [TFEQ-disinhibition: $F(1, 66) = 4.10$, $p = .047$, $\eta p^2 = .06$; TFEQ-external disinhibition: $F(1, 66) = 4.53$, $p = .04$, $\eta p^2 = .06$; DEBQ-external eating: $F(1, 66) = 5.70$, $p = .02$, $\eta p^2 = .08$]. The current sample scored lower in TFEQ-restraint, flexible control, DEBQ-restraint, and DEBQ-emotional eating compared to participants in Chapter 4 [TFEQ-restraint: $F(1, 66) = 4.39$, $p = .04$, $\eta p^2 = .06$; flexible control: $F(1, 66) = 9.16$, $p < .001$, $\eta p^2 = .12$: DEBQ restraint: $F(1, 66) = 8.16$, $p = .006$, $\eta p^2 = .11$; DEBQ-emotional eating: $F(1, 66) = 8.16$, $p = .006$, $\eta p^2 = .05$]. There were also significant study x diet status interactions on DEBQ-emotional and external eating [DEBQ-emotional: $F(1, 66) = 6.10$, $p = .02$, $\eta p^2 = .09$; DEBQ-external: $F(1, 66) = 10.17$, $p = .002$, $\eta p^2 = .13$). Examination of the means showed dieters scored higher in emotional eating in Chapter 4 than the current study [$t(25) = 2.69$, $p = .01$], whereas non-dieters did not differ. Non-dieters scored higher in DEBQ-external eating in the current study, whereas dieters did not differ in DEBQ-external scores [$t(41) = 4.90$, $p < .001$] (see Table 5.7).

Table 5.7. Participant characteristics (mean ± SEM).

	Chapter 4 (n = 40)	Chapter 5 (n = 30)
Age (years)	25.9 ± 1.6	28.1 ± 1.9
BMI (kg/m²)	23.7 ± 0.6	25.2± 0.7
TFEQ –re	11.37 ± 0.7	9.0 ± 0.9*
Flexible	3.7 ± 0.3	2.5 ± 0.3**
Rigid	3.8 ± 0.3	3.1 ± 0.4
TFEQ-d	7.8 ± 0.6	9.6 ± 0.7*
Internal-d	3.3 ± 0.3	4.0 ± 0.4
External-d	3.1 ± 0.3	3.9 ± 0.3*
TFEQ-Hunger	6.1 ± 0.6	7.0 ± 0.7
DEBQ-re	3.3 ± 0.1	2.8 ± 0.1**
DEBQ-em	3.1 ± 0.1	2.8 ± 0.1
DEBQ-ex	2.6 ± 0.1	3.0 ± 0.1*
PFS-available	16.0 ± 1.0[a]	17.8 ± 1.2[b]
PFS-present	12.1 ± 0.7[a]	13.9 ± 0.9[b]
PFS-tasted	15.2 ± 0.6[a]	14.5 ± 0.7[b]
PFS-total	42.8 ± 2.2[a]	46.0 ± 2.7[b]
PSRS	3.7 ± 0.4[c]	3.9 ± 0.4
WS	2.4 ± 1.0	3.9 ± 1.5[e]

Note. TFEQ = Three Factor Eating Questionnaire (Stunkard & Messick, 1985); TFEQ-re = TFEQ-restraint; TFEQ-d = TFEQ-disinhibition; Internal-d = Internal disinhibition; External-d = External disinhibition; DEBQ = Dutch Eating Behavior Questionnaire (van Strien, et al., 1986); DEBQ-re = DEBQ restraint; DEBQ-em = DEBQ-emotional; DEBQ-ex = DEBQ-external; PFS = Power of Food Scale (Lowe, et al., 2009); PSRS = Perceived Self-Regulatory Success (Fishbach et al. 2003); WS = Weight suppression.
[a]n = 39; [b]n = 29; [c]n = 18; [d]n = 35; [e]n = 16.
**p* < .05 between studies.
***p* < .01 between studies.

5.6 Discussion

The current study exposed dieters and non-dieters to a diet-congruent food odour (fresh orange), a tempting food odour (chocolate) and a non-food control odour (soap) and measured subsequent snack intake and the salience of diet and tempting thoughts. The study did not find any effects of diet-congruent food odour on dieters' or non-dieters' snack intake. There was also no evidence of increased diet goal salience in the diet condition relative to the tempting and control conditions. Participants were faster to recognise both diet and tempting food words in the diet and tempting conditions compared to control exposure. Furthermore, examination of restraint disinhibition subtypes yielded no effects of condition on energy intake.

Results from the lexical decision task might suggest that exposure to both diet and tempting food cues simultaneously increased the salience of diet and tempting thoughts. However, due to an error in data collection, responses to neutral words could not be analysed which means the results must be interpreted conservatively. It might be that in the current study exposure to any food heightened participants' general cognition which resulted in increased responsiveness to detect words rather than a specific response to diet and tempting words.

The lack of effect in the current study is problematic since the outcome deviates from the previous studies with images and sight/smell and from predictions made. However, alongside the issue of the current study being underpowered, there are methodological differences between the studies which might account for the lack of effect. Firstly, participants in the current study were less hungry than participants in Chapter 4. Appetite might moderate the effect of diet-congruent cues on food intake. Dieters have reported hunger to be main factor for breaking diets (Stubbs, et al., 2012) and diet-congruent odours might only be effective when assistance is most needed, such as in hungry states. Indeed, one study found that diet-congruent cues only reduced restrained eaters' food intake when self-control resources were low and not high (Boland, et al., 2013). Thus, future studies might examine the moderating effect of motivational states on the effect of diet-congruent food cues.

Secondly, the nature of the snack test provided is another key difference between studies that might explain the varying outcomes. In Chapter 4 the diet-congruent food used for the cue exposure task was also present and available for consumption at the snack test and this might have bolstered diet goals. In contrast, in the current study the diet-congruent cue was present at the snack test but was not available for consumption. Whether or not available food has the opportunity to be consumed has been shown to affect the power of cues to exert an effect on food intake (Geyskens, Dewitte, Pandelaere, & Warlop, 2008). It might be that diet-congruent food needs to be offered for consumption to be sufficient to trigger diet-consistent behaviour. Thus a more potent diet-congruent cue than odour, such as a consumption cue (Jansen & van den Hout, 1991), may be needed to produce inhibition of food intake in dieters.

Sample differences between studies might also account for the discrepant findings. Participants in the current study scored higher in TFEQ-disinhibition, external disinhibition, and DEBQ-external eating and scored lower in restraint and flexible control than participants in Chapter 4. Dieters were less emotional in the current study than dieters in Chapter 4. As participants in the current study scored lower in restrained eating it is possible these participants are less occupied with diet cognitions and have less active diet goals than participants in Chapter 4. The goal conflict theory predicts that diet-congruent cues will only exert an effect in those with strong weight control goals (Stroebe et al. 2008). Thus, it is possible that dieters in the current study did not have strong accessible diet goals and therefore were unaffected by exposure to diet-congruent food cues.

5.7 Directions for subsequent study

To expand upon the current findings subsequent studies should test more potent diet-congruent food cues compared to odours and test the effect of these more potent diet-congruent cues in motivated states. Subsequent studies might also examine the effect of diet-congruent cues on meal intake because meals make up a large proportion of daily energy intake (Bellisle, et al., 2003), thus is important to identify whether diet-congruent cues can curb dieters' meal intake.

5.8 Key Findings

- Pre-exposure to diet-congruent food, tempting food and non-food control odours did not affect dieters' and non-dieters' snack intake.
- In a lexical decision task dieters and non-dieters recognised diet and tempting words faster after exposure to diet-congruent and tempting food odours compared to non-food control cues. However, caution is needed when interpreting the lexical decision task due to the absence of reaction times to neutral words.
- No effects of diet-congruent cues might be attributable to low motivation drive following the procedures to standardise appetite. A comparative analysis showed that the current sample were less hungry, had lower desire to eat and were fuller compared to the sample tested in Chapter 4.
- The current sample were also less restrained, scored lower in flexible control and scored higher in disinhibition, external disinhibition and DEBQ-external eating than participants in Chapter 4. Dieters specifically also scored lower in emotional eating in the current study compared to Chapter 4.

Chapter 6

Slimming Starters: Diet-congruent preloads and meal intake in dieters

6.1 Abstract

The current study examined the effect of consuming diet-congruent, tempting and non-food preloads on subsequent meal intake. The salience of diet, tempting and neutral thoughts post-preload were also measured with a lexical decision task. In a repeated measures design participants consumed fixed isocaloric, preloads matched for weight, completed a lexical decision task and were offered an ad libitum meal of pizza. Results showed dieters (n = 13) reduced total meal intake by 21% when consuming a diet-congruent preload compared to a tempting and control preload. Non-dieters' (n = 13) meal intake did not differ between conditions. The diet-congruent preload reduced participants' desire to eat and increased fullness compared to the tempting and control preloads. Additionally, dieters were less hungry after the diet-congruent preload compared to the tempting and control conditions. The lexical decision task provided no indication of increased diet goal salience in the diet condition relative to the tempting condition. Due to the selective response of dieters to adjust intake after a diet-congruent preload and non-dieters did not, a goal priming explanation is implicated. Since the diet-congruent preload also influenced appetite ratings it is clear that the orosensory and volumetric properties of the preload influenced intake.

6.2 Introduction

Intake of palatable preloads can prime overconsumption. For example, a pizza preload increased participants' subsequent pizza intake (Cornell, Rodin, & Weingarten, 1989). Restrained eaters scoring high in disinhibition have been found to be particularly vulnerable to palatable preloads (Westenhoefer, et al., 1994). The effect of palatable preloads on dieters is less clear (Lowe, 1995; Lowe, et al., 1991). However, due to dieters' susceptibility to weight gain the goal conflict theory suggests that palatable preloads invoke a tempting situation that can suppress dieters' long term goals to lose weight and increase the risk of overeating (Stroebe et al. 2008; Stroebe et al. 2013).

The perception of food categories can influence subsequent food intake. Research shows that the health and temptation perceptions of consumed foods affect estimated energy content (Gravel, et al., 2012) and can affect subsequent intake. For instance, explicit "healthy" descriptions compared to "tempting" have increased snack intake in general samples (Provencher, et al., 2009) and dieters (Irmak, et al., 2011). Similar results have also been obtained based on the perceived healthiness of cookie brands (Cavanagh & Forestell, 2013). Such studies suggest that a "health halo" effect encourages intake of a food perceived as low in energy or healthier than one perceived as high calorie or less healthy even if the foods are not different in reality. Importantly, whilst most of these studies refer to health generally rather than weight loss specifically, healthy foods tend to be linked to weight loss (Carels, et al., 2007) therefore consumers may associate health labels with weight benefits.

In contrast to the health halo effect, fewer chocolates labelled with "antioxidants" were consumed compared to those labelled with "fat" (Belei, et al., 2012). Mixed findings on the effect of food perception on intake might be due to the use of explicit labels to manipulate perceptions of foods that are not prototypical examples of healthy foods such as, cookies and candies. The incongruent pairing of an explicit healthy label with a tempting food might lead to demand characteristics (Brunstrom, et al., 2011). Additionally, explicit food labels are likely to be used only in the absence of stronger information (Chambers, Ells, & Yeomans, 2013). As dieters have more comprehensive knowledge of foods compared to non-dieters (Carels et al. 2007) dieters might be likely to use their own perceptions of foods to inform subsequent intake rather than using explicit labels. Previous research suggests that low calorie foods are perceived as diet-congruent (Carels et al. 2007; Sobal, 1987; 1990) (see Chapter 4). According to the goal conflict theory, due to the association between low energy dense foods and dieting, consumption of low energy dense foods might increase the salience of diet thoughts and prime dieters to restrict food intake in tempting situations (Stroebe et al. 2008; Stroebe et al. 2013). As dieters are vulnerable to hedonic environmental cues and weight gain (Cameron et al. 2008; Lowe et al. 2005) it is important to test the effect of consuming diet-congruent preloads on dieters' subsequent intake.

Consumption of low energy dense preloads might also facilitate reduced intake compared to higher energy dense preloads via their oral transit time or volumetric effects. Low energy dense salad preloads (Rolls et al. 2004), and soup preloads (Flood et al. 2007) reduced subsequent meal intake in non-dieters compared to higher energy dense preloads. A much greater volume of low energy dense foods can be consumed than high energy dense foods to match for energy content (Chapter 1). Intake of large volumes of low energy dense foods can influence gastric distension (de Castro, 2005) and oral processing of times (de Graaf, 2012) to shorten food intake.

The combined action of diet goal congruency and the volumetric effects of low energy density food could provide a benefit to dieters in lowering overall intake. Similarly since consumers who are both restrained and disinhibited (HRHD) have been found to overeat in response to palatable preloads, consumption of diet-congruent preloads might also reduce overeating in these consumers (Westenhoefer, Broeckmann, Munch, & Pudel, 1994).

Since exposure to diet-congruent images (Chapter 3) and to the sight and smell of diet-congruent foods (Chapter 4) has reduced dieters' snack intake compared to tempting food cues, it follows that consumption of these foods is predicted to reduce intake by combining cognitive and physiological effects. However, the lexical decision tasks used in Chapter 3 and 5 showed no effects of diet-congruent cues on the salience of diet and tempting thoughts. Consumption of diet-congruent foods is likely to potentiate diet goal effects relative to images and odour (Jansen & van den Hout, 1991; Mattes, 1997) and might extend the findings of diet-congruent cues on snacks to meals.

6.3 Aims

The overall aim of this study was to test the hypothesis that consumption of diet-congruent preloads would curb intake of a meal in dieters.

6.4 Pre-study Survey – identification of diet-congruent and tempting food preloads

6.4.1 Method

6.4.2.1 Participants

In total 302 participants responded to the survey. Of these, 72 respondents were excluded due to a history of eating disorders (n = 9), being male (n= 2), not providing consent to take part (n = 6) and dropping out before survey completion (n = 55). The remaining sample consisted of 230 females aged from 21 - 61 years (*M*: 33.2 ± 0.7 years) with a BMI range of 15.81 – 41.98 (*M*: 24.11 ± 0.31 kg/m, n = 218). The sample was predominantly non-students (60.6%). Of the sample, 69.9% were recruited by email, 13.6% from an online forum, 9.3% from a social network website, 4.2% from the University of Leeds newsletter, 1.7% from word of mouth, 1.3% from the University of Leeds participant pool database. The sample comprised of 70 participants on a diet to lose weight, 31 on a diet to maintain weight and 129 non-dieters. Upon completions participants were entered in to a £50 prize draw.

6.5.1 Materials

The survey was designed using Qualtrics software version 12018 (Provo, Utah, 2009). The duration of the study was approximately 15 minutes 23 seconds (± 24 seconds).

6.5.1.2 Foods

In total 23 food items were used for the survey (see Appendix F). The candidate items were selected to represent diet-congruent, tempting and neutral savoury foods which could be commonly considered as appropriate to a first course and would be convenient to use for a laboratory based preload study (see Table 6.1).

Table 6.1. Candidate diet-congruent, tempting and neutral preloads.

Candidate food items		
Diet	Neutral	Tempting
Baby corn	Bread and butter	Crisps
Carrots /hummus	Bread sticks	Fishcake
Celery/ hummus	Crackers and butter	Garlic bread
Pepper/ hummus	Olives	Cheese sticks
Crispbread/hummus	Pitta bread and hummus	Pasta mayonnaise
Salad	Prawns	Quiche
Soup		Sausage rolls
Tomatoes		Scotch eggs
		Prawn toast

6.5.1.3 Demographics and screening

Participants were requested to provide details of their age, gender, student status, history of eating disorders and food allergies.

6.5.1.4 Procedure

Notices of the survey were disseminated through email distribution lists, social network websites and online forums. Participants directly accessed the survey by following an online link. Participants were informed about the purpose of the study and consent was obtained prior to participation. Next, participants were requested to indicate how they became aware of the survey, indicated their age, gender, student status, whether they had any food allergies or were vegetarians and whether they had a history of eating disorders. Participants with an eating disorder were thanked for their time but declined eligible for participation in the survey. Next participants completed the association task for the concept “dieting to lose weight” (see Appendix D). A 7-point response scale ranging from 1 (not at all associated) to 7 (extremely associated) was used in this study rather than categorical responses to examine whether any foods received a neutral rating that could be used for a control food. Next participants completed the selection task for “dieting to lose weight” by selecting one food that was most associated with dieting to lose weight (see Appendix C). The association and selection task was then repeated for the construct “temptation (eating purely for pleasure)”. Next, participants completed the cognitive restraint and disinhibition subscales of the TFEQ (Stunkard & Messick, 1985), indicated diet status (see Chapter 2), completed the PSRS (Fishbach et al. 2003) and self-reported height and weight.

6.5.1.5 Strategy for data analysis

Independent samples t-tests were conducted to compare height, weight, BMI, TFEQ-restraint and TFEQ-disinhibition scores. Mean scores ± SEM for food association ratings were recorded for each food. Foods most associated with dieting and temptation were converted to percentages.

6.5.2 Pre-study survey Results

6.5.2.1 Participants

Dieters losing weight self-reported a greater weight and BMI than non-dieters. Dieters losing weight also scored higher in TFEQ-restrained eating and TFEQ-disinhibited eating (see Table 6.2). Thus, self-report weight and psychometric measures that indicate increased food intake corresponded with dieting to lose weight.

6.6. Table 6.2. Participant characteristics (mean ± SEM).

Trait	Dieters	Non-dieters
Height (m)	1.7 ± 0.0[a]	1.7 ± 0.0[d]
Weight (kg)	73.1 ± 1.8[b]	63.3 ± 1.0[e]***
BMI (kg/m²)	26.6 ± 0.6[b]	23.2 ± 0.4[e]***
TFEQ-restraint	12.5 ± 0.5[c]	6.3 ± 0.4[f]***
TFEQ-disinhibition	10.5 ± 0.4	5.5 ± 0.3[f]***

Note. TFEQ = Three Factor Eating Questionnaire
[a]n = 68; [b]n = 66; [c]n = 70; [d]n = 128; [e]n = 126; [f]n = 129
***$p < .001$ between groups.

6.5.2.2 Ratings and selection of foods

Participants rated salad as the item most associated with dieting to lose weight, followed by tomatoes, celery, baby corn, carrots and peppers. Dieters and non-dieters were equally likely to associate these foods with dieting to lose weight. Salad was selected most frequently as most associated with dieting to lose weight.

Garlic bread was rated as most associated with temptation followed by crisps, cheese sticks and prawn toast. When selecting the food item most associated with temptation cheese sticks, crisps and garlic bread were the most frequently selected food items by the full sample. Crisps, cheese sticks and garlic bread were equally likely to be selected as most associated with temptation (see Table 6.3).

Table 6.3. Rated associations of foods.

Food	Association task				Selection task (%)			
	Lose weight		Tempting		Lose weight		Tempting	
	Full sample	Dieters	Full sample	Dieters	Full sample	Dieters	Full sample	Dieters
Salad	6.3 ± 0.1	6.6 ± 0.1	3.3 ± 0.1	2.9 ± 0.2	64	70	0	0
Tomatoes	5.9 ± 0.1	6.3 ± 0.1	2.8 ± 0.1	2.5 ± 0.2 [b]	11	13	0	0
Celery/hum	5.4 ± 0.1	5.6 ± 0.2	2.8 ± 0.1	2.7 ± 0.2 [a]	11	6	0	0
Baby corn	5.3 ± 0.1	5.3 ± 0.2	0.1 ± 0.1	2.3 ± 0.2	0	0	0	0
Carrots/hum	5.3 ± 0.1	5.2 ± 0.2	3.6 ± 0.1	3.5 ± 0.2 [b]	2	1	1	1
Pepper/hum	5.1 ± 0.1	5.1 ± 0.2	3.5 ± 0.1	3.4 ± 0.2[b]	1	0	1	0
Soup	4.6 ± 0.1	4.9 ± 0.2	3.5 ± 0.1	3.0 ± 0.1$_b$	3	3	0	0
Prawns	4.3 ± 0.1	4.7 ± 0.2	3.7 ± 0.1	3.3 ± 0.2	1	1	2	3
Crisp bread	4.0 ± 0.1	4.1 ±0.2	3.2 ± .1	3.2 ± 0.2 [b]	3	1	0	3
Pitta/hum	3.7 ± 0.1	3.7 ± 0.2	4.1 ± 0.2	4.0 ± 0.2	0	0	2	3
Olives	3.3 ± 0.1	3.5 ± 0.2	4.0 ± 0.1	3.6 ± 0.3[b]	0	0	4	1
Bread sticks	2.9 ± 0.1	3.1 ± 0.2	3.1 ± 0.1	3.4 ± 0.2	0	0	0	0
Crackers	2.8 ± 0.1	2.8 ± 0.2	3.1 ± 0.1	3.4 ± 0.2[a]	0	0	0	1
Fishcakes	2.6 ± 0.1	2.6 ± 0.1	3.9 ± 0.1	4.0 ± 0.2 [a]	0	0	2	3
Bread/butter	2.1 ± 0.1	2.1 ± 0.1	3.5 ± 0.1	3.8 ± 0.2 [a]	0	0	1	0
Pasta Mayo	1.7 ± 0.1	1.8 ± 0.1	3.6 ± 0.1	3.7 ± 0.2 [b]	0	0	1	3
Quiche	1.6 ± 0.1	1.7 ± 0.1	3.7 ± 0.1	3.9 ± 0.2[a]	0	1	1	3
Prawn toast	1.6 ± 0.1	1.3 ± 0.1	4.5 ± 0.2	4.5 ± .3[b]	0	0	12	9
Crisps	1.3 ± 0.1	1.5 ± 0.2	5.6 ± 0.1	5.6 ± 0.1	0	1	22.	24
Garlic bread	1.3 ± 0.1	1.3 ± 0.1	5.7 ± 0.1	5.7 ± 0.1	0	0	15	17
Cheese sticks	1.3 ± 0.1	1.3 ± 0.1	5.4 ± 0.1	5.4 ± 0.1	0	0	26	20
Scotch eggs	1.3 ± 0.0	1.2 ± 0.1	3.6 ± 0.2	3.4 ± 0.3	0	1	1	0
Sausage rolls	1.1 ± 0.1	1.1 ± 0.1	4.4 ± 0.1	4.6 ± 0.3	0	0	7	9

Note. /hum = with hummus

[a] n = 68; [b] n = 69

Responses on the Association task were on a 7-point scale, 1 = not at all associated and 7 = extremely associated.

6.5.3 Summary and discussion

The current online survey evidenced foods associated with dieting to lose weight and temptation. This survey was necessary to add to the snack foods which were identified in Chapter 4 since the current laboratory study assessed meal items. Salad was identified as being most associated with dieting to lose weight and garlic bread was most associated with temptation. These findings reflect those presented in Chapter 4 and previous research (Carels et al. 2007; Sobal, 1987; 1900).

6.6 Laboratory study

6.6.1 Method

6.6.1.1 Participants

Participants comprised of staff and students of the University of Leeds and members of the local community. In addition to recruitment procedures detailed in Chapter 2, the current study was advertised in the Yorkshire Post (regional broadsheet), verbally advertised at a "University of Leeds Women in Science, Engineering and Technology Network" meeting, and with an advert on the University of Leeds gym website (see Figure 6.1). Participants who were dieting to maintain weight and those who had taken part in studies presented in Chapter 4 and 5 were excluded from recruitment. The recruitment process focused on recruiting a predominant non-student sample. Upon competition participants were awarded with £15. Using the large effect size obtained in Chapter 4, G*power estimated that a sample size of 32 would be sufficient to detect a difference in dieters' intake with 80% power and a significance level at 0.05.

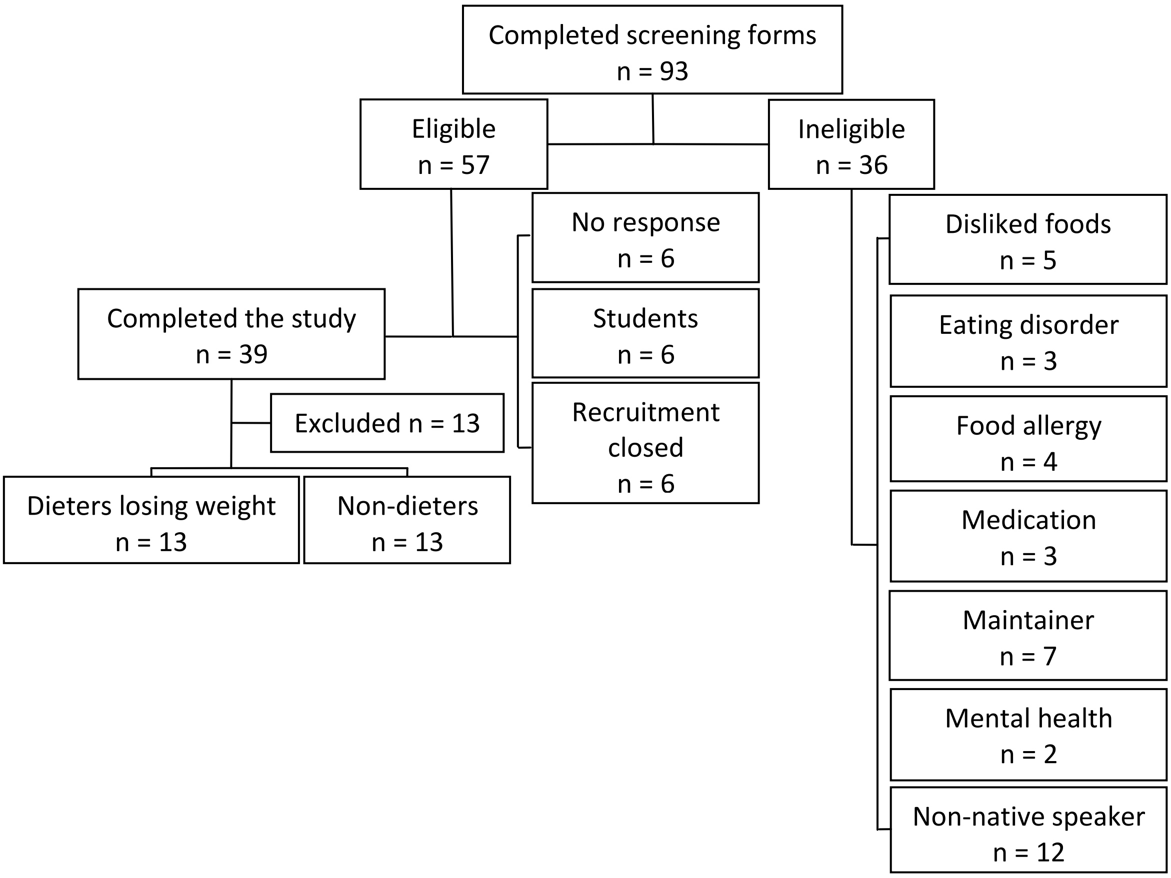

Figure 6.1. Process of recruitment.

6.6.1.2 Design

A 3 (condition: diet-congruent, tempting, neutral) x 2 (diet status: dieting to lose weight, not dieting) mixed design with condition as a repeated measures factor and diet status as between-subjects factor was used. Participants completed 3 separate sessions and were provided with a different preload in each session. The order of condition was counterbalanced and there was at least a 7 day interval between each test session. All participants were recruited with a cover story that the study was investigating the effect of different first courses on subsequent meal taste perception.

6.6.1.3 Materials

6.6.1.3.1 Preloads

The preloads were selected based on the results of the pre-study survey (see section 6.4). Salad was selected for the diet-congruent preload and garlic bread was selected for the tempting preload. Water was used as the non-food control. It was decided to avoid a food for the control condition because foods tend to be categorised as either “healthy” or "tasty" (Carels, et al., 2007; Rozin, et al., 1996) and "diet" or "fattening" (Sobal & Cassidy, 1987, 1990) making it difficult to find an appropriate food that is neither perceived as diet-congruent nor as tasty. The decision to use non-labelled foods rather than liquids was based on a pilot study testing diet labelled beverages (see Appendix G).

The salad consisted of lettuce, tomatoes, cucumber, salad dressing, parmesan cheese and garlic flavoured croutons. To increase participation rates the salad was tailored to participants' liking with adjusted weights of ingredients and water provided (for example, if participants disliked cucumbers then cucumbers would be replaced with tomatoes (n = 5). The garlic bread was prepared and sourced from a supermarket. The water was obtained from a water dispenser at a chilled temperature. The flavour of the experimental conditions was matched so that garlic flavour in the croutons and on the bread would be similar. The energy content of the salad and garlic bread was matched to 100 kcal. Each of the preloads were presented with a fixed amount of water and the amount of water provided varied across conditions to counter differences in energy density of the salad and garlic bread. By varying water contents provided the experimental preloads were matched for energy content and all three preloads were matched for total weight (food plus water). The total weight of each portion matched to 284g (see Table 6.4).

Table 6.4. Portion size and energy density of preloads.

	Food Amount (g)	Energy (kcal/100g)	Water (g)	Total weight (g)	Energy density
Salad	**134.0**	**74.67**	**150.0**	**284.0**	**0.35**
Lettuce[a]	35.00	26.0	-		-
Tomatoes[b]	55.00	20.0	-		-
Cucumber[c]	27.50	10.0	-		-
Dressing[d]	6.00	490.0	-		-
Cheese[e]	3.50	388.0	-		-
Croutons[f]	7.00	489.0	-		-
Garlic bread[g]	**26.70**	**374.0**	**257.3**	**284.0**	**0.35**
Control	**0.00**	**0.00**	**284.0**	**284.0**	**0.00**

Note. [a]Herb garden salad (Morrisons supermarkets PLC); [b]Vittoria variety tomatoes (Sainsbury, UK); [c]Sainsbury, UK; [d]Newman's own Italien dressing (Newman's Own Inc.); [e]fresh grated Parmigiano (Sainsbury, UK); [f]Garlic croutons (La Rochelle Foods Ltd); [g]Sainsbury, UK.

6.6.1.4 Preload task

To ensure attention was focused on the preloads participants were asked to give first thoughts about the preload, their typical frequency of consumption, when they are most likely to eat the preload and provided a specific memory associated with the preload. In the control condition, rather than specifying a memory, participants were requested to list as many water brands as they could. Participants rated the preload's appearance (pleasant, fresh, appealing), odour (strong, pleasant) and taste (fresh, moreish) on 9-point scales ranging from 1 (not at all) to 9 (extremely associated). Participants also rated the extent each preload was tempting and healthy on a 9-point rating scale ranging from 1 (not at all) to 9 (extremely associated). The term "healthy" was used rather than "dieting to lose weight" to prevent participants guessing the purpose of the study. Other research shows foods that are rated as healthy also tend to be associated with weight loss (Carels et al. 2007). These two validation questions were embedded within filler items on the appearance (pleasant, fresh, appealing), odour (strong, pleasant) and taste (pleasant, fresh, moreish) of the preload.

6.6.1.5 Measures

6.6.1.5.1 Test meal intake

Energy intake of an *ad libitum* cheese and tomato pizza meal was recorded. Pizza was selected based on a previous survey (see Chapter 4), and previous studies have used pizza because it is generally considered a tempting and diet-forbidden food (Fedoroff et al. 1997). The pizza (Goodfella's, Green Isle Foods Ltd.; 452 kcal/100g) was bought pre-prepared and additional oil (5g; Napolina Ltd.; 823 kcal/100g) and grated cheese (45g; Sainsbury's Supermarkets, Ltd.; 389 kcal/100g) were evenly distributed over the pizza to increase the palatability of the pizza. The pizza was cooked according to the manufacturers' instructions. In total 310g (1188 kcal) was presented in bite-size pieces with 350g of chilled water.

6.6.1.5.2 Salience of diet, tempting and neutral thoughts

The lexical decision task was identical to that used in Chapter 5. The task included 15 diet-congruent words, 15 tempting words, 15 neutral words and 15 non-words. All words were selected based on a survey results (see Chapter 5). The trial commenced with 5 practice trials and participants completed the task in their own time.

6.6.1.5.3 VAS

Appetite sensations and mood were recorded on VAS pre-lunch, post-lunch, pre-preload, post-preload, pre-meal and post-meal to examine whether they differed as a function of condition or group. See Chapter 2 for more detail on the use of VAS.

6.6.1.5.4 Individual differences in eating behaviour

The TFEQ (Stunkard & Messick, 1985) was used to measure restraint, disinhibition and hunger. All subscales showed good internal reliability (Cronbach's α restraint = .72; disinhibition = .71; hunger = .81).[10] Diet status, weight suppression, nature of diet and history of dieting were recorded (see Chapter 2 for details). To compare perceived success at dieting participants completed the PSRS (Cronbach's α = .68) (Fishbach, et al., 2003). These questions were administered using an online survey (Qualtrics software version 12018 Provo, Utah, 2009).

6.6.1.6 Procedure

Each session commenced with consumption of a fixed lunch between 1200 and 1400 hours. Lunch consisted of a pre-packaged sandwich and yoghurt (approximately 450 kcal). Participants either collected their lunch the evening or morning before test day to eat in their own environment, or were provided with the lunch in a private cubicle in the Human Appetite Research Unit (HARU). If participants pre-collected the lunch and consumed it at home or work they were given instructions to eat all of the lunch at a specified time without eating any other foods and to return the lunch box with the food packaging (to improve compliance) when they returned for the main session. Prior to and after lunch, participants completed VAS 1 and VAS 2.

Four hours after lunch, participants returned to the HARU for the main session. Participants completed VAS 3 and were then provided with a preload (see Figure 6.2) and asked to complete the sensory assessment and memory task and eat the preload to entirety within

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[10] The DEBQ and PFS were also administered to examine group differences. However, these did not enhance study findings and shall not be reported.

10 minutes. Next participants completed VAS 4 and then completed the lexical decision task followed by VAS 5. Next participants were provided with the test meal. To maximise the effect of the preload on intake, participants were reminded of the preload they had consumed by being encouraged to think about the flavours tasted in the preload before rating the test meal. Participants were instructed to help themselves to as much or as little of the pizza as they liked. While eating the test meal participants rated the taste properties (e.g. pleasant, savoury, crunchy, sweet, salty, moist, chewy, and tempting). The test meal was not timed and participants were instructed to eat as much or as little as they wished and to contact the experimenter when they were finished. Participants then completed VAS 6 and indicated whether or not they had engaged in exercise that day, all affirmative responses were required to indicate the form of exercise and the duration they engaged in. For the purposes of the study, exercise was defined as "any activity that raised your heart rate and broke a sweat" (NHS Choices, UK). For the first and second session this was the end of the test day. However, in the third and final session participants were probed about the nature of the study. Next participants were shown a photo of each preload and estimated the energy content of each preload and rated the extent they associated each preload with health and temptation on a 7-point scale ranging from 1 (not at all) to 7 (extremely). Next participants indicated diet status, those who were dieting to lose weight proceeded to describe the nature of the diet, the duration of the diet, and their heaviest weight. Next all participants completed psychometric questionnaires, were weighed and measured for height (one participants declined) and were debriefed and thanked for their time. For a summary of the procedure see Figure 6.3.

Figure 6.2. The diet-congruent, tempting and neutral preload.

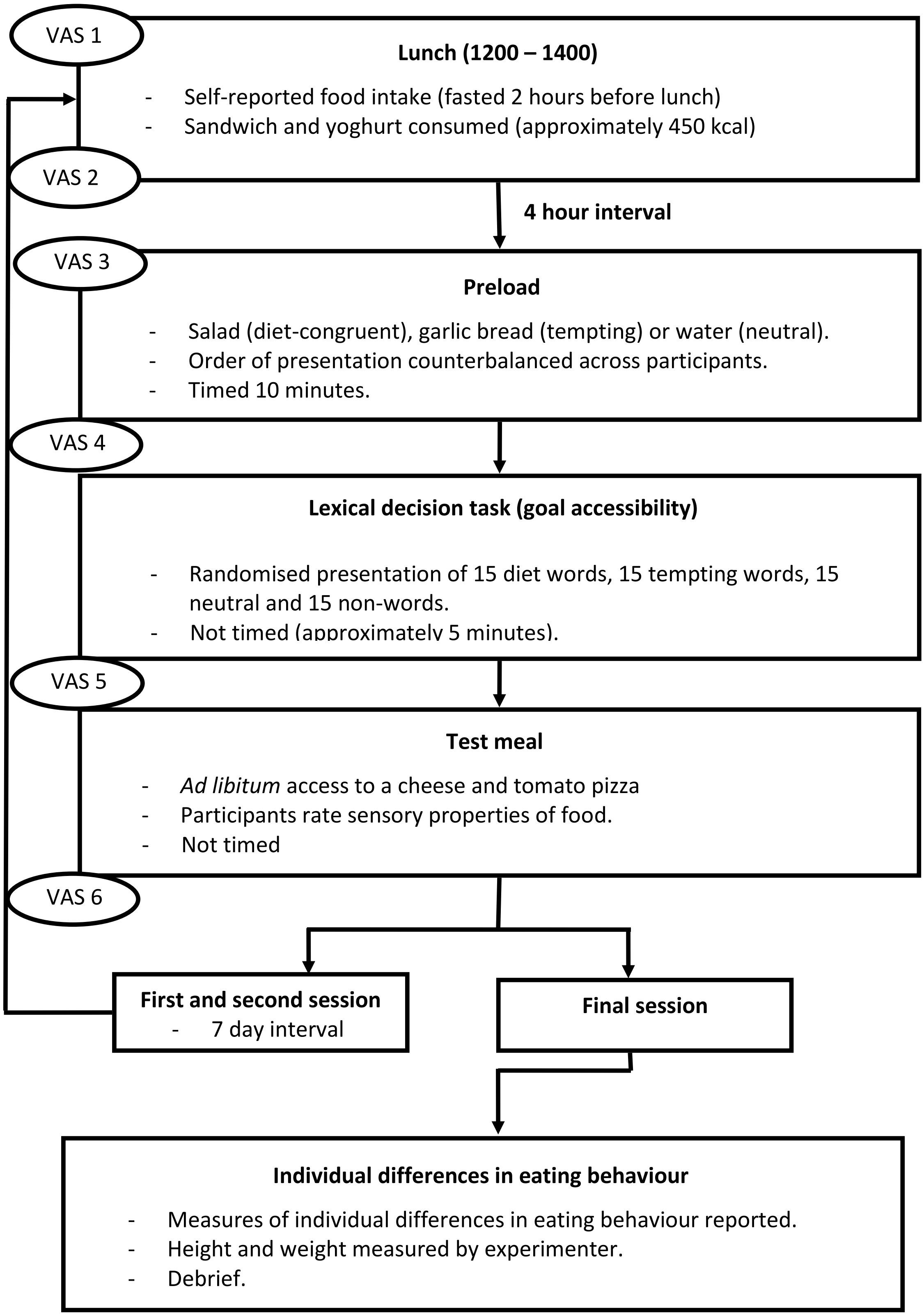

Figure 6.3. Study Procedure.

6.6.1.7 Data analysis

Independent t-tests were used to compare groups on age, BMI, and psychometric scores. To examine relationships between age, BMI and psychometric scores bivariate correlations were conducted separately for dieters and non-dieters.

The weight of pizza consumed was converted to energy intake based on manufacturers' information. Total energy intake over the two courses was calculated by summing pizza intake with preload intake. To assess the influence of condition and diet status on energy intake a mixed ANOVA with condition as repeated measures factor and diet status as a between-subjects factor was conducted. Any factors that significantly correlated with energy intake were entered as covariates in a separate ANCOVA. To assess the impact of condition, diet status and time on appetite ratings several mixed ANOVAs were conducted with preload and time as repeated measures factors and diet status as a between-subjects factors. The non-parametric Wicoxon Signed Ranks test was conducted to compare taste evaluations of preloads collected using Likert scales. To assess the impact of restraint disinhibition subtypes and condition on energy intake a median split divided participants scores on the TFEQ-restraint scale as either low or high restrained (low restrained ≤ 11 and high restrained > 11) and scores on TFEQ-disinhibition scale as either low or high disinhibited eaters (low disinhibition ≤ 8 and high disinhibition > 8). The combination of these factors produced 4 groups (HRHD, HRLD, LRHD and LRLD) that were entered as a between-subjects factor in a mixed ANOVA with condition as a repeated measures factor. For the lexical decision task all incorrect responses and extreme reaction times (> 3 SDs) were excluded from analysis. Mean scores were calculated for the diet, tempting and neutral words. The mean scores for each word type were entered in to a mixed ANOVA with condition and word type as repeated measures factor and diet status as a between-subjects factor. Bonferroni correction was applied for post hoc comparisons. When the assumption of sphericity was violated the Greenhouse-Geisser correction was applied. In instances when the Mauchly's test of sphericity was not provided it was assumed sphericity was met. Any significant interactions were explored using paired samples t-test. To correct for multiple comparisons alpha was set at $p < .025$ with the exception of one tailed hypotheses where alpha was set at $p < .05$.The results are presented as mean ± SEM.

Partial eta squared (ηp^2) was used for effect sizes and interpreted as: .01 = small, .09 = medium and .25 as large effects.

6.6.2 Results

6.6.2.1 Manipulation check

To check the current sample perceived salad as diet-congruent, garlic bread as tempting and water as neutral, the taste evaluations for each preload recorded at the time of consumption and estimated energy contents of the preloads recorded at the end of the study were examined.

Participants rated the salad to be healthier than garlic bread ($Z = 4.47$, $p < .001$), whereas the health perception of water did not differ to salad (salad: 8.2 ± 0.2; garlic bread: 3.4 ± 0.4; water: 7.9 ± 0.3, $Z = 0.5$, p = ns). For temptation ratings there were no differences between the salad and garlic bread as measured during consumption (salad: 7.0 ± 0.3; garlic bread: 6.8 ± 0.4, $Z = 0.07$, $p = ns$). The salad and garlic bread were considered more tempting than water (water: 4.7 ± 0.5, smallest $Z = 2.61$, $p = .009$). Ratings were unaffected by diet status [largest F: $F(1, 28) = 0.85$, $p = ns$, $\eta p^2 = .03$]

The estimated energy contents of the preloads differed, $F(2, 48) = 53.00$, $p < .001$. The energy content of salad was perceived to be less than garlic bread (salad: 110 ± 15 kcal; garlic bread: 149 ± 15 kcal, $p \leq .05$). Participants correctly estimated that water contains no energy (0.2 ± 0.2 kcal). Energy estimations did not differ across diet status [$F(1, 24) = .03$, $p = ns$, $\eta p^2 = .001$].

In summary, salad was perceived as an item most associated with dieting to lose weight and with lower energy content compared to garlic bread. This rating corresponds with evidence from the online surveys (Chapter 4 and current chapter) to add support that salad is diet-congruent. The perceptions of temptation for garlic bread did not differ to salad, however, the energy estimations suggested that garlic bread was a tempting food and was more diet-forbidden compared to salad due to its high energy content.

6.6.2.2 Memories recalled

All participants reported a memory associated with each preload. The memories recalled were neither of a positive or negative nature. In the diet condition, participants recalled memories of “healthy eating or dieting” (n = 7) and eating in the “summer time/hot weather” (n = 7). In the tempting condition, participants recalled memories about “sociable eating” and “eating at restaurants.”

6.6.2.3 Participant characteristics

In total 39 participants completed the study. Six participants correctly guessed the true purpose of the study and were excluded from subsequent analysis[11]. In addition, 6 participants were excluded for being on a diet to maintain weight[12] and one was excluded for not complying with the study procedure. The remaining sample consisted of 13 dieters losing weight and 13 non-dieters (62% were non-students).

Dieters reported adopting multiple behaviours to lose weight including healthy eating (n = 4), a low calorie diet (n = 5), avoiding snacks (n = 6), low carbohydrate diet (n = 3), low fat diet (n = 1), low sugar intake (n = 1), high protein diet (n = 1), eating smaller portions (n = 2), engaging in a commercial weight loss program (n = 1), being in control over food (n = 1) and exercising (n = 3). For dieters, 64% reported previous dieting attempts and of those 44% reported dieting more than once per year. For non-dieters 39% reported previously dieting and of those, 29% reported dieting more than once per year.

Dieters scored significantly higher in TFEQ-restraint, flexible and rigid control than non-dieters [TFEQ-restraint: $t(24) = 2.65$, $p = .01$; flexible control: $t(24) = 2.09$, $p < .05$; rigid control: $t(24) = 3.91$, $p = .001$]. In terms of height, dieters were shorter than non-dieters, $t(23) = 2.66$, $p = .01$. There were no other group differences between dieters and non-dieters in age, BMI, or any other psychometric scores (largest t: $t(24) = 1.96$, $p = ns$) (see Table 6.5).

[11] The main effects of condition on energy intake persisted with suspicious participants included, $F(1.56, 46.86) = 5.61$, $p = .01$. However, the condition x group interaction on energy intake was reduced to non-significant, $F(2, 60) = 1.52$, $p = ns$. Therefore, participants who were aware that food intake was being measured were excluded.

[12] In support, dieters maintaining weight scored lower in rigid control and were older compared to dieters losing weight [rigid control: $t(17) = 1.28$, $p = .008$; age: $t(17) = 1.06$, $p = .02$].

6.6.2.4 Study compliance

There were no differences across conditions in the time reported since participants last ate on the day of testing, $F(2, 36) = 1.82$, *p = ns*, $\eta p^2 = .09$. Thus, participants complied with the instruction to fast for at least 2 hours prior to lunch. There were no differences between conditions in reported exercise durations on each test day, $F(1.36, 28.50) = 1.16$, *p* = ns, $\eta p^2 = .05$ and there was no effect of condition order on energy intake, $F(5, 13) = 0.30$, *p = ns*, $\eta p^2 = 0.07$.

Table 6.5. Participant characteristics (mean ± SEM).

Characteristic	Dieters (n = 13)	Non-dieters (n = 13)
Age (years)	27.6 ± 2.3	32.5 ± 2.8
Height (m)	1.6 ± 0.0	1.7 ± 0.0*
Weight (kg)	66.6 ± 2.6	72.6 ± 5.4[a]
BMI (kg/m²)	25.5 ± 1.0	25.5 ± 1.6[a]
TFEQ-re	13.5 ± 0.8	8.9 ± 1.5*
Flexible	4.4 ± 0.4	2.9 ± 0.6*
Rigid	4.8 ± 0.3	2.6 ± 0.5**
TFEQ-d	8.0 ± 1.0	7.1 ± 0.9
Internal-d	3.2 ± 0.6	2.3 ± 0.7
External-d	2.9 ± 0.5	3.5 ± 0.5
TFEQ-Hunger	5.9 ± 1.1	7.0 ± 1.0
DEBQ-re	3.2 ± 0.2	2.9 ± 0.2
DEBQ-em	3.0 ± 0.2	2.5 ± 0.2
DEBQ-ex	2.8 ± 0.1	2.5 ± 0.1
PFS-available	16.4 ± 1.8	15.0 ± 1.5
PFS-present	12.2 ± 1.5	13.5 ± 0.9
PFS-tasted	14.8 ± 1.5	16.1 ± 1.3
PFS-total	43.3 ± 4.4	44.5 ± 3.3
PSRS	4.0 ± 0.3	4.3 ± 0.4
Weight suppression	1.5 ± 1.3	N/A

Note. TFEQ = Three Factor Eating Questionnaire (Stunkard & Messick, 1985); TFEQ-re = TFEQ-restraint; TFEQ-d = TFEQ-disinhibition; Internal-d = Internal disinhibition; External-d = External disinhibition; DEBQ = Dutch Eating Behavior Questionnaire (van Strien, et al., 1986); DEBQ-re = DEBQ restraint; DEBQ-em = DEBQ-emotional; DEBQ-ex = DEBQ-external; PFS = Power of Food Scale (Lowe, et al., 2009); PSRS = Perceived Self-Regulatory Success (Fishbach et al. 2003); WS = Weight suppression.
**p* < .05 between groups.
***p* < .01 between groups.

6.6.2.5 Correlations between dieters' and non-dieters' energy intake and eating behaviour traits across conditions.

For dieters, flexible control negatively correlated with energy in each condition. In the tempting condition as TFEQ-restraint scores increased, dieters' energy intake decreased, whereas higher weight suppression scores were associated with increases in energy intake. In the control condition as PFS-tasted and PFS-total increased dieters' energy intake increased. In contrast, there were no relationships between non-dieters' energy intake and any psychometric eating behaviour traits (see Table 6.6).

Table 6.6. Correlations between dieters' and non-dieters' characteristics and energy intake across conditions.

	Dieters			Non-dieters		
	Diet	Tempting	Control	Diet	Tempting	Control
Age (years)	-.55	-.22	-.52	.01	-.15	0.08
BMI (kg/m²)	.14	.001	-.07	-.20	-.22	-.19
TFEQ-re	-.43	-.56*	-.53	.25	.23	.13
Flexible	-.64*	-.78**	-.75**	.17	.07	.04
Rigid	.42	-.06	.26	.33	.37	.27
TFEQ-d	.10	.15	.25	-.13	-.08	-.10
Internal-d	-.02	.10	.26	-.05	-.10	.06
External-d	.18	.14	.27	-.26	-.43	-.39
TFEQ-Hunger	.03	.19	.34	-.01	-.25	-.18
DEBQ-re	-.19	.04	.20	.19	.17	.11
DEBQ-em	-.15	.08	.16	.18	.09	.05
DEBQ-ex	.08	-.27	-.02	.22	.19	.10
PFS-available	.02	.27	.38	.24	.07	.09
PFS-present	.01	.25	.48	.42	.17	.21
PFS-tasted	.31	.53	.75**	.37	.16	.16
PFS-total	.11	.37	.56*	.37	.15	.16
PSRS	.27	-.17	-.07	.35	.14	.11
Weight suppression	.34	.69*	.60.	.56.	.66	.64

Note. TFEQ= Three Factor Eating Questionnaire (Stunkard & Messick, 1985); TFEQ-re = TFEQ-restraint; TFEQ-d = TFEQ-disinhibition; Internal-d = Internal disinhibition; External-d = External disinhibition; DEBQ = Dutch Eating Behavior Questionnaire (van Strien, et al., 1986); DEBQ-re = DEBQ restraint; DEBQ-em = DEBQ-emotional; DEBQ-ex = DEBQ-external; PFS = Power of Food Scale (Lowe, et al., 2009); PSRS = Perceived Self-Regulatory Success (Fishbach et al. 2003); WS = Weight suppression.
[a]n = 12
*p < .05
**p < .01

6.6.2.6 Impact of cue and diet status on energy intake

Pizza intake was significantly affected by condition $F(1.39, 33.39) = 14.13$, $p < .001$, $\eta p^2 = .37$. Pizza intake was lower after consuming a diet-congruent preload compared to tempting and control preloads; and lower after the tempting preload compared to control preload (diet-congruent: 634.08 ± 48 kcal; tempting: 746.81 ± 46.20 kcal; control: 806.96 ± 42 kcal). The effect of group on pizza intake approached significance, $F(1, 24) = 3.53$, $p = .07$, $\eta p^2 = .13$, with a trend for dieters to consume less than non-dieters. There was a significant condition x diet status interaction, $F(1.39, 33.39) = 3.78$, $p \leq 05$, $\eta p^2 = .14$. Dieters' reduced pizza intake after the diet-congruent preload compared to the tempting and control preloads. Dieters consumed less after consuming the tempting preload compared to the control preload. Non-dieters consumed less after a diet-congruent preload compared to tempting preloads but pizza intake did not differ between the tempting and control preloads.

There was a main effect of condition on total energy intake (preload plus pizza intake), $F(1.39, 33.39) = 5.99$, $p = .01$, $\eta p^2 = .20$. Participants consumed less when eating a diet-congruent preload compared to a tempting preload, but total energy intake did not differ between the control condition and diet-congruent and tempting preloads. A condition x diet status interaction on total energy intake emerged, $F(2, 48) = 3.78$, $p = .03$, $\eta p^2 = .14$. Dieters' suppressed total energy intake when consuming a diet-congruent preload compared to a tempting or control preload. Non-dieters consumed more when consuming a tempting preload compared to a control preload, but intake in the diet condition did not differ between the tempting and control conditions (see Figure 6.4). This condition x diet status interaction on energy intake remained significant when accounting for TFEQ-restrained eating and flexible control, $F(2, 44) = 3.23$, $p < .05$.

In summary, dieters consumed less over a two course meal when consuming a diet-congruent preload compared to tempting or control preloads. In contrast, non-dieters' intake was unaffected by consuming a diet-congruent preload. However, non-dieters consumed more total energy intake when consuming a tempting preload compared to a control preload.

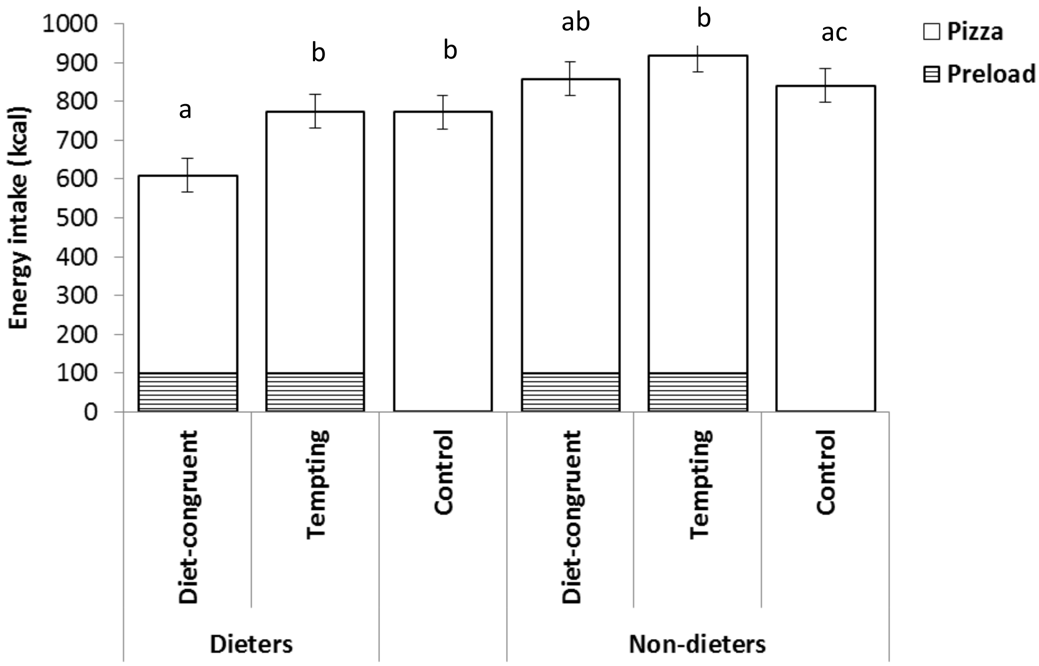

Figure 6.4. Dieters' and non-dieters' mean total energy intake (± SEM) across conditions.

Different letters denote significant differences between conditions within a group.

6.6.2.7 Evaluation of preloads

It is possible that taste evaluation influenced intake across conditions therefore the rated pleasantness and appeal of each preload was assessed. The analysis revealed no differences in taste evaluations of the salad and garlic bread preloads in terms of pleasantness and appeal, (pleasantness: $Z = 1.58$, $p = ns$; appeal: $Z = 1.50$, $p = ns$). The water was rated as less appealing than the salad ($Z = 4.39$, $p < .001$) and garlic bread ($Z = 2.98$, $p = .003$) and less pleasant than the salad ($Z = 2.53$, $p = .01$) but there were no differences in pleasant ratings between the water and garlic bread preload ($Z = 0.58$, $p = ns$). Evaluation of preloads did not differ by group [pleasant: $F(1, 23) = 0.74$, $p = ns$, $\eta p^2 = .03$; appeal: $F(1, 23) = .09$, $p = ns$, $\eta p^2 = .004$] and the preload x diet status interaction on preload evaluations was non-significant [pleasant: $F(2, 46) = 0.58$, $p = ns$, $\eta p^2 = .02$; appeal: $F(1.47, 33.87) = 3.45$, $p = ns$, $\eta p^2 = .13$]. Thus, dieters and non-dieters equally rated the salad and garlic bread in terms of pleasantness and appeal.

6.6.2.8 Impact of condition and diet status on appetite ratings

There was a main effect of time on hunger, desire to eat and fullness [hunger: $F(3.04, 73.02) = 93.66$, $p < .001$, $\eta p^2 = .80$; desire to eat: $F(2.80, 67.14) = 90.11$, $p < .001$, $\eta p^2 = .79$; fullness: $F(5, 20) = 98.23$, $p < .001$, $\eta p^2 = .80$]. At post-lunch (VAS 2) and at pre-preload (VAS 3) there were no differences across conditions for hunger, desire to eat or fullness. Hunger and desire to eat significantly declined from pre-preload (VAS 3) to post-preload (VAS 4). Hunger and desire to eat did not change between post-preload (VAS 4) and post-lexical decision task (VAS 5). At post-meal (VAS 6) both hunger and desire to eat significantly declined. Fullness sensations mirrored the hunger patterns such that, fullness increased from pre-preload (VAS 3) to post-preload (VAS 4), showed no difference after the lexical decision task (VAS 5) and increased post-test meal (VAS 6).

There were main effects of condition on desire to eat and fullness [desire to eat: $F(2, 48) = 3.82$, $p = .03$, $\eta p^2 = .14$; fullness: $F(2, 48) = 7.45$, $p = .002$, $\eta p^2 = .24$] but no effects of condition on hunger, $F(2, 48) = 2.25$, $p = ns$, $\eta p^2 = .09$. Participants reported lower desire to eat and were fuller in the diet condition compared to control. There were no reported differences in hunger, desire to eat or fullness between the tempting and control conditions (all *p*s = *ns*).

The condition x time interactions were significant for hunger and desire to eat [hunger: F(4.99, 119.73, $p = .002$, $\eta p^2 = .14$; desire to eat: $F(5.20, 124.91) = 3.15$, $p = .009$, $\eta p^2 = .12$]. Comparison of the means revealed lower hunger and desire to eat at post-preload (VAS 4) and at post-lexical decision task (VAS 5) after the diet-congruent preload compared to the tempting preload [hunger: VAS 4: $t(25) = 3.31$, $p = .003$; VAS 5: $t(25) = 2.55$, $p = .02$; desire to eat: VAS 4: $t(25) = 3.39$, $p = .002$; VAS 5: $t(25) = 3.90$, $p = .001$] and control preloads [hungry: VAS 4: $t(25) = 4.38$, $p < .001$; VAS 5: $t(25) = 4.57$, $p < .001$; desire to eat VAS 4: $t(25) = 2.78$, $p = .01$; VAS 5: $t(25) = 3.56$, $p =.002$]. There were no other differences in hunger or desire to eat between conditions at any other time points (largest $t = 1.21$, $p = ns$). Similarly, there was a close significant condition x time interaction on fullness ratings, $F(5.31, 127.45) = 2.20$, $p = .05$, $\eta p^2 = .08$. At post-preload (VAS 4), post-lexical decision task (VAS 5) and post-meal (VAS 6) participants were fuller in the diet condition compared to tempting [VAS 4: $t(25) = 3.49$, $p = .002$; VAS 5: $t(25) = 4.31$, $p < .001$; VAS 6: $t(25) = 2.92$, $p =$

.007] and control conditions [VAS 4: t(25) = 3.82, *p* = .001; VAS 5: t(31) = 3.05, *p* = .005; VAS 6: t(25) = 2.57, *p* = .02].

A significant condition x time x diet status interaction on hunger ratings F(4.99, 119.73) = 2.45, *p* = .04, ηp^2 = .09 showed that dieters were less hungry at post-preload (VAS 4) and post-lexical decision task (VAS 5) in the diet condition compared to the tempting and [VAS 4: t(12) = 2.94, *p* = .01; VAS 5: t(12) = 2.06, *p* = .06] and control conditions [VAS 4 water: t(12) = 4.12, *p* = .001]. Non-dieters reported lower hunger in the diet condition compared to control at VAS 4 and VAS 5 [T4: t(12) = 2.58, *p* = .02; T5: t(12) = 2.52, *p* = .03], but non-dieters hunger did not differ between the diet and tempting conditions (largest t = t(25) = 1.72, *p* = *ns*) (see Table 6.7).

In summary, both dieters and non-dieters reported less desire to eat and were fuller after the diet-congruent preload compared to the tempting and control preloads. Dieters were also less hungry after the diet-congruent preload compared to the tempting and control preloads at VAS 4 and VAS 5), while non-dieters only reported feeling less hungry after the diet-congruent preload compared to control but there were no differences between the diet-congruent preload and tempting preload conditions.

Table 6.7. Dieters and non-dieters' hunger, desire to eat and fullness sensations (mm) across conditions (mean ± SEM).

	Dieters			Non-dieters		
	Diet	**Tempting**	**Control**	**Diet**	**Tempting**	**Control**
Hunger						
Pre-lunch	55.9 ± 6.0^{a}	64.1 ± 5.2^{a}	73.9 ± 5.3^{a}	75.2 ± 6.0	77.3 ± 5.2	58.7 ± 5.3
Post-lunch	16.6 ± 6.4^{a}	21.4 ± 5.6^{a}	15.2 ± 5.5^{a}	29.3 ± 6.4	26.7 ± 5.6	25.2 ± 5.5
Pre-preload	62.8 ± 4.8^{a}	57.0 ± 7.3^{a}	59.7 ± 7.2^{a}	64.7 ± 4.8	61.5 ± 7.3	62.4 ± 7.2
Post-preload	35.2 ± 4.9^{a}	54.5 ± 6.1^{b}	54.2 ± 7.7^{b}	38.1 ± 4.9^{a}	49.4 ± 6.1^{b}	56.6 ± 7.7^{b}
Post-LDT	41.9 ± 5.7^{a}	55.2 ± 6.5^{b}	60.9 ± 6.9^{b}	41.1 ± 5.7^{a}	53.6 ± 6.5^{b}	56.4 ± 6.9^{b}
Post-meal	15.2 ± 4.4^{a}	13.8 ± 3.8^{a}	8.0 ± 1.9^{a}	4.8 ± 4.4^{a}	7.7 ± 3.8^{a}	7.5 ± 1.9^{a}
Desire to eat						
Pre-lunch	59.9 ± 5.9^{a}	67.2 ± 5.0^{a}	74.6 ± 6.8^{a}	78.7 ± 5.9^{a}	80.6 ± 5.0^{a}	60.2 ± 6.8^{a}
Post-lunch	17.6 ± 6.9^{a}	19.0 ± 5.8^{a}	16.9 ± 6.5^{a}	30.8 ± 6.9^{a}	33.6 ± 5.8^{a}	40.1 ± 6.5^{a}
Pre-preload	61.9 ± 5.8^{a}	57.3 ± 7.1^{a}	57.9 ± 6.7^{a}	66.0 ± 5.8^{a}	64.2 ± 7.1^{a}	69.1 ± 6.7^{a}
Post-preload	38.4 ± 6.6^{a}	58.8 ± 6.5^{b}	61.2 ± 7.6^{b}	41.5 ± 6.6^{a}	59.7 ± 6.5^{b}	61.0 ± 7.6^{b}
Post-LDT	45.0 ± 6.3^{a}	59.9 ± 6.5^{b}	61.7 ± 6.1^{b}	42.5 ± 6.3^{a}	59.8 ± 6.5^{b}	58.7 ± 6.1^{b}
Post-meal	7.5 ± 3.9^{a}	7.8 ± 3.0^{a}	10.5 ± 2.8^{a}	9.5 ± 3.9^{a}	10.5 ± 3.0^{a}	11.3 ± 2.8^{a}
Fullness						
Pre-lunch	33.5 ± 5.4^{a}	28.2 ± 4.2^{a}	13.4 ± 4.1^{a}	17.6 ± 5.4^{a}	16.5 ± 4.2^{a}	26.7 ± 4.1^{a}
Post-lunch	76.5 ± 5.4^{a}	75.7 ± 5.4^{a}	74.2 ± 6.8^{a}	66.6 ± 5.4^{a}	59.3 ± 5.4^{a}	52.8 ± 6.8^{a}
Pre-preload	30.2 ± 4.9^{a}	32.9 ± 4.4^{a}	30.9 ± 5.0^{a}	24.5 ± 4.9^{a}	23.7 ± 4.4^{a}	23.9 ± 5.0^{a}
Post-preload	59.4 ± 5.1^{a}	45.3 ± 5.1^{b}	40.8 ± 6.1^{b}	51.5 ± 5.1^{a}	35.5 ± 5.1^{b}	37.6 ± 6.1^{b}
Post-LDT	54.2 ± 4.7^{a}	36.8 ± 4.5^{b}	31.7 ± 5.3^{b}	50.7 ± 4.7^{a}	34.9 ± 4.5^{b}	44.8 ± 5.3^{b}
Post-meal	86.8 ± 3.0^{a}	84.5 ± 3.7^{b}	81.7 ± 4.6^{b}	91.5 ± 3.0^{a}	79.6 ± 3.7^{b}	82.7 ±4.6^{b}

Note. Different letters denote significant differences between conditions within a group.

6.6.2.9 Correlations between dieters' and non-dieters' appetite sensations and energy intake.

Dieters' hunger and desire to eat positively correlated with energy intake in the diet condition but not in the tempting or control conditions (diet condition: desire to eat $r = .71$, $p = .007$; hunger $r = .63$, $p = .02$; tempting condition: desire to eat $r = .51$, $p = ns$; hunger $r = .43$, $p = ns$; control: desire to eat $r = .34$, $p = ns$; hunger, $r = .38$, $p = ns$). As hunger and desire to eat increased, dieters' energy intake increased in the diet-congruent preload condition, but there were no significant correlations in the tempting or control conditions. In the tempting condition, fullness negatively correlated with dieters' energy intake but there were no other relationships between fullness and energy intake in the diet and control conditions (tempting condition: $r = -.58$, $p = .04$; diet condition: $r = -.30$, $p = ns$; control: $r = -.29$, $p = ns$). As fullness increased in the tempting condition, dieters' energy intake decreased. For non-dieters, desire to eat positively correlated with energy intake in the tempting conditions but no other conditions (tempting condition: $r = .65$, $p = .02$; diet condition: $r = .38$, $p = ns$; control: $r = .45$, $p =$ ns). As desire to eat increased, dieters' energy intake increased in the tempting condition. Hunger and fullness did not correlate with non-dieters' energy intake in any conditions (all *p*s = ns).

6.6.2.10 Impact of condition and restraint disinhibition subtypes on energy intake

Restraint scores for the high restraint subgroup were significantly higher compared to the low restraint subtypes, $F(3, 25) = 14.40$, $p < .001$. Additionally, disinhibition was higher in the high disinhibited subtypes compared to the low disinhibition subtypes, $F(3, 25) = 25.75$, $p < .001$ (see Table 6.8). There was a main effect of condition on total energy intake, $F(1.39, 30.66) = 5.87$, $p = .006$, $\eta p^2 = .21$. Participants consumed 120.2 ± 42.9 kcal less when consuming a diet-congruent preload compared to tempting preload and 80.3 ± 39.2 kcal less when consuming the diet-congruent preload compared to control preloads. There were no main effects of group on total energy intake, $F(3, 22) = 0.74$, $p =$ ns, $\eta p^2 = .09$ nor a condition x group interaction on total energy intake, $F(6, 44) = 0.95$, $p =$ ns, $\eta p^2 = .11$.

Table 6.8. Restraint and disinhibition score for the restraint disinhibition subtypes (mean ± SEM).

	HRHD (n = 6)	HRLD (n = 5)	LRHD (n = 6)	LRLD (n = 9)
TFEQ-re	15.8 ± 0.9	15.4 ± 1.1	9.2 ± 1.1	7.1 ± 1.3
TFEQ-d	9.7 ± 0.5	5.0 ± 0.9	11.5 ± 0.6	4.9 ± 0.6
Dieters (n)	5	3	2	3

Note. TFEQ = Three Factor Eating Questionnaire (Stunkard & Messick, 1985); TFEQ-re = TFEQ-restraint; TFEQ-d = TFEQ-disinhibition.
Different letters denote significant differences between groups.

6.6.2.11 Impact of diet status and condition on the salience of diet and tempting thoughts

There were no main effects of condition on reaction times to words, F(1.23) = 1.11, *p* = *ns*, ηp^2 = .04. There was a main effect of word type on reaction times, F(2, 48) = 60.33, $p <$ .001, ηp^2 = .72. Reaction times to diet and tempting words were faster compared to neutral words across conditions (diet words: 611.2 ± 21.8 ms; tempting words: 616.4 ± 22.2 ms; neutral words: 693.9 ± 26.1 ms) (see Figure 6.5). There was a trend for dieters to recognise words faster than non-dieters but this only approached significance (dieters: 595.8 ± 32.5 ms; non-dieters: 685.2 ± 32.5 ms, F(1, 24) = 3.80, *p* = .06, ηp^2 = .14). There were no preload x word type x diet status interactions on reaction times to words [F(4, 96) = 1.42, *p* = *ns*, ηp^2 = .06] indicating similar RTs by group and condition.

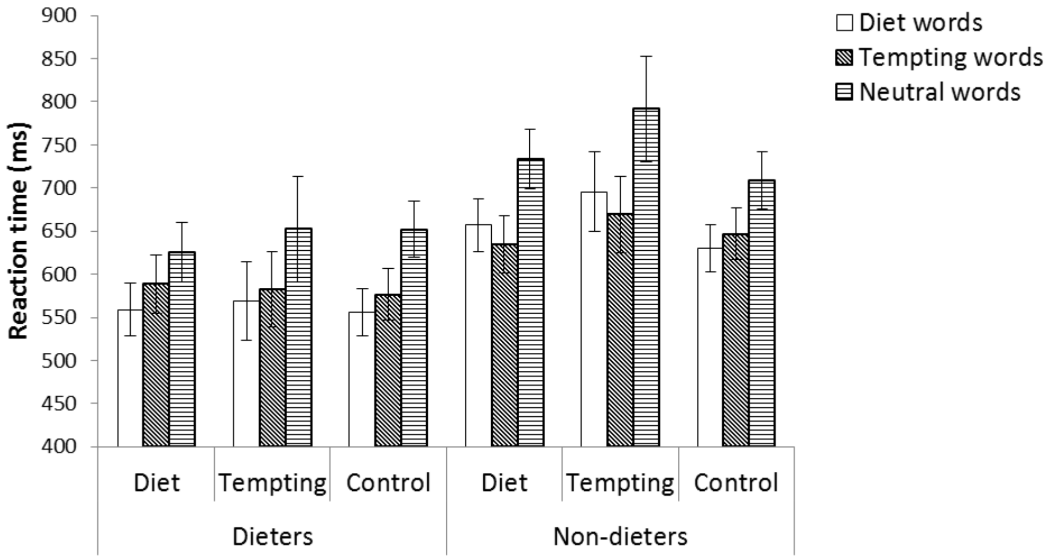

Figure 6.5. Reaction times to diet, tempting and neutral words across conditions (mean ± SEM).

Note: There was a main effect of word type ($p < .001$), participants were faster to detect diet and tempting words than neutral words across conditions.

6.6.2.12 Mood

Mood states did not differ between conditions or diet status [tiredness: conditions: $F(2, 48) = 0.21$, p = ns, $\eta p^2 = .009$, diet status: $F(1, 24) = 0.11$, p = ns, $\eta p^2 = .005$; relaxed: condition: $F(2, 48) = 0.39$, $p = ns$, $\eta p^2 = .02$; diet status: $F(1, 24) = 0.26$, $p = ns$, $\eta p^2 = .01$; stressed: condition: $F(2, 48) = 0.27$, $p = ns$, $\eta p^2 = .01$, diet status: $F(1, 24) = 0.83$, $p = ns$, $\eta p^2 = .03$; happiness: condition: $F(2, 48) = 0.31$, $p = ns$, $\eta p^2 = .01$; diet status: $F(1, 24) = 0.89$, $p = ns$, $\eta p^2 = .04$]. There were no condition x diet status interactions on any of the subjective sensations (largest F: $F(2, 48) = .07$, $p = ns$, $\eta p^2 = .03$). Thus, mood is an unlikely explanation for the differences in dieters' energy intake between conditions.

6.6.3 Discussion

Intake of a diet-congruent preload reduced participants' subsequent test meal intake compared to garlic bread and water preloads. Moreover, when considering total energy intake (preload plus pizza), dieters consumed 21% less when consuming a salad preload compared to garlic bread and water. In contrast, non-dieters' total energy intake did not change when consuming the diet-congruent preload compared to the tempting and control preload. Non-dieters consumed more total energy intake when consuming garlic bread compared to the water preload. Additionally, measures of appetite showed dieters and non-dieters reported feeling fuller and had lower desire to eat after a diet-congruent preload compared to a tempting and neutral preload. Dieters also reported feeling less hungry after the diet-congruent preload compared to the garlic bread and water preload. Against expectations, participants were faster to detect diet and tempting words across all conditions regardless of diet status. Nevertheless, the present study confirms and extends earlier findings on the effects of diet-congruent images (Chapter 3) and odours (Chapter 4) on snack intake, by showing diet-congruent food cues to inhibit *meal intake* in dieters.

The suppressant effect of diet-congruent foods on meal intake can be accounted for with two alternative explanations. Firstly, the findings might be due to a cognitive process derived from the goal conflict theory. Secondly, the findings might be due to physiological responses to varying characteristics of preloads such as volume and oral processing time.

The goal priming theory would suggest that in a tempting situation, such as being offered garlic bread and pizza, dieters' goals to eat and enjoy food become salient at the cost of suppressing diet goals, leading a dieter vulnerable to diet violations (Custers & Aarts, 2010; Stroebe, et al., 2008; Stroebe, et al., 2013). However, intake of a diet-congruent food should protect the salience of diet goals in tempting situations and assist dieters to control pizza intake. In the current study the low calorie estimations of salad compared to garlic bread suggest salad was a diet-congruent preload (Sobal & Cassidy, 1987, 1990). Yet, only dieters were responsive to this diet-congruent preload while non-dieters' food intake was unaffected by this diet-congruent preload. This selective responsiveness to the diet-congruent preload is consistent with the goal priming prediction that only those with goals to diet will be affected by diet-congruent cues (Custers & Aarts, 2010; Stroebe et al. 2008).

However, results from the lexical decision task do not provide support for the goal priming mechanism. The heightened responsiveness to diet and tempting words suggests that such words have increased salience compared to neutral words regardless of preload consumed (limitations of the lexical decision task are discussed in Chapter 7). Alternative methods of assessing the salience of diet and tempting thoughts might be needed to support the goal priming explanation.

Interestingly, the finding that diet-congruent food reduced desire to eat and hunger (only in dieters) and increased fullness is novel within diet goal priming research. Previous research has not administered measures of appetite sensations following diet-congruent cues (Anschutz, et al., 2008; Brunner, 2010; Brunner & Siegrist, 2012; Papies & Hamstra, 2010). The general effect of a diet-congruent preload on dieters' and non-dieters' desire to eat and fullness sensations is not consistent with the goal priming prediction that diet-congruent cues will only affect those with relevant weight control goals (Stroebe, et al., 2008). Thus, the effects of a diet-congruent preload on appetite sensations might involve processes other than a pure cognitive explanation.

Another explanation is the volumetrics account (Rolls, 2010). Given the low energy density of salad a larger volume of food was required to match the energy content of garlic bread. The increased bulk of salad compared to garlic bread might have influenced meal intake in two ways. Firstly, the increased volume of salad might have increased gastric distension and induced negative feedback faster than garlic bread and water preloads. Indeed, volume of food influences gastric distension (de Castro, 2005) and subsequent food intake independent of energy density (Rolls & Roe, 2002). Secondly, the increased bulk of the salad might have increased oral transit time. Longer oral exposure times initiate cephalic phase responses and reduce meal intake compared to shorter oral exposure times (Cecil, Francis, & Read, 1998; de Graaf, 2012). Thus, the volumetic properties of salad might explain the general effects of the diet-congruent preload to reduce dieters' and non-dieters' desire to eat and fullness sensations relative to garlic bread and water preloads. However, the volumetric explanation cannot account for why dieters were responsive to the diet-congruent preload and non-dieters were not. Therefore, integration of cognitive and physiological processes could account for these findings.

Further research is needed to replicate the current finding and address several limitations of the current study. Although, the current study controlled for preload weight, the weight of food and water differed between preloads. Gastric emptying rates are faster for water compared to food (Holt, Heading, Taylor, Forrest, & Tothill, 1986). In the current study the diet-congruent preload had the lowest water content and might have involved the slowest gastric emptying rates compared to the tempting and control preloads. Additionally, the preloads differed in factors known to affect satiety, such as macronutrient contents (Rolls, et al., 1994); energy density differences (Bell, Castellanos, Pelkman, Thorwart, & Rolls, 1998) and temperature (Rolls, Fedoroff, Guthrie, & Laster, 1990), in the current study both dieters and non-dieters were subject to these factors but, only dieters varied meal intake across conditions. Thus, it is likely such factors played a minimal role on the current findings. Yet, subsequent studies should control for these factors to substantiate the mechanism of the effect reported.

A strength of the current study is that a large proportion of the sample were recruited from the local community. The previous chapters of this thesis have tested the effects of diet-congruent cues in predominant university samples (staff and students) whereas the current study extends the effect of diet-congruent cues to a sample more representative of the general population.

6.7 Key findings

- An online survey showed salad to be diet-congruent and garlic bread to be tempting. This was supported with lower energy estimations of the diet-congruent preload compared to the tempting preload.

- Dieters' meal intake was reduced by 21% when consuming a diet-congruent preload compared to a tempting or control preload.

- Dieters and non-dieters had lower desire to eat and were fuller after the diet-congruent preload compared to the tempting and control preloads. Dieters were also less hungry after diet-congruent preload compared to the tempting and control preloads, whereas non-dieters were only less hungry after the diet-congruent preload compared to control but showed no difference in hunger between the diet-congruent preload and tempting preload.

- In the lexical decision task participants were faster to detect diet and tempting words compared to neutral words across conditions and this did not vary by diet status. Thus, the results on the lexical decision task did not provide support for the goal priming explanation.

- The specific response of dieters to reduce meal intake when consuming a diet-congruent preload whilst non-dieters' meal intake was unaffected by a diet-congruent preload can be explained by the goal conflict theory. However, general effects of the diet-congruent preload on appetite are not consistent with the goal conflict theory and suggest that physiological processes were also involved.

Chapter 7

General discussion

7.1 Thesis aims

This thesis examined the effects of diet-congruent cues on dieters' snack and meal intake. Different types of diet-congruent cues varying in potency were systematically examined in four laboratory studies. Exposure to diet-congruent cues included images, the sight and smell of foods and preload intake on subsequent snack or meal intake. The overall aim emerged from recent literature integrating models of goal priming and the influence of subtle environmental cues to explain why dieters experience difficulty adhering to diet plans (Stroebe, et al., 2008; Stroebe et al. 2013). To date the focus has been on priming overconsumption in restrained eaters whose trait eating could be regarded as independent of active dieting (Lowe, 1993). These studies have shown that different experimental manipulations, such as exposure to tempting food cues (Fedoroff, et al., 1997; Fedoroff, et al., 2003; Harris, et al., 2009; Jansen & van den Hout, 1991; Pelaez-Fernandez & Extremera, 2011; Rogers & Hill, 1989; Shimizu & Wansink, 2011; Stirling & Yeomans, 2004), and an overweight experimenter (McFerran, et al., 2010), have tempted restrained eaters and HRHD eaters (Soetens, et al., 2008) away from their diet goal. The magnitude of the effects of tempting cues to stimulate intake have mostly been large (see Table 7.1). In contrast, preliminary findings on diet-congruent cues have shown that diet-congruent cues can reduce snack intake in restrained eaters (Anschutz, et al., 2008; Harris, et al., 2009; Papies & Hamstra, 2010) and in general samples (Boland, et al., 2013; Brunner, 2010; Brunner & Siegrist, 2012; Mann & Ward, 2004). Despite most of these studies using subtle exposure to diet-congruent cues, the magnitude for the effects of diet-congruent cues to inhibit subsequent intake have ranged from small to large (see Table 7.1). Thus, these studies demonstrate the influence of subtle environmental cues to resolve conflict between diet and eating enjoyment goals (Stroebe, et al., 2008; Stroebe, et al., 2013).

Table 7.1. Summary of tempting and diet-congruent cue literature.

Cue exposure	Design	Sample	Cue	Duration	Explicitly aware of cue(s)?	Mean change in intake	Cohen d
Tempting							
Fedoroff et al. (1997).	BS	Restrained eaters (Polivy, et al., 1988).	Smell and thoughts of pizza.	10 minutes.	✓ Think and write about pizza.	↑37.65g of pizza compared to no cue.	0.62 medium.
Fedoroff et al. (2003).	BS	Restrained eaters (Polivy, et al., 1988).	Smell and thoughts of either cookies or pizza.	10 minutes.	✓ Think and write about cookies/pizza.	↑49.38g of cookies ↑60.85g of pizza compared to control.	1.41 (cookies) large; 1.83 (pizza) large.
Harris et al. (2009).	BS	Restrained eaters (Polivy, Herman, & Warsh, 1978).	4 food/beverage television commercials – fast food, sweets and soft drink.	Not specified.	X No explicit instructions to attend. Clearly visible.	↑ compared to control. Amount not specified.	Missing.
Jansen & van den Hout (1991).	BS	Restrained eaters (Polivy, et al., 1978).	Sight and smell of snack foods.	12 minutes.	✓ Focus on smell of food.	↑compared to no cue. Amount not specified.	0.95 large.
McFerran et al. (2010).		Restrained eaters (Herman & Polivy, 1980).	Overweight experimenter.	Serving of snacks. No time specified.	X No explicit instructions to attend.	↑ 2.41 cookies/rice cakes compared to control.	Missing.
Pelaez-Fernandez & Extremera (2011).	BS	Restrained eaters (Polivy, et al., 1988).	Gourmet magazine on table.	10 minutes (attention not directed).	X No explicit instructions to attend.	↑28.65g of cookies compared to control.	0.69 medium.
Rogers & Hill (1989).	BS	Restrained eating (Stunkard, 1981).	Sandwich and cream cakes with pictures of food.	5 minutes.	✓ Imagine eating food.	↑ 52.3g of biscuits compared to no	Missing.

Cue exposure	Design	Sample	Cue	Duration	Explicitly aware of cue(s)?	Mean change in intake	Cohen d
			Imagine eating.			exposure.	
Shimizu & Wansink (2011).	BS	Restrained eaters (Herman & Polivy, 1980).	Television programme featuring food.	30 minutes.	X No explicit instructions to attend. Clearly visible.	↑ 60 kcal of chocolate and sweets compared to control.	0.51 medium.
Soetens et al. (2008).	BS	HRHD (van Strien, et al., 1986).	Tempting snack.	24 hours.	✓ Smell every 3 hours.	↑ compared to no cue. Amount not specified.	1.38[a] large.
Stirling & Yeomans (2004).	BS	Restrained eating (Stunkard & Messick, 1985).	30 chocolates.	24 hours.	✓ Responded to questions about chocolate x 4.	↑amount not specified.	0.78[a] large.
Diet-congruent							
Anschutz et al. (2008).	BS	Restrained eating (van Strien, et al., 1986).	Television commercial of slim models or diet products.	3.5 minutes.	X No explicit instructions to attend. Clearly visible.	↓ compared to control. Amount not specified.	0.43 small-medium[b].
Boland et al. (2013).	BS	General.	3 television commercials of healthy food.	Not specified.	X No explicit instructions to attend. Clearly visible.	↓ 1.08 ounces of M&Ms compared to control (only in afternoon).	0.83 large.
Brunner (2010).	BS	General.	Weighing scales.	10 minutes.	X No explicit instructions to attend, 50% reported noticing the cue.	↓ 2.21 pieces of chocolate compared to control.	Missing.
Brunner & Siegrist (2012).	BS	General.	Slim human-like sculptures on computer screensaver.	Not specified.	X No explicit instructions to attend. Participants could see cue if “moved	↓ 1.72 pieces of chocolate compared to control.	0.45 small-medium.

Cue exposure	Design	Sample	Cue	Duration	Explicitly aware of cue(s)?	Mean change in intake	Cohen d
					head slightly to the side" (p. 1110).		
Harris et al. (2009).	BS	Restrained eaters (Polivy, et al., 1978).	4 food and beverage television commercials.	Not specified.	X No explicit instructions to attend. Clearly visible.	↓ compared to control. Amount not specified.	Missing.
Mann & Ward (2004).	BS	General.	Weighing scales, diet books and a tempting recipe.	7 minutes.	X No explicit instructions to attend but all participants included in the analysis reported seeing 2/3 of the cues.	↓ 89g of milkshake compared to tempting cue.	0.99 large.
Papies & Hamstra (2010).	BS	Restrained eaters (Herman & Polivy, 1980).	Poster featuring a slimming recipe.	Not specified.	X 23% reported noticing the poster.	↓ compared to control. Amount not specified (less than 1 meat snack).	Not specified[13].
Pelaez-Fernandez & Extremera (2011).	BS	Restrained eaters (Polivy, et al., 1988).	Diet magazine with slim models.	10 minutes.	X No explicit instructions to attend.	No effects.	Not specified.
Strauss et al. (1994).	BS	Restrained eaters (Herman & Polivy, 1980).	Television commercial with references to	1.5 minutes.	X No explicit instructions to attend. Clearly	↑ 44g compared to control.	0.63 medium.

[13] Papies & Hamstra (2010) report partial eta squared for the effect size and indicate a small effect for diet-congruent cues on restrained eaters intake compared to control, $\eta p^2 = .03$.

Cue exposure	Design	Sample	Cue	Duration	Explicitly aware of cue(s)?	Mean change in intake	Cohen d
			dieting, diet products and slim body image.		visible.		
Diet-congruent (current thesis)							
Chapter 3	WS	Dieters	Images of diet-congruent food/beverages.	2.08 seconds in total (2 phases of 45 images exposed for 23ms each) distributed across 10 minutes.	X Images appeared while participants completed a different task.	↓ 106 ± 45 kcal compared to control (p = .04).	0.93, large.
Chapter 4	WS	Dieters	Sight and smell of diet-congruent food (fresh oranges).	10 minutes.	✓ Sensory assessment of food and memory recall task.	↓ 91 ± 57 kcal compared to tempting (p = *ns*).	0.84, large.
Chapter 6	WS	Dieters	Intake of diet-congruent food (salad).	10 minutes.	✓ Sensory assessment and memory task.	↓ 163 ± 61 kcal compared to control (p = .02).	1.33, large[14].

Note.
BS= Between-subjects.
WS = Within-subjects.
All effect sizes refer to between condition effects within one group unless stated
[a] Assuming equal distribution of participants.
[b] Effect size refers to the restraint x condition interaction.

[14] Please note in Chapter 3, 4, and 5 partial eta squared was reported for the effect size. However, to compare effect sizes with previous studies Cohen's d was calculated and reported here.

However, there are a number of issues with the existing literature on diet-congruent cues that were important to address in the current thesis. Firstly, as previous studies focused on restrained eaters and general samples it was unclear whether diet-congruent cues were equally potent to remind dieters to adhere to their diet goal. Since dieters are particularly vulnerable to tempting food cues (Cameron, et al., 2008; Hill, 2004) and prone to weight gain or regain (Mann & Ward, 2004; Thomas, 1995), diet-congruent cues could assist in attempts to limit intake. Furthermore, diet-congruent cues might be particularly salient to dieters because of their relevance to diet goals. It has been shown that those with goals to lose weight, bias their attention and perceptual processes to detect cues in the environment that are instrumental to fulfilling the weight loss goal (Papies, et al., 2008a; van Koningsbruggen, et al., 2011). Thus examining dieters' response to diet-congruent cues was worth investigation. Secondly, a lot of the diet-congruent and tempting cue research has classified participants based on the Restraint Scale (Herman & Polivy, 1980; Polivy, et al., 1988). However, this scale has been criticised for confounding restrained eating with disinhibition and purer measures of restraint and disinhibition are preferable (Stunkard & Messick, 1985). Thirdly, a criticism of the studies examining diet-congruent and tempting cues is the use of between-subject designs (see Table 7.1). The alternative within-subject designs have been advocated over between-subject designs because they reduce non-systematic variance involved in eating behaviour (Blundell, et al., 2010). Finally, the type of diet-congruent cues have varied across studies from displaying cues in television adverts (Anschutz, et al., 2008; Boland, et al., 2013; Harris, et al., 2009; Strauss, et al., 1994) and screensavers (Brunner & Siegrist, 2012) to the use of cues in the real world (Papies & Hamstra, 2010) and the experimental room (Brunner, 2010; Mann & Ward, 2004; Pelaez-Fernandez & Extremera, 2011). Some studies indicate that healthy or diet perceived foods presented in television adverts (Anschutz, et al., 2008; Boland, et al., 2013; Harris, et al., 2009) might limit snack intake in restrained eaters. Yet engaging with the sensory properties of diet-congruent food might be more effective to reduce dieters' food intake and offer a convenient and cheap strategy for dieters to engage themselves with diet-congruent cues. Thus, the current thesis examined dieters' and restraint and disinhibition subtypes' (as classified with the TFEQ) (Stunkard & Messick, 1985) snack and meal intake in response to diet-congruent cues (specifically diet-congruent food or beverages) using between-subject designs (Chapter 3) and within-subject designs (Chapter 4, 5, and 6).

Diet-congruent food cues were selected as the diet-congruent cue because foods can be perceived as diet-congruent (Carels, et al., 2007; Sobal & Cassidy, 1987, 1990) and are cues that are instrumental to weight loss (van Koningsbruggen et al. 2011). Furthermore, evidence for the goal priming mechanism has yet to be discerned clearly alongside changes in intake. For the first time, this thesis examined the role of diet-congruent food cues on dieters' food intake and measured the salience of diet and tempting thoughts to elaborate the goal priming explanation.

In order to meet the overall aim of this thesis, a number of specific objectives were expressed and tested:

a) To invite consumers to categorise a range of foods as diet-congruent or tempting since those most associated with dieting are likely to be potent diet-congruent cues

b) To assess appetite in response to diet-congruent cues since subjective sensations influence intake

c) To consider the impact of individual differences such as restrained eating and disinhibition in response to diet-congruent cues

7.2 Summary of thesis findings

Consumer surveys of snack based foods (Chapter 4) and appetisers (Chapter 6) provided clear prototypical examples of diet-congruent and tempting foods (Loersch & Payne, 2011). Salad, rice cakes, carrots, tomatoes, oranges and grapefruit were revealed as diet-congruent foods and chocolate, cake, biscuits, garlic bread, pizza, crisps and cheese sticks were identified as tempting foods.

This thesis has shown that using progressively more complex diet-congruent cues from images, sight and smell to consumption of diet-congruent foods were effective under some circumstances to reduce dieters' snack and meal intake. Specifically, Chapter 3 showed diet-congruent *image* cues reduced dieters' intake of a LFSW food by 40% compared to non-food control images. Chapter 4 reported that exposure to the *sight and smell* of a diet-congruent food (fresh oranges) reduced dieters' energy intake of a tempting food (chocolate) by 40% compared to exposure to a tempting food cue (chocolate orange). However, when this study was extended to include a control condition, diet-congruent odour cues did not produce any differences in dieters' and non-dieters' energy intake in conditions of moderate hunger (Chapter 5). Finally, *consumption* of diet-congruent food (salad) was shown to reduce dieters' energy intake by 21% compared to isocaloric loads of a tempting food (garlic bread) and non-caloric control intake (water) (Chapter 6). Across all studies, non-dieters' energy intake did not differ in response to a diet-congruent cue.

As well as diet status, individuals scoring high in restraint and disinhibition (HRHD) were selectively responsive to diet-congruent cues. Following exposure to diet-congruent images (Chapter 3) and the sight and smell of diet-congruent food (Chapter 4) HRHD eaters reduced snack intake compared to control images and a tempting food cue. Yet, HRHD energy intake was unaffected by consumption of a diet-congruent food (Chapter 6).

The salience of diet and tempting thoughts appeared not to form part of the mechanism by which energy intake was reduced in response to diet-congruent cues. Rather, diet words appeared to have increased salience over neutral words (Chapter 6) and tempting words (Chapter 3) regardless of condition and results were unclear in Chapter 5. Thus, the current thesis did not find support for increased diet salience in dieters to account for reduced energy intake following diet-congruent cues.

The effects of diet-congruent cues on subjective appetite sensations were only found after consumption of diet-congruent food, thus appetite appears to be most affected by eating itself not just more subtle exposure to the diet-congruent cues. Both dieters and non-dieters reported lower desire to eat and felt fuller after intake of a diet-congruent food compared to intake of a tempting food or control. In contrast, hunger, desire to eat and fullness did not change in response to diet-congruent images nor the sight and smell of diet-congruent food.

Taken together, the studies established the role for diet-congruent cues to reduce dieters' snack and meal intake (for a progression of studies see Table 7.2). Limitations of the studies are recognised but the implications of these findings could involve translation to real world situations to assist dieters in resisting temptation when actively limiting intake.

Table 7.2. Summary of research findings.

Study characteristic	**Chapter 3**	**Chapter 4**	**Chapter 5**	**Chapter 6**
Design				
	Between-subjects	Within-subjects	Within-subjects	Within-subjects
Cue type				
Potency	Images 9 diet-congruent images. - 9 control images.	Odour - Diet-congruent (fresh oranges). - Tempting (chocolate orange).	Odour - Diet-congruent (fresh oranges). - Tempting (chocolate orange) - Non-food odour (soap).	Intake Diet-congruent (salad). - Tempting (garlic bread). - Control (water).
Rated diet-congruency.	- Post-study ratings on VAS.	- Pre-study online survey showed fresh oranges were associated with dieting and chocolate orange was associated with temptation. - Post-study health and temptation ratings.	- Same as Chapter 4. - Pre-study survey confirmed diet related words.	- Pre-study online survey confirmed salad was diet-congruent and garlic bread was tempting. - Participants estimated salad to contain fewer calories compared to garlic bread at post-study.
Food intake				
Assessment	Snack - LFSW, LFSA, HFSW, HFSA.	Snack - Diet-congruent, tempting, intermediate.	Snack - LFSW, LFSA, HFSW, HFSA.	Meal - Cheese and tomato pizza.
Outcome	- Dieters reduced LFSW intake by 40%.	- Dieters reduced intake of tempting snack by 40%.	- No effects. Dieters and non-dieters consumed similar amounts between conditions.	- Dieters reduced meal intake by 21% in the diet-congruent condition compared to tempting and control conditions.
Appetite				
Outcome	No differences between	No differences between	No differences between	Less desire to eat and greater

Study characteristic	Chapter 3	Chapter 4	Chapter 5	Chapter 6
	conditions for dieters and non-dieters.	conditions for dieters and non-dieters.	conditions for dieters and non-dieters.	fullness in the diet-congruent condition compared to tempting and control for dieters and non-dieters.
Salience				
Measured	✓	X	✓	✓
Design	Lexical decision task included 4 diet words, 4-tempting words, 48-neutral and 48-non-words. Words selected from previous research.	N/A	Lexical decision task included 15-diet words, 15-tempting words, 15-neutral words (RTs not recorded to neutral words) and 15-non-words. Words rated in pre-study survey for association with dieting and temptation.	Same as Chapter 5.
Outcome	RTs to diet words were faster compared to tempting and neutral words. No group differences.	N/A	RTs faster in diet-congruent and tempting condition regardless of word type or group.	RTs to diet and tempting words were faster compared to neutral words regardless of condition and group.
Directions	-	-	-	-
	- Test more potent cues than images to increase likelihood of reducing HFSW food. - Examine food intake independent of lexical decision task. - Isolate one diet-congruent	- Examine eating behaviour in more tempting situations (not offering diet-congruent food). - Include a control condition to identify whether the difference in energy intake between conditions is due to inhibition of intake or	- Test diet-congruent cues in hungry participants. - Test a more potent cue than odours. - Examine the effect of diet-congruent cues on meal intake.	- Apply diet-congruent findings to more ecologically valid settings.

Study characteristic	Chapter 3	Chapter 4	Chapter 5	Chapter 6
	cue to examine to identify effects on food intake. - Use WS design (Blundell, et al., 2010).	cue reactivity in response to a tempting food. - Examine goal salience in response to diet-congruent food odours. - Test effect of diet-congruent food odours on general snack intake, not specific preload snacks.		

Note. WS = within-subjects.

7.3 Implications of findings

7.3.1 Nature of diet-congruent preloads

As the experiments progressed within this thesis, the potency of diet-congruent cues increased. The idea that diet-congruent cues from images to odours to intake could reveal a greater efficacy of action was tested. Thus sensory modality was manipulated via visual (Chapter 3), visual and olfactory (Chapter 4 and 5) visual, olfactory and taste preloads (Chapter 6). Imagery, whilst the most common form of food cue is also the least potent cue to prompt food intake compared to the sight and smell of food and, that the combination of appearance, smell, texture and taste provides the most potent cue compared to odours and image preloads (Jansen & van den Hout, 1991; Mattes, 1997). This spectrum of potency might also apply to diet-congruent cues' capacity to inhibit intake of tempting food. Images might be the least potent to inhibit snack intake because they are less physiologically stimulating and more subject to distraction compared to odours and consumption. Indeed, Pelaez-Fernandez & Extremera (2011) found the presence of diet-congruent imagery in the form of a diet magazine left on the table was not sufficient to reduce restrained eaters' snack intake. It is possible that participants' attention was distracted away from the cues and thus images had little impact on subsequent intake (Pelaez-Fernandez & Extremera, 2011). Odours might be less subject to distraction compared to images because of greater physiological stimulation (Engelen, de Wijk, Prinz, van der Bilt, & Bosman, 2003; Epstein, Saad, et al., 2003; Rogers & Hill, 1989) and closer links between food odours and food intake (Rogers & Hill, 1989). Finally, consumption of food might be the most salient cue to impact appetite and food intake. Indeed, across the three types of diet-congruent cues, the magnitude that the diet-congruent cues reduced intake were all large and were greatest for consumption compared to odours and images (see Table 7.1). Also, when comparing energy intake across cues relative to the amount offered in each study, participants reduced intake the most when consuming diet-congruent food compared to exposure to images and odours.[15][16] Figure 7.1 illustrates this

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[15] Comparing the proportion of energy intake consumed from the test meal in the diet condition minus the proportion of energy intake consumed from the test meal in the tempting (preload and odour cues – within-comparisons) or control condition (images cue- between comparisons).

[16] Main effect of cue, $F(2, 127) = 3.52$, $p = .03$, . $\eta p^2 =$ 05. Bonferroni corrections showed the difference in the proportion of intake between conditions was greatest following intake of diet-congruent food compared to exposure to diet-congruent images ($p < .05$) and marginally greater compared to odours ($p = .06$).

pattern with absolute difference scores for energy intake between the diet-congruent and tempting or control conditions. Thus, the pattern of suppressed energy intake suggests intake of diet-congruent foods might be the most potent diet-congruent cue.

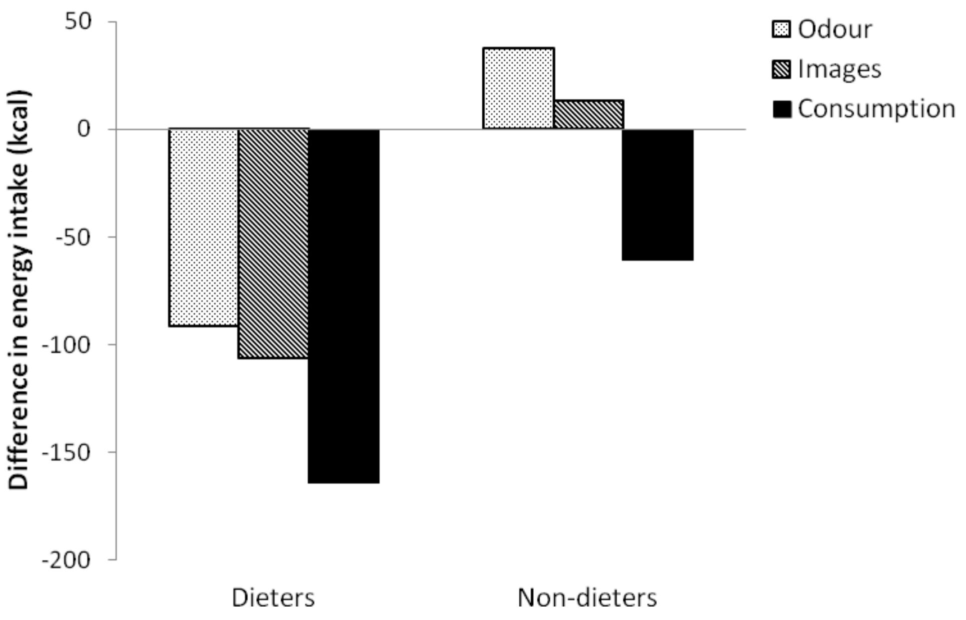

Figure 7.1. Absolute energy difference between diet-congruent cue exposure and control (images) or tempting food cue exposure (odour and intake).

Note: for odours and consumption the difference scores refer to intake in the diet condition less intake in the tempting condition. For images, the difference scores refers to intake in the diet condition less intake in the control condition. A negative score indicates suppression in the diet condition relative to the comparison condition.

As well as changing modality, the degree to which the cue was attended to increased across studies. For instance, image exposure for 2.08 seconds (2 phases of 45 trials at 23 ms each) distributed across 10 minutes (Chapter 3) was subsequently followed with instructions to attend to the diet-congruent odour for 10 minutes (Chapter 4) and consumption of the preload was paced at 10 minutes (Chapter 6). Taken together, diet-congruent cue exposure varied from subtle and short to explicit and long in duration, with engaged attention also varying. Previous studies with successful suppression of food intake have exposed participants to diet-congruent commercials for 3.5 minutes (Anschutz et al. 2008), tested participants in a laboratory room with scales, diet books and a tempting recipe for 7 minutes (Mann & Ward, 2004) and scales for 10 minutes (Brunner et al. 2010). Other studies have not reported exposure duration (Brunner & Siegrist, 2012; Papies & Hamstra, 2010). In terms of attentiveness to cues all the previous studies have used subtle exposure to cues without explicitly directing participants' attention to the cues. Furthermore, when asked whether participants noticed diet-congruent cues (during debrief) in some instances only half (Brunner, 2010) or 25% of the sample noticed diet-congruent cues (Papies & Hamstra, 2010), while Brunner & Siegrist (2012) did not report whether participants noticed the diet-congruent cues or not. Critically, subtle exposure to diet-congruent cues is not always effective to reduce intake (Pelaez-Fernandez & Extremera 2011), possibly because subtle cues can be subject to distraction. Importantly, the present thesis showed that as well as subtle exposure (Chapter 3), mindful interaction with diet-congruent cues can successfully reduced dieters' snack and meal intake (Chapter 4 and 5). The findings on mindful interaction with diet-congruent cues reflect similar reports on mindfulness training.

Mindfulness training has been applied and tested in the control of eating behaviour. Mindful eating is characterised by focused attention to the experience of eating (such as sight, smell and taste of food), to bodily sensations that arise from eating (such as appetite sensations) and food related thoughts including awareness of cravings (Framson, et al., 2009). Training mindful eating seems to be beneficial to the control of food intake. For instance, an 8-week cognitive based mindfulness strategy (Alberts, Thewissen, & Raes, 2012) targeting awareness of taste, appetite sensations, eating related thoughts , acceptance of desires and changes in eating behaviour reduced cravings in problematic eaters (emotional eaters, stress induced eaters, mindless eaters) compared to a waiting list control. Mindfulness strategies focusing on accepting rather than avoiding food related thoughts also curbed cravings in overweight participants (Alberts, Mulkens, Smeets, & Thewissen, 2010), those with increased appetite for palatable food cues (Forman, Hoffman, Juarascio, Butryn, & Herbert, 2013; Forman, et al., 2007) and reduced snacking in overweight women (Forman, et al., 2013). Even short term mindfulness training in the laboratory, that encouraged participants to view bodily sensations as temporary, reduced approach biases to palatable food images (Papies, Barsalou, & Custers, 2012). Moreover, female dieters had lower BMI scores 6 months after a mindfulness intervention which trained motivation and acceptance techniques (Tapper, et al., 2009). Similarly, in Chapter 4 and 6 dieters focussed on the sensory properties of diet-congruent food cues (odour and memory recall) and this reduced subsequent energy intake. Thus, mindfulness strategies increasing awareness of sensory properties of food, awareness of appetite sensations and accepting food related thoughts appear to be effective as strategies to limit intake with potential benefits for weight loss.

7.3.2 Appetite sensations

Subjective sensations of appetite were tracked across studies in response to diet-congruent and tempting cues. The goal conflict theory makes no predictions about appetite sensations (Stroebe, et al., 2008; Stroebe, et al., 2013) but the emphasis on non-conscious goal-directed behaviour would infer that intake occurs independent of motivational state. Indeed hunger, desire to eat and fullness were similar after exposure to diet-congruent images and odours compared to control or tempting cues. Yet, with consumption of a diet-congruent food, dieters reported decreased sensations of hunger and desire to eat and increased fullness relative to a tempting and control preload. Interestingly, as hunger has been given as a main reason for dieters' breaking restrictive eating plans (Stubbs, et al., 2012) managing hunger alongside exposure to diet-congruent cues seems a potentially successful weight control strategy.

Interestingly, the lack of differences in energy intake reported in Chapter 5 indicated that motivational state was centrally important in moderating the effects of diet-congruent cues. Diet-congruent cues may be most effective in dieters when hungry and this idea should be a focus of subsequent research on diet-congruent cues.

7.3.3 Goal priming as a mechanism?

Evidence for a goal priming explanation in the current studies rests on the finding that only dieters responded to the diet-congruent preloads by reducing energy intake compared to tempting and control conditions. In contrast, non-dieters' energy intake did not differ after diet-congruent preloads compared to control and tempting preloads. This specific response is consistent with goal priming theory that only those with goals to lose weight will be responsive to diet-congruent cues (Custers & Aarts, 2010; Stroebe, et al., 2008; Stroebe, et al., 2013).

To test the goal priming explanation, lexical decision tasks were administered in Chapters 3, 5 and 6 to measure the salience of diet and tempting thoughts. The lexical decision task in

Chapter 3 included 4 words used in previous goal priming studies. Due to a floor effect in reaction times to diet words across the diet and control conditions, the lexical decision tasks in Chapter 5 and 6 were modified to improve the reliability of the task. The lexical decision tasks in Chapter 5 and 6 included more diet words, and all words were selected based on their close association with dieting to lose weight as attested in a pre-study survey (Chapter 5). Despite modifications neither Chapter 5 nor 6 showed enhanced diet salience in the diet condition relative to the tempting and control conditions. In Chapter 5, the lexical decision task was difficult to interpret due to a data collection error for neutral words. For Chapter 6 the shortened reaction times to both diet and tempting words suggested increased salience of these words regardless of condition.

The current findings are inconsistent with other studies that included lexical decision tasks and reported differences in reaction times to diet words following exposure to tempting food words compared to control (Stroebe et al. 2008; Papies et al. 2008). Such studies have only yielded effects when using between-subjects designs (Stroebe et al. 2008; Papies et al. 2008). It is possible that a lexical decision task on diet words is not appropriate for repeated measures designs examining eating behaviour constructs. The shorter reaction times to diet and tempting words in Chapter 6 might be due to practice effects occurring over the three sessions with participants becoming increasingly faster to recognise words that were salient even at baseline. Additionally, the lexical decisions tasks used in the current studies included both diet and tempting words to ambitiously demonstrate the competing nature of diet and tempting thoughts (Shah, Friedman, & Kruglanski, 2002). The presence of both diet and tempting words might have negated the impact of the preload on the detection of preload-consistent words as tempting words have been shown to lengthen reaction times to diet words (Papies, et al., 2008b; Stroebe, et al., 2008).

Furthermore, there are methodological drawbacks of measuring the effects of both goal salience and food intake, as the lexical decision task can interfere with eating behaviour (Stroebe et al. 2013). However, it is essential to resolve underlying cognitive explanations and to develop sensitive tasks to measure the salience of diet and tempting thoughts. In the current thesis, there is insufficient evidence of the role of goal salience in the reported outcomes.

7.3.4 Novel contributions

The current findings advance goal priming research in two main ways. Firstly, the research has systematically provided evidence for the efficacy of direct interaction with diet-congruent food cues to limit snack and meal intake under conditions of temptation. Secondly, the effect of diet-congruent food cues has been demonstrated in active dieters. These findings are important because knowing that attention to diet-congruent cues and more importantly consumption of diet-congruent foods can help dieters to limit intake, then these can be sought out actively by those dieting to lose weight. As the environment contains a constant mix of diet-congruent and tempting cues, foods are likely to be more common and available within the home than weighing scales (Brunner 2010; Mann & Ward 2004), diet books (Mann & Ward, 2004), and slim models (Anschutz, et al., 2008; Brunner & Siegrist, 2012). Whether these cues are effective in the long term is not yet known. What is known is that hunger seems to moderate the effect of diet-congruent odours (Chapter 5) and that dieters are more selectively responsive to diet-congruent cues than non-dieters (Chapter 3, 4, and 6).

It is also possible that increasing exposure to diet-congruent foods cues in the environment might reduce feelings of perceived deprivation (Lowe & Levine, 2005; Timmerman & Gregg, 2003). It has been suggested that in response to tempting food cues, dieters have to decline opportunities to eat palatable food, which leads dieters to feel like they have consumed less food than desired (Lowe & Levine, 2005; Timmerman & Gregg, 2003). This perceived deprivation might partially explain dieters' difficulty to adhere to restrictive eating plans (Lowe & Levine, 2005; Timmerman & Gregg, 2003). In contrast, attending to the sensory properties (such as the odour, feel and taste) of diet-congruent food could divert attention away from tempting food cues and reduce perceived deprivation. Thus, the effects of diet-congruent cues on perceived deprivation poses an interesting question for future research.

7.3.5 Limitations

Despite the merits of testing diet-congruent cues in controlled settings, this approach does not reflect the complexity of real world settings. The studies presented diet-congruent cues free from competing cues. In more ecologically valid settings diet-congruent cues might occur within a wealth of competing tempting cues which can limit the extent diet-congruent cues can affect subsequent intake (Strauss, et al., 1994). It is also unclear whether an additive effect might occur for multiple diet-congruent cues, and what the optimal number of diet-congruent cues is to reduce dieters' intake. Thus, although the current study provided evidence for the role of diet-congruent cues, the effect of diet-congruent cues within multiple tempting and diet-congruent cues is unknown.

Another issue related to ecological validity is that the current thesis tested the short term effects of diet-congruent cues on food intake, and the longevity of diet-congruent cues remains to be established. It is currently unclear how effective diet-congruent cues are when used repeatedly over a longer period of time. It is possible that responsiveness to specific diet-congruent cues might decline over time and that a variety of diet-congruent cues are needed to maintain responsiveness. Future research needs to address this issue.

To further understand the usage and efficacy of diet-congruent cues it might have been useful to obtain qualitative data on dieters' attitudes and beliefs about diet-congruent cues. The current quantitative data presented in the current thesis was essential to objectively understand and substantiate the role of diet-congruent cues on dieters' snack and meal intake. However, the absence of qualitative data reduces understanding about whether dieters were consciously thinking about dieting when interacting with the food. The studies did record qualitative data on memories and these did not suggest that dieters were recalling memories about dieting. However, it could be useful to conduct qualitative interviews post-study to identify whether dieters thought diet-congruent cues reduced their subsequent intake for this reason or reduced intake due to an alternative reason. The current studies did not include this post-study measure to prevent contamination across participants about the true purpose of the study. However, in-depth interviews with dieters would complement the quantitative data in terms of identifying potential explanations for the reduced food intake.

The use of diet-congruent cues has real world implications. In 2010, the UK coalition government were inspired by the book "Nudge: Improving decisions about health wealth and happiness" (Thaler & Sunstein, 2009) and established a "behavioural insights team" to specifically examine the impact of nudges, such as priming with environmental cues, for behaviour change. However, the magnitude that priming alone can impact clinical outcomes such as weight loss has been questioned (Marteau, Ogilvie, Roland, Suhrcke, & Kelly, 2011; Michie & West, 2013). In support that small behavioural manipulations can affect weight loss, an internet delivered weight loss program focusing on small behaviour changes, such as drinking water with every meal and using smaller plates, reported weight loss of 1kg per month for those who adhered to the intervention (Kaipainen, Payne, & Wansink, 2012). However, the results of the intervention were based on self-report data and were not compared to a control group. Future studies need to assess the efficacy of short term manipulations such as diet-congruent cues for clinical outcomes. It might be that diet-congruent cues can complement weight loss regimens but their sole impact to affect clinical outcomes on a wide scale might be minimal.

7.4 Future Directions

The promising results of diet-congruent preloads to reduce food intake in the laboratory urge this approach to be applied and tested in weight loss programs. Integrated in to a weight loss program dieters could be encouraged to i) increase the presence of diet-congruent foods at home and places where they are most likely to overeat; ii) focus on the sensory properties of diet-congruent foods when tempted by diet-forbidden food and iii) eat diet-congruent preloads prior to each meal. Indeed one study has found that consumption of grapefruit preloads prior to meals was associated with weight loss amounts equivalent to consuming water preloads (Silver, 2012). The current findings suggest that encouraging dieters to be mindful of the diet-congruent preload during consumption might enhance weight loss to be greater compared to intake of water.

Ways to deliver diet-congruent strategies in weight loss programmes to ensure dieters initiate engagement with diet-congruent cues should also be a focus of future research. Implementation intentions might be one approach to deliver diet-congruent cues (van Koningsbruggen, et al., 2011). Implementation intentions form a mental link between an event and a specific behaviour, thus when the event is encountered the behaviour will be automatically initiated (Gollwitzer, 1999). Implementation intentions consist of “if (situation)…then (behaviour)” plans. For example, specifying detailed plans about when and where dieters would exercise and eat certain foods increased weight loss over 2 months in commercial weight loss dieters compared to those who did not form implementation intentions (Luszczynska, Sobczyk, & Abraham, 2007). There is some evidence that implementation intentions can be effective to initiate diet-congruent thoughts to cue regulated food intake. For example, forming the plan “if I am tempted to eat chocolate then I will think of dieting!” reduced restrained eaters’ (scoring low on PSRS) self-reported food intake over 2 weeks (van Koningsbruggen, Stroebe, & Aarts, 2012b).

Applying this technique to diet-congruent food cues and including objective measures of food intake needs to be tested. Another strategy might be to deliver diet-congruent image exposure through the use of smart phone applications. One study demonstrated the feasibility of smart phone applications for weight loss trials showing participants used the application regularly and with ease (Robinson, et al., 2013). A diet-congruent smart phone application could be set to regularly display images of diet-congruent preloads to dieters, and even be timed to be triggered at set meal times to ensure dieters were exposed to diet-congruent images.

Individual differences in response to diet-congruent cues are likely to be important. Each study reported a range of behaviours adopted by dieters which reflects large variation within dieters (Martz, et al., 1996; Stubbs, et al., 2012; Timko, et al., 2006). In larger sample sizes, future researchers might explore subgroups of dieters to identify those most susceptible to overeating who might benefit most from diet-congruent preloads. This thesis has provided convincing evidence for the efficacy of diet-congruent cues overall, but specific food items could be identified as personally significant and tailored to the needs of individual dieters. The idea that nutrition and weight management interventions can be tailored to genetic differences between individuals is hotly debated and under current scrutiny. Electronic monitors have been developed in which consumers can identify their phenotype and receive tailored nutritional and exercise plans via email or smart phone applications (Hurling, et al., 2007; Morikawa, Yamasue, Tochikubo, & Mizushima, 2011). However, there is question about whether there is sufficient evidence that tailored interventions are more effective than general programmes, especially as tailored programmes might be unlikely to affect motivations to change eating behaviours (Gorman, Mathers, Grimaldi, Ahlgren, & Nordstrom, 2013). The European Union Seventh Framework Program Food4Me is currently seeking to identify consumer attitudes towards and the efficacy of tailored interventions (Gibney & Walsh, 2013).

Importantly, Chapter 5 highlighted the potential impact of moderators. Future research should examine whether motivated states affect the efficacy of diet-congruent primes. Indeed, research has found primes to only be effective in the afternoon and not morning, suggesting primes might be most beneficial when self-control resources are low (Boland, et al., 2013). Similarly, research on diet-congruent food cues should be examined under hunger and sated states.

7.5 Closing Statement

Despite the limitations of the experiments reported here, the role of diet-congruent food-related cues to assist dieters to regulate snack and meal intake has been demonstrated. The underlying processes that explain this effect are yet to be fully understood. Research priming diet-congruent foods is in its early stages and the findings reported here hope to generate future avenues of exploration that apply goal priming more. In the absence of a specific goal salience explanation it is nevertheless worthwhile to explore the application of diet-congruent cues within a mindful approach to weight management in real world weight loss settings. This research suggests that being mindful by attending to the sensory properties of diet-congruent food can help dieters to limit snack and meal intake when tempted to violate diet plans.

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Appendices

Appendix A

1.1 Piloting image cue exposure and a lexical decision task

1.2 Aims

A pilot study was conducted to inform the design of image exposure in Chapter 3, and was used as a training exercise to develop skills to design and conduct experiments in E-prime 2.0 software (Psychology Software Tools, Inc).

1.3 Participants and design

Data was collected on 4 test mornings in July, September, November 2011 and June 2012. Participants were 173 sixth-form students (mean age: 17.00 ± 0.04 years; 133 females) attending University of Leeds open days. Of the female participants 25 reported being on a diet to lose weight, 18 were dieting to maintain weight and 90 were not dieting. Groups of up to 30 participants were tested in each session at individual computers. Participants were randomly allocated to be exposed to either 13 diet-congruent food images (n = 36) (e.g. banana, rice cakes, and yoghurt), 13 exercise images (n = 48) (e.g. sports shoe, sports clothing, yoga DVD), 13 tempting images (n = 53) (cake, chocolate and biscuits) or control non-food images (n = 36) (e.g. pencil case, cleaning products, and washing detergent). The main outcome variable was snack intake (cookies or cheese flavoured crisps). For control, subjective appetite sensations (hungry, desire to eat, fullness) and mood (tired, alert, happy, sad, relaxed, and anxious) were recorded on VAS.

1.4 Procedure

Measures of subjective states were recorded at the start of the session. Participants were then exposed to images. The images were presented during a bogus reaction time task and the pattern of image exposure started with a fixation cross on the screen (1500ms) followed by an asterisk pre-mask (80ms), an image (13ms) and was completed with an asterisk post-mask (80ms). The image exposure was followed by a pattern of coloured circles (ranging from 2-10 circles) appearing on screen. Participants made judgements about whether there were an odd or even number of coloured circles. The circles remained on screen until the participant responded by pressing either number ‘3’ (for odd numbers) and number ‘8’ (for even numbers) on the keypad. This bogus reaction time task was selected as a previous procedure showed it to be effective (Cesario, Higgins, & Plaks, 2006[17]). Next a lexical decision task was administered[18] followed by the snack test. Participants were given transparent bags of either cookies or cheese crisps and selected one snack to taste and complete a taste evaluation task on VAS (e.g. sweet, crunchy, bitter, moist, pleasant and tempting). After the 10 minute snack test participants completed questionnaires which asked them to report images they recalled seeing in the image exposure task, reported current diet status and height and weight. Finally participants were debriefed.

1.5 Results

An ANCOVA controlling for hunger, desire to eat and fullness was conducted on energy intake with condition as a between-subjects factor. There was a main effect of condition, $F(3, 164) = 5.00$, $p = .002$, $\eta p^2 = .08$[19]. Bonferroni corrections showed participants consumed 75 ± 19 kcal more after exposure to diet-congruent images compared to control images ($p = .001$). There were no other energy intake differences between conditions. However, desire to eat was a significant covariate, $F(1, 164) = 10.93$, $p = .001$, $\eta p^2 = .06$ with greater desire to eat in the diet condition compared to control.

Most participants were not aware of seeing any images (57%), 26% reported seeing one or 2 images, 9% saw 3 of the 13 images and 3% reported 4 or 5 images. The number of images seen did not differ between conditions.

1.6 Summary of findings

Conducting this pilot study served to practice using E-prime to design and conduct experiments, and to inform the design of image exposure for Chapter 3. In a group setting, subtlety exposing adolescent students to diet-congruent images increased snack intake compared to control non-food images.

Most participants were unaware of seeing images and tended to report circles from the exposure task. This suggests the circle task is distracting and that an alternative task should be used in Chapter 3. Additionally, the findings suggest the duration of cue exposure should be longer than 13 ms. The images are likely too complex for subliminal processing whereas

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[17] Cesario, Higgins, Plaks (2006). Automatic social behaviour as motivated preparation to interact. *Journal of Personality and Social Psychology*, 90, 893 – 910.

[18] The lexical decision task was included to practice using this task and exporting data from E-Merge to MS Excel 2007, not to analyse data.

[19] Despite males consuming more energy intake compared to females, [$F(1, 171) = 4.10$, $p < .05$] examining females only made no difference to the main effect of condition, $F(3, 125) = 4.82$, $p = .003$, $\eta p^2 = .10$.

conscious exposure at short durations [e.g. 23 ms (Stroebe, et al., 2008)] might be more effective to increase self-control in response to diet-congruent images.

In terms of the snack test, it was recognised that the snack foods provided were not sufficient quantities and too few choices to examine participants' intake. There were a number instances participants consumed very few or all of the snacks. This supports the idea that greater choice of snacks and larger quantities are needed to examine participants' food intake free from experimental constraints (Blundell, et al., 2010).

The nature of the group testing environment highlighted the importance of conducting human appetite research in high controlled settings and testing participants in individual cubicles. During the snack test some participants communicated with each other and a research assistant noticed some participants shared their snacks with fellow participants. Food intake might have also been influenced by the presence of others (Herman, Roth, & Polivy, 2003[20]). Therefore, this pilot study demonstrated the importance of examining eating behaviour in controlled settings.

Finally, the pilot study neatly illustrated the need to adopt procedures to standardise appetite. The pilot study involved no standardised instructions for participants to fast prior to each session. Consequently, desire to eat differed between conditions. The studies in the current thesis incorporated fasting periods and administered fixed lunches to control for appetite.

[20] Herman, Roth & Polivy (2003). Effects of the presence of others on food intake: A normative interpretation. *Psychological Bulletin*, 129, 873 – 886.

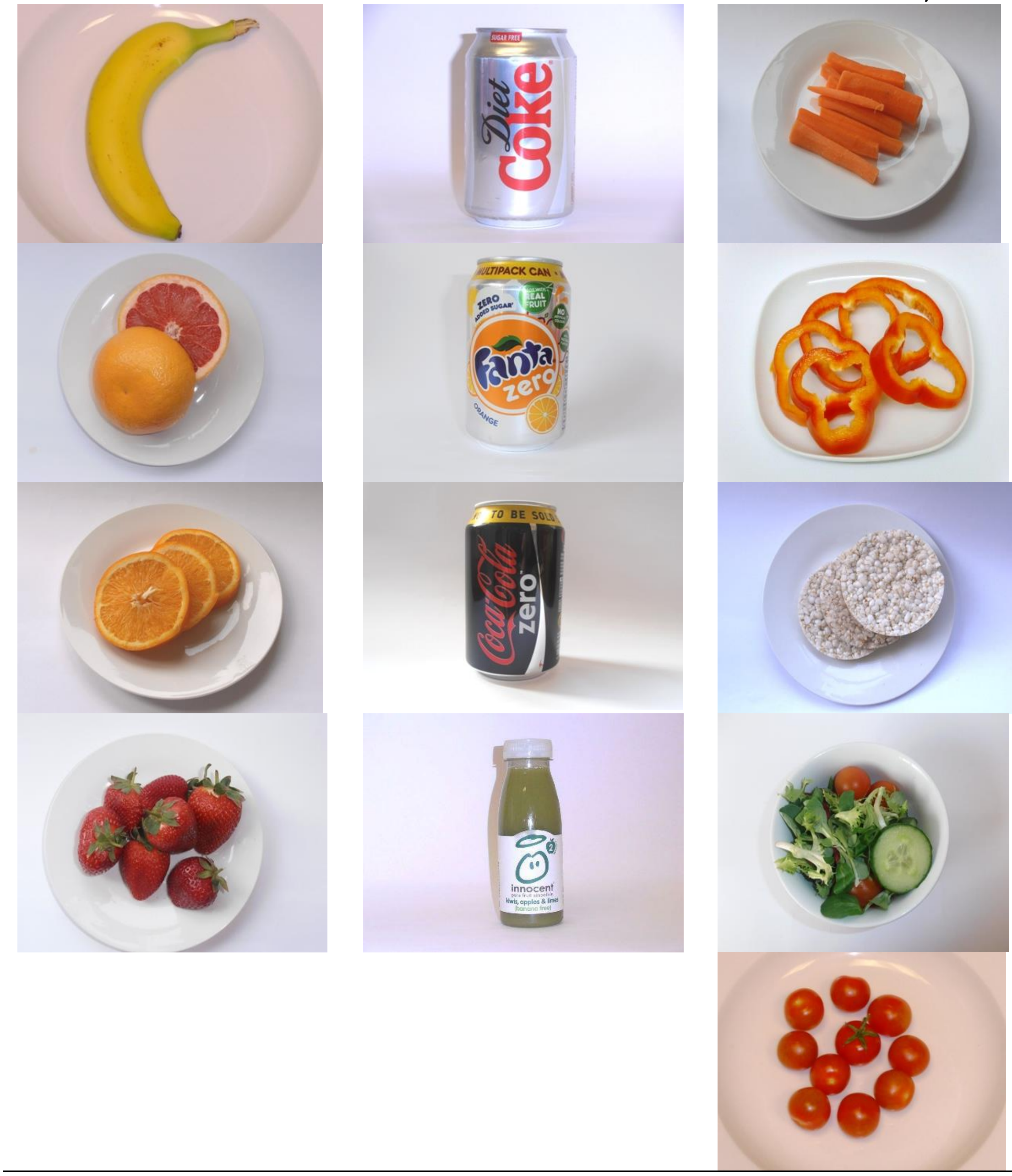
Appendix B

2.1 Survey items

All photos in Chapter 4 were photographed with an 8 megapixel camera, and edited for brightness in Microsoft Picture Manager. All photos were matched for size and brightness and sized to 408 (width) x 306 (height) pixels.

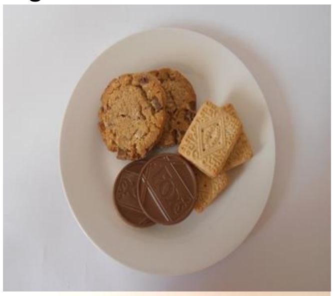
2.2 Low calorie sweet and savoury items

Low calorie sweet items | Low calorie savoury items



2.3 High calorie sweet and savoury items

High calorie sweet items | High calorie savoury items





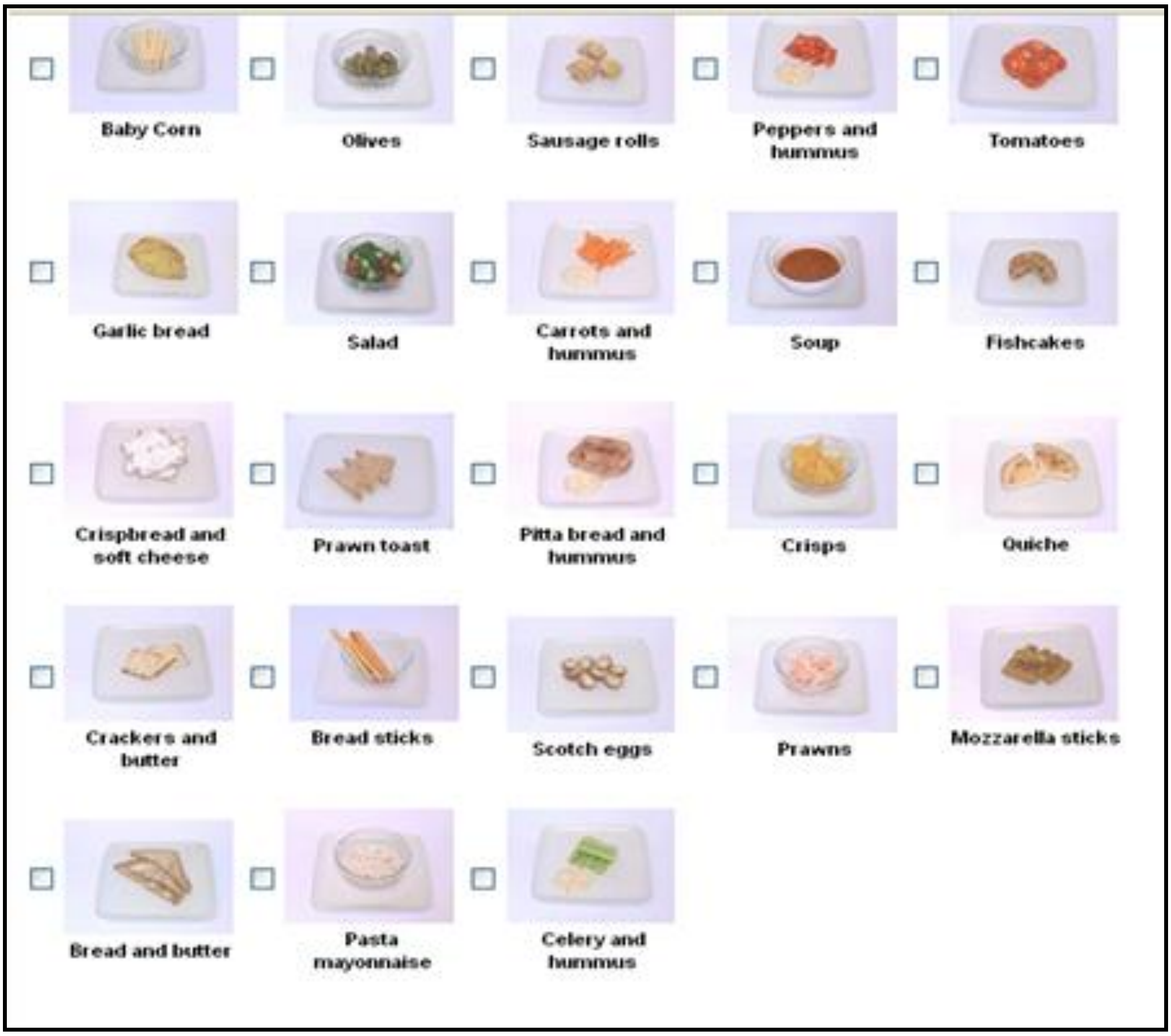






Appendix C

3.1 Survey selection task



Appendix D

4.1 Association Task

In Chapters 4 and 6 participants completed an association task on the survey food or beverage items. Each item was displayed individually and in Chapter 4 participants indicated whether they associated the food with “dieting to lose weight” and/or “temptation.” These constructs were embedded amongst two other constructs (“feeling energised” and “convenience”). The order of presentation of each item was randomly set prior to the survey for each respondent.

In Chapter 6 the association task was repeated but instead of categorical responses participants indicated the extent they associated each item with “dieting to lose weight” and “temptation” on a 7-point scale ranging from 1 (not at all associated) to 7 (extremely associated). A continuous scale was chosen in Chapter 6 to examine whether any foods were neither associated with dieting to lose weight nor temptation that could be used as a control. As result of the survey Chapter 6 selected water for a control rather than food.

Importantly, in the association tasks to prevent participants mindfully assessing each item participants were instructed not to spend long on each question but to respond with a rating that instantly came to mind. To prevent contamination ratings from items previously seen in the survey and to encourage uninhibited responses, participants were instructed to rate each item in isolation to those previously rated in the survey.

Appendix E

5.1 Survey candidate words

Diet candidate words	Hedonic candidate words	Neutral candidate words
Apple	Appetite	Bathing
Attractive	Baking	Blossoms
Body	Biscuits	Boxer
Calories	Buffet	Braces
Carbohydrates	Cake	Brick
Carrots	Cheesecake	Car
Celery	Chips	Contacted
Control	Comfort	Corrected
Dieting	Consume	Doubles
Disciplined	Craving	Doubt
Fasting	Creamy	Drain
Fibre	Decadence	Dust
Figure	Delectable	Empires
Fitness	Delicious	Fingertip
Fruit	Dessert	Fountain
Healthy	Divine	Futures
Kilograms	Eat	Gazing
Lean	Feast	General
Light	Food	Gusts
Monitoring	Gluttony	Handcuffs
Pounds	Gorge	Herds
Protein	Indulge	Holes
Regime	Melts	Husks
Restraint	Palatable	Lumps
Salad	Pizza	Molar
Scales	Restaurant	Molecule
Shape	Salivate	Parked
Size	Salty	Placed
Skinny	Satisfaction	Quickly
Slender	Savoury	Scared
Slimming	Scrumptious	Scored
Strict	Snacks	Sharpener
Thinner	Stuff	Sped
Tomatoes	Succulent	Structural
Trim	Sugar	Sweaters
Vegetables	Sweet	Taxed
Waist	Tasty	Tired
Water	Tempting	Triangle
Weigh	Urge	Updated
Willpower	Wanting	Whistling

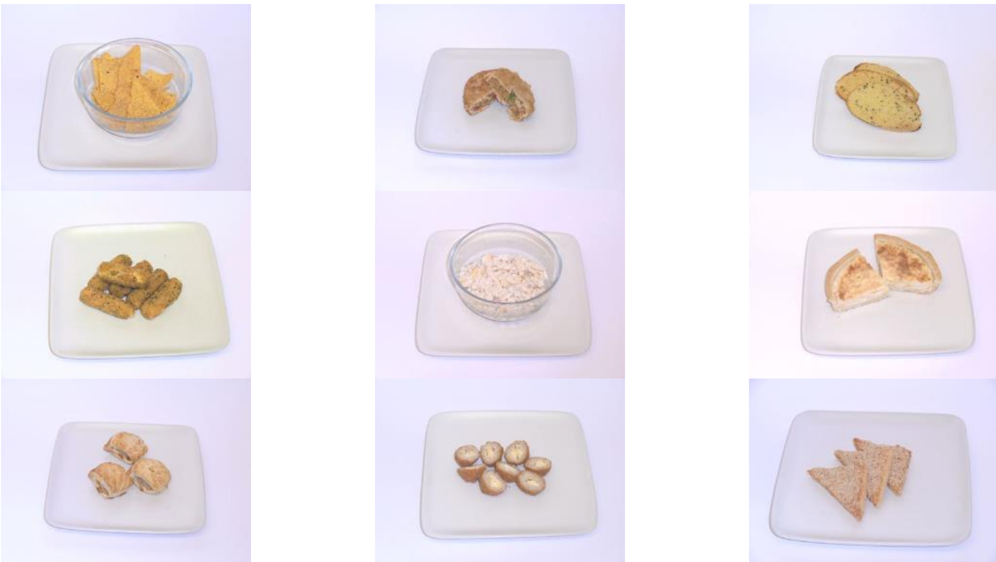
Appendix F

6.1 Pre-study preload foods

All photos in Chapter 4 were photographed with an 8 megapixel camera, and edited for brightness in Microsoft Picture Manager. All photos were matched for size and brightness and sized to 408 (width) x 306 (height) pixels.

6.2 Diet-congruent candidates

6.3 Tempting candidates



6.4 Neutral candidates






Appendix G

7.1 Piloting consumptive liquid preloads

7.2 Aims

The current study aimed to test the effect of labelled beverages on food intake in dieters and non-dieters.

7.3 Participants and design

The study tested 21 female participants aged 19 – 55 years (*M*: 28.7 ± 2.1 years), of which 3 were dieting to lose weight, 2 were maintaining weight and 17 were not dieting. Participants were recruited for a study with a cover story that the effect of packaging on flavour perception was being investigated. In a repeated measures design, participants attended the Human Appetite Research Unit on 3 days to receive a standardised lunch and two hours later were exposed to a diet-congruent beverage, a control regular beverage and no beverage (control). In the diet-congruent condition participants were provided with a diet branded can with a 40g sample of the regular version of the branded drink. In the control beverage condition, participants were provided with a regular branded can with a 40g sample of the regular branded drink. In the control-no beverage condition participants were provided with no packaging and no sample beverage. Importantly, despite incongruency between the diet condition and the sample provided, no participants reported that the sample in the diet-congruent condition tasted like the regular version. The control condition was administered first to increase the credibility of the cover story (this condition was presented as an eligibility check that the snack foods were liked) and the order of the beverage control and diet-congruent condition was counterbalanced across participants. After package exposure and beverage tasting, participants completed a lexical decision task and were provided with sweet and savoury, low and high fat snacks[21]. Subjective appetite sensations were recorded at pre-lunch, post-lunch, pre-cue exposure, post-cue exposure, post-lexical decision task and post-snack test[22]. The main outcome measures were snack intake and diet goal salience.

[21] In the control-no beverage condition, a research assistant working on the project incorrectly administered the snack test *before* the lexical decision task on a substantial number of participants. For this reason the results omit the control-no beverage condition.

[22] In the control-no beverage condition a research assistant recorded subjective appetite sensation pre-lunch, post-lunch, pre-snack and post-snack only. For this reason the control-no beverage condition was excluded from analysis.

7.4 Results

There were no effects of condition on energy intake between the diet-congruent and control beverage condition [diet: 373 ± 59 kcal; control beverage: 354 ± 56 kcal, $F(1, 20) = 1.30$, *p* = *ns*, $\eta p^2 = .06$].[23] A 2 x 6 ANOVA showed no differences in hunger, desire to eat or fullness between the diet-beverage and control beverage [hunger: $F(1, 20) = 0.35$, *p* = *ns*, $\eta p^2 = .02$; desire to eat: $F(1, 20) = 0.02$, *p* = *ns*, $\eta p^2 = .001$; fullness: $F(1, 20) = 1.51$, *p* = *ns*, $\eta p^2 = .07$][24]. For the lexical decision task there was no effect of condition on reaction times, $F(1, 19) = 1.13$, *p* = *ns*, $\eta p^2 = .06$. There was a main effect of word type, $F(1.53, 29.11) = 16.18$, *p* <. 001, $\eta p^2 = .46$. Diet words were recognised 32 ± 11 ms faster than tempting words ($p = .02$), and 79 ± 17 ms faster compared to neutral words ($p = .001$). Tempting words were also recognised 46 ± 13 ms faster compared to neutral words ($p = .006$). There were no condition x word type interaction on reaction times $F(2, 38) = 1.11$, *p* = *ns*, $\eta p^2 = .06$[25].

7.5 Discussion

The current study manipulated the perceived diet-congruency of beverages with explicit labels on packaging. There were no differences in snack intake or appetite sensations when participants consumed a beverage labelled with a “diet” packaging compared to the same beverage labelled as “regular” (control beverage).

The null findings suggest that beverage labels are not sufficient to elicit differences in perceptions of diet-congruency. These findings suggest that i) examining foods rather than beverages and ii) using participants own perceptions rather than explicit labels might be more informative to understand the role of diet-congruent consumptive cues. Indeed it has been suggested that explicit labels might result in demand characteristics (Brunstrom, et al., 2011) and this study confirms that the explicit labels might not be the optimal approach to manipulating perceptions about food. Furthermore, the amount consumed was small

[23] When including the control condition there was a main effect of condition on energy intake, $F(1.30, 26.02) = 6.18$, $p = .01$, $\eta p^2 = .24$. Bonferroni comparisons showed energy intake in the diet-congruent condition was significantly greater than control (control: 269 ± 38 kcal).

[24] When including the control condition participants reported greater hunger, more desire to eat and were less full in the control condition compared to the diet condition. [hunger: $F(2, 40) = 5.42$, $p = .008$, $\eta p^2 = .21$; desire to eat: $F(2, 40) = 50.33$, $p < .001$, $\eta p^2 = .72$; fullness: $F(2, 40) = 9.35$, $p < .001$, $\eta p^2 = .32$].

[25] The control condition was not included this analysis.

(40g) and to yield effects of diet-congruent preloads greater amounts might need to be consumed.

The pilot study demonstrated that care is needed when delivering a cover story. The current study was confounded by an incongruent beverage and label in the diet-congruent condition (i.e. a diet branded drinks can with a sample of the regular branded drink) and although no participants reported suspicion about the drink, discrepancies between taste expectations and actual taste might have influenced the findings. Therefore, cover stories are needed which do not interfere with the manipulation of the independent variables.