DOCTOR OF PHILOSOPHY

Inter-temporal choice for high-value food rewards as a model of food-scheduling behaviour

Stokes, Laura Jean

Award date:
2017

Awarding institution:
Bangor University

Prifysgol Bangor

Bangor University

Inter-temporal choice for high-value food rewards as a model of food-scheduling behaviour

Laura-Jean Gresham Stokes

School of Psychology

November 2017

Thesis submitted to Bangor University, in partial fulfilment for the degree of Doctor of Philosophy

Declaration and Consent

Details of the Work

I hereby agree to deposit the following item in the digital repository maintained by Bangor University and/or in any other repository authorized for use by Bangor University.

Author Name: Laura-Jean Stokes

Title: Inter-temporal choice for high-value food rewards as a model of food-scheduling behaviour

Supervisor/Department: Professor Robert Rogers, School of Psychology

Funding body (if any): Economic Social Research Council

Qualification/Degree obtained: PhD Psychology

This item is a product of my own research endeavours and is covered by the agreement below in which the item is referred to as "the Work". It is identical in content to that deposited in the Library, subject to point 4 below.

Non-exclusive Rights

Rights granted to the digital repository through this agreement are entirely non-exclusive. I am free to publish the Work in its present version or future versions elsewhere.

I agree that Bangor University may electronically store, copy or translate the Work to any approved medium or format for the purpose of future preservation and accessibility. Bangor University is not under any obligation to reproduce or display the Work in the same formats or resolutions in which it was originally deposited.

Bangor University Digital Repository

I understand that work deposited in the digital repository will be accessible to a wide variety of people and institutions, including automated agents and search engines via the World Wide Web.

I understand that once the Work is deposited, the item and its metadata may be incorporated into public access catalogues or services, national databases of electronic theses and dissertations such as the British Library's EThOS or any service provided by the National Library of Wales.

I understand that the Work may be made available via the National Library of Wales Online Electronic Theses Service under the declared terms and conditions of use (http://www.llgc.org.uk/index.php?id=4676). I agree that as part of this service the National Library of Wales may electronically store, copy or convert the Work to any approved medium or format for the purpose of future preservation and accessibility. The National Library of Wales is not under any obligation to reproduce or display the Work in the same formats or resolutions in which it was originally deposited.

Statement 1:

This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree unless as agreed by the University for approved dual awards.

Signed …….. (candidate)

Date ……..

Statement 2:

This thesis is the result of my own investigations, except where otherwise stated.

Where correction services have been used, the extent and nature of the correction is clearly marked in a footnote(s).

All other sources are acknowledged by footnotes and/or a bibliography.

Signed ……. (candidate)

Date …….

Statement 3:

I hereby give consent for my thesis, if accepted, to be available for photocopying, for inter-library loan and for electronic storage (subject to any constraints as defined in statement 4), and for the title and summary to be made available to outside organisations.

Signed ……. (candidate)

Date …….

NB: Candidates on whose behalf a bar on access has been approved by the Academic Registry should use the following version of **Statement 3:**

Statement 3 (bar):

I hereby give consent for my thesis, if accepted, to be available for photocopying, for inter-library loans and for electronic storage (subject to any constraints as defined in statement 4), after expiry of a bar on access.

Signed …… (candidate)

Date ……

Statement 4:

Choose **one** of the following options

a) I agree to deposit an electronic copy of my thesis (the Work) in the Bangor University (BU) Institutional Digital Repository, the British Library ETHOS system, and/or in any other repository authorized for use by Bangor University and where necessary have gained the required permissions for the use of third party material.	
b) I agree to deposit an electronic copy of my thesis (the Work) in the Bangor University (BU) Institutional Digital Repository, the British Library ETHOS system, and/or in any other repository authorized for use by Bangor University when the approved **bar on access** has been lifted.	
c) I agree to submit my thesis (the Work) electronically via Bangor University's e-submission system, however I **opt-out** of the electronic deposit to the Bangor University (BU) Institutional Digital Repository, the British Library ETHOS system, and/or in any other repository authorized for use by Bangor University, due to lack of permissions for use of third party material.	

Options B should only be used if a bar on access has been approved by the University.

In addition to the above I also agree to the following:

1. That I am the author or have the authority of the author(s) to make this agreement and do hereby give Bangor University the right to make available the Work in the way described above.

2. That the electronic copy of the Work deposited in the digital repository and covered by this agreement, is identical in content to the paper copy of the Work deposited in the Bangor University Library, subject to point 4 below.

3. That I have exercised reasonable care to ensure that the Work is original and, to the best of my knowledge, does not breach any laws – including those relating to defamation, libel and copyright.

4. That I have, in instances where the intellectual property of other authors or copyright holders is included in the Work, and where appropriate, gained explicit permission for the inclusion of that material in the Work, and in the electronic form of the Work as accessed through the open access digital repository, *or* that I have identified and removed that material for which adequate and appropriate permission has not been obtained and which will be inaccessible via the digital repository.

5. That Bangor University does not hold any obligation to take legal action on behalf of the Depositor, or other rights holders, in the event of a breach of intellectual property rights, or any other right, in the material deposited.

6. That I will indemnify and keep indemnified Bangor University and the National Library of Wales from and against any loss, liability, claim or damage, including without limitation any related legal fees and court costs (on a full indemnity bases), related to any breach by myself of any term of this agreement.

Signature: ……

Date : …….

Acknowledgements

There are many people who have made my PhD possible and without them, this thesis wouldn't exist. My first thanks go to the ESRC for my studentship and to the School of Psychology for supporting this. Thank you to my PhD committee, Professor Robert Rogers, Professor John Parkinson and Dr Paloma Mari-Beffa for your academic support and guidance. Your ideas have shaped this thesis and my development as a researcher. My biggest and most grateful thanks goes to my supervisor, Professor Robert Rogers. Thank you for your support and for guiding me through; thank you for all you've taught me about research and about myself as a researcher. You've put up with a lot from me over the last four years!

Thank you to Dave McKiernan and James, for all your work in building me a treat dispenser, on which this PhD is based. Thank you to Andrew Fischer for all the hours programming help you gave me, diagnosing and fixing problems in Presentation. Thank you to Dr Gareth Harvey, for all the time and advice you gave me helping to develop my scent testing procedure. Thank you to Professor Greg Madden, for your advice on delay discounting procedures, and helping me formulate a working protocol. Thank you to everyone in the lab, particularly Tim, Ciaran, Sammy, and Paul. You have all been there for me and supported me. Sharing your company in the office has made the stresses and challenges of my PhD so much easier to manage.

My next thanks go to my friends for all your support over the last four years. A few in particular deserve a special mention. (Dr!) Catherine Sharp, diolch yn fawr iawn cariad for the number of times you have encouraged and supported me to keep going, dealt with my tears, and everything else you put up with whilst living with me. Thank you to Matt & Vicky Yarrington, not just for your ongoing friendship, but for offering me a place to stay (and putting up with me!) for the final few months. Thank you to Rhi Wilmot, Kate Isherwood, Ruth Harrison, Laura Tillings and Georgia Wass, and everyone else, who over the course of my PhD has been there, to drink tea/gin with, eat cake with, go climbing/walking with, been there to chat to, given me a hug and told me to keep going. The last three months have been hard so special thanks go to the staff of Teras lounge, particularly Laura, Jack & Lee, for the numerous pots of earl grey tea and pain-au-chocolats, and the friendly smiles keeping me going every morning.

My most sincere and heart-felt thanks go to Mum and Dad. You have supported me in so many ways throughout my PhD, it'd take another thesis just to list them all and say how grateful I am. Thank you for always being on the end of the phone and your never-ending support. Thank you, Dad, for discussing ideas with me and troubleshooting problems. Thank you Mum for the hours spent proof-reading every page of this thesis! I love you both, and I'm sharing this PhD with you.

Contents

List of Figures

List of Tables

List of Appendices

Thesis summary

The increased prevalence of obesity has become a worldwide problem in the last forty years (French, Epstein, Jeffery, Blundell, & Wardle, 2012; WHO, 2016). Obesity is associated with significant physical (WHO, 2016) and mental health problems (Luppino et al., 2010). From an evolutionary perspective, animals' food-seeking strategies promote the overconsumption of high-energy foods in environments where food can be scarce. Possibly, these inherited strategies are unhealthy in contemporary environments in which food is available and its energy costs low, promoting weight gain and obesity. However, this possibility has not been explored experimentally. My thesis is intended to test one such strategy in human subjects: tolerating risk to gain access to food quickly. One method of investigating our inherited food foraging strategies is to examine how we schedule our food intake, specifically intertemporal preferences to obtain food reward. My PhD used a novel task to measure individuals' intertemporal preferences to food rewards. Participants chose between two reinforcement schedules, offering highly valued food rewards following variable or fixed delays. Overall, I found that preference for variable delay schedules was driven by the previous delivery of immediate rewards. Choice of the variable delay schedule following longer delays was enhanced following exposure to food aromas, perhaps indicating a role for food cues in tolerating prolonged delays to food rewards. By contrast, preferences for variable delay schedules were not straightforwardly related to delay discounting rates. Exploratory analyses showed only inconsistent associations with factors linked to future weight gain – body mass index (BMI), cognitive restraint, and emotional eating. However, preferences for variable delay schedules following immediate food rewards were only subtly enhanced in individuals with higher rather than lower BMIs and higher delay discounting rates. Preferences for variable delay schedules were sometimes reduced in individuals with higher restraint but increased in these individuals following exposure to food cues. This suggests that food cues might override restraint to enhance preferences for quick foods. Collectively, my findings suggest that further investigations of intertemporal preferences in food-scheduling behaviours might tell us about the value of quick foods in individuals vulnerable to weight gain.

"For our chronically and extremely hungry man, Utopia can be defined very simply as a place where there is plenty of food. He tends to think that, if only he is guaranteed food for the rest of his life, he will be perfectly happy and will never want anything more. Life itself tends to be defined in terms of eating. Anything else will be defined as unimportant. Freedom, love, community feeling, respect, philosophy, may all be waved aside as fripperies which are useless since they fail to fill the stomach. Such a man may fairly be said to live by bread alone."

Maslow (1943). A theory of human motivation. *Psychological Review, 50*(4), 370-396

Chapter 1: Introduction

1. Introduction

Obesity and its health, social and economic consequences are significant challenges across both developed and developing countries (French et al., 2012). Obesity and unhealthy weight gain reflect energy surplus relative to decreased energy expenditure that, if prolonged, results in weight gain (Hill, Wyatt, & Peters, 2012). Environmental, socio-economic and biological (including genetic) factors each contribute to the eating and consumption behaviours that lead to obesity (Albuquerque, Stice, Rodriguez-Lopez, Manco, & Nobrega, 2015; Berridge, 2009; Lieberman, 2006; Mesas, Munoz-Pareja, Lopez-Garcia, & Rodriguez-Artalejo, 2012).

Obesity is defined as having a Body Mass Index (BMI) of 30 or above (WHO, 2016). Rates have steadily increased since 1980 (WHO, 2016). In the UK, 68% of men and 58% of women were classed as overweight or obese in 2015 (Moody, 2013), increases from 13% of men and 16% of women in 1993 (HSCIC, 2006). At a population level, this involves heart disease, stroke, metabolic syndrome (MS) and diabetes, of which heart disease and stroke were the leading cause of death in 2012 (WHO, 2016). A BMI over 30 dramatically increases the risk of oesophageal, colon, endometrial, and gall bladder cancers by 24-59% (Wang, McPherson, Marsh, Gortmaker, & Brown, 2011). Weight gain and obesity is estimated to cost the UK government £2.47 billion, 1.8% of the total NHS budget (Tovey, 2017). Population BMI relates to measures of a country's wealth, with a 0.4kg.m^2 increase in BMI for every $1000 in GDP per capita (Subramanian, Perkins, Ozaltin, & Davey Smith, 2011), demonstrating its association with national wealth. The prevalence of overweight across Europe stands at 34.8% (Gallus et al., 2015), moderated by factors

such as ethnicity, changes in lifestyle such as decrease in physical activity levels, and migration of different cultures across country boundaries accounting for much of the variation in BMI (Berghofer et al., 2008).

Evolutionary perspectives posit that obesity occurs through a mismatch between our current environment which is an obesogenic one where high-energy/calorie-dense food is readily available, and our inherited food seeking strategies which favour immediate overconsumption to compensate for future scarcity (Lieberman, 2006; Pinel, Assanand, & Lehman, 2000). Possibly, this food-seeking/food environment mismatch reflects the continuance of ′thrifty′ genes (Neel, 1999); selectively neutral genetic drift (that also accounts for the mixed incidence of obesity across individuals; Nielsen, Nielsen, & Holm, 2015); or the impacts of previous climate change upon genetic influences over food-seeking behaviours (Sellayah, Cagampang, & Cox, 2014). It is also possible that obesity (and any of its genetic substrate) has never been adaptive and may not even have been present in our evolutionary past (Albuquerque et al., 2015; Speakman, 2013).

Notwithstanding these possibilities, there is little experimental exploration of this broad evolutionary model of weight gain as arising from persisting food-seeking strategies. My thesis explores the possible value of one way to assess food-seeking behaviours to inform this discussion: namely, individuals' tolerance of risk to obtain food quickly, operationalised as preferences for varied delay over fixed delay reinforcement schedules for real edible food rewards. There are though, a huge range of factors that moderate food seeking behaviours and, hence, weight gain of which I

have needed to take account. Here, I review only the most salient psychological and behavioural issues relevant to my work.

2. Behavioural factors

Individual behavioural factors are obviously relevant to individuals′ weight gain and risk of obesity. These range from fluctuating physical activity and other lifestyle factors (addressed under environmental factors above) to different eating patterns (e.g., Mesas et al., 2012). Specific forms of behaviour, such as eating patterns, food attitudes and facets of eating such as emotional eating, disinhibited eating and cognitive restraint, as well psychological factors, such as impulsiveness (delay discounting) have been linked to weight gain and obesity (Burton, Smit, & Lightowler, 2007; Canetti, Bachar, & Berry, 2002; Fedoroff, Polivy, & Herman, 1997; Manwaring, Green, Myerson, Strube, & Wilfley, 2011; Nederkoorn, Smulders, Havermans, Roefs, & Jansen, 2006; Turner, Luszcynska, Warner, & Schwarzer, 2010; Westenhoefer, Broeckmann, Münch, & Pudel, 1994). I review these in the sections below.

2.1. Eating patterns

Eating behaviours related to obesity can be categorised by discrete patterns of eating. Some of these illustrate the psychological processes relevant to my thesis. Many of the behaviours relate to food choices and, in particular, to what I will call 'food-scheduling' decisions about when next to eat. Decisions about when we eat, and the tolerance of risk to eat quickly, are central to my thesis.

Overall, there is little consistent evidence regarding the association between irregular meals and the development of obesity (Mesas et al., 2012). In one study, individuals who ate regular meals had a lower likelihood of metabolic syndrome (MS) and smaller waist circumference than individuals who ate irregular meals (Sierra-Johnson et al., 2008), suggesting that disturbed food-scheduling (over periods of hours and minutes) is linked to weight gain. This result remained robust following correction for physical activity, fruit and vegetable consumption. However, this is not a consistent finding: for example, Shin, Lim, Sung, Shin, and Kim (2009) reported no difference for meal regularity between individuals with or without MS.

Skipping breakfast can show associations with obesity (Huang, Howarth, Lin, Roberts, & McCrory, 2004; Ma et al., 2003; Marin-Guerrero, Gutierrez-Fisac, Guallar-Castillon, Banegas, & Rodriguez-Artalejo, 2008; Mesas et al., 2012). In some studies, breakfast consumption has been linked with lower BMI and a decreased risk of weight gain (Berg et al., 2009; van der Heijden, Hu, Rimm, & van Dam, 2007). Conversely though, similar rates of obesity have been reported in samples of people who consume breakfast as compared to samples of individuals those who do not, independent of MS (Shin et al., 2009). These findings suggest no association between breakfast consumption and obesity or MS (Shin et al., 2009). However, the inconsistencies between results could be reconciled by adjustment for daily energy intake (Mesas et al., 2012).

Surprisingly, there is at least some indication that the risk of obesity deceases with a greater number of eating episodes per day. In one study, an eating episode

was defined as consuming a minimum of 50 kilocalories, separated by at least 15 minutes between each time of food consumption (Ma et al., 2003). Similarly, a lower number of eating episodes were associated with more severe obesity (Berg et al., 2009). In other studies, higher eating frequency is associated with an increased likelihood of obesity (Howarth, Huang, Roberts, Lin, & McCrory, 2007). The inconsistencies between findings for the relationship between eating frequency and obesity may reflect the arbitrary limits set to define eating frequency, with little difference between the higher bound of one category and the lower bound of the next (Howarth et al., 2007).

The number of eating episodes, or eating frequency, is also related to the frequency of snacking behaviour. Not only does the frequency of snack consumption contribute to obesity, BMI and waist circumference, the calorie content of individual snacks will also increase the total energy consumed (Mesas et al., 2012). In one example, snackers reported greater overall total energy intake per day than non-snackers, and showed greater weight change in a one-year period (Bes-Rastrollo et al., 2010). These effects remained robust when accounting for age, sex, physical activity, total energy intake, variables associated with a sedentary lifestyle, dietary variables, alcohol intake and any changes in lifestyle (smoking, physical activity, differences in food consumption) after a 5-year follow-up (Bes-Rastrollo et al., 2010).

Further evidence also reported increased waist circumference in individuals who consumed snacks over a 5-year period, compared to those who did not consume snacks (Halkjaer, Tjonneland, Overvad, & Sorensen, 2009). This suggests that

snacking is related to increased weight gain and obesity. Both the number and frequency of snacks consumed, and the calorie content of the snacks contributes to weight gain and the risk of obesity (Mesas et al., 2012). Additionally, individuals do not adjust their energy intake at meal times to compensate for the energy of consumed snacks (Marmonier, Chapelot, & Louis-Sylvestre, 1999). The pattern of snacking behaviour is relevant to this thesis. Snacking behaviour might represent choices individuals make about when they schedule their food intake over relatively short intervals: e.g. impulsive so eat now. Similarly, I am interested in decisions about when to eat high-energy food rewards (as small snacks or treats at short time delays).

There is inconsistent evidence relating takeaway/fast food consumption to abdominal obesity (Simmons et al., 2005; Smith et al., 2009). Evidence points towards an increased risk of obesity and higher BMI with greater fast food consumption (Bes-Rastrollo et al., 2010; Duffey, Gordon-Larson, Jacobs, Williams, & Popkin, 2007; Pereira et al., 2005; Schroder, Fito, & Covas, 2007). However, there have been studies showing no association between fast food intake and weight gain and/or obesity (Bezerra & Sichieri, 2009; Jeffery & French, 1998). As such, it is difficult to determine if there is a casual relationship between fast food consumption and increased BMI/obesity.

It is difficult to draw conclusions on the extent eating away from home has on obesity due to a number of contrasting findings. Eating breakfast or lunch away from home has been linked to obesity (Ma et al., 2003; Veugelers & Fitzgerald, 2005). There is also some evidence that food consumed outside the home (fast

food, restaurant food) is associated with larger portion sizes, supplying surplus calories to our daily energy requirements (Cohen, 2008). The size of portions consumed from fast food establishments has increased over recent years, in line with observed increases in obesity (Cohen, 2008; Nestle, 2003; Young & Nestle, 2002). Conversely, evidence has also shown no association between restaurant food and obesity but as presented previously, there are associations reported between an increase in fast food intake and increases in BMI (Duffey et al., 2007).

Following food consumption, the brain receives satiety signals, such as gut hormones to reduce the desire for food (craving) and suppress eating. However, when food is consumed quickly, the brain is not able to process the satiety signals as effectively, leading to more food being consumed before the effects of satiation are registered (Rolls, 2007). Mesas et al. (2012) reports an association between eating quickly and increased weight. Faster eaters were at greatest risk of obesity and having a higher BMI (Maruyama et al., 2008; Otsuka et al., 2006; Shin et al., 2009). Individuals who ate quickly and ate until full were approximately three times more likely to be overweight than individuals who did not eat eat quickly or eat until full (Maruyama et al., 2008). This evidence suggests there is a positive association between eating quickly on the one hand and weight gain and obesity on the other hand.

2.2. Food and eating attitudes

The evidence described above suggests that choices about what to eat, how much to eat, and when to eat probably underlie vulnerability to weight gain.

However, some of the epidemiological patterns are mixed. In this thesis, I will be looking to explore one lab-based model of choices about when to eat: choices between variable and fixed delay reinforcement schedules. Although the laboratory offers a high degree of control over participant and environment, psychological and attitudinal factors associated with food consumption will exert their own effects. In this next section, I describe some of the psychological and attitudinal factors linked to weight gain and those most related to people's choices about when next to eat.

2.2.1. Cognitive restraint

Individuals' capacity to control their food-scheduling decisions may relate to factors such as cognitive restraint. It relates to the ability to delay gratification as an index of self-control and relates to restraint in eating habits (Nederkoorn et al., 2006). Restraint has been defined as "the deliberate effort to combat the physiologically-based urge to eat in order to lose weight or maintain a reduced weight" (Fedoroff et al., 1997). In contrast, self-control is an individual's ability to make advantageous decisions regarding future consequences (Kuijer, de Ridder, Ouwehand, Houx, & van de Bos, 2008). Individual differences in self-control in relation to eating behaviours may also relate to decision-making impairments that contribute to dieters' ability to reduce weight or maintain weight loss (Kuijer et al., 2008). My experiments explore individuals' decisions about when to eat next using real edible rewards, with exploratory tests of the effects of restraint on simple food-scheduling decisions.

Individuals who are more restrained pay less attention to internal cues such as hunger in order to adhere to their diet (Herman, Polivy, Lank, & Heatherton, 1987). As a result of ignoring these internal cues, individuals rely more on external cues (Schachter, 1971), similar to the evidence for external eating below. For example, restrained eaters ate more following exposure to food cues specific to the meal they consumed compared to unrestrained eaters who were also exposed to the same cues (Fedoroff et al., 1997). This suggests that exposure to a congruent cue may increase the value of receiving food immediately in restrained eaters.

As these findings show, some food cues are more salient to some individuals than to others (Schachter, 1971), and the more salient food cues are to an individual, the greater their consumption (Wansink, 2004). Restrained eaters are also more sensitive to food cues, particularly those that are forbidden, as a result of increased craving (Polivy, Coleman, & Herman, 2005). This is shown by greater salivation following exposure to attractive cues (Klajner, Herman, Polivy, & Chhabra, 1981; Legoff & Spigelman, 1987). Restrained eaters' responsiveness to food cues has been shown to be specific to the food presented in the cue, as demonstrated by Fedoroff, Polivy, and Herman (2003) who presented restrained and unrestrained eaters with (olfactory and cognitive) cues of pizza or cookies. The above studies support the arguments that restraint can be a contributory factor in the

development of obesity (McGuire, Jeffery, French, & Hannan, 2001). Additionally, the role of specific food cues for restrained eaters supports the model of incentive-induced hunger suggested by Cornell, Roddin, and Weingarten (1989) in line with the ideas on priming outlined below. These data suggest that eating restraint will be related to decisions about when to eat next and that restrained eaters will show less tolerance of risk to obtain food quickly, as reflected in preferences for variable over fixed delay reinforcement schedules.

2.2.2. Emotional eating

Another important aspect of food seeking behaviour is its emotional functions. Complementing the role of restraint (Fedoroff et al., 1997), the concept of emotional eating was developed from psychosomatic theory (Canetti et al., 2002). Original psychosomatic theory (Kaplan & Kaplan, 1957) posited that eating reduces anxiety in people who are overweight, as it is physiologically incompatible to feel intense anxiety while eating, meaning that these negative feelings dissipate during food consumption (Canetti et al., 2002). For this reason, people with weight and obesity difficulties can learn to associate eating with feelings of hunger and feelings of anxiety, and therefore find it difficult to differentiate the two states (Canetti et al., 2002).

Alternatively, people who are vulnerable to weight gain have difficulty recognising physiological states of hunger and satiety, due to problematic early experiences of hunger. In addition, people who

might qualify as obese are unable to tell the difference between other uncomfortable states and hunger or the urge to eat (Bruch, 1973). Therefore, vulnerable individuals eat in response to emotional states and hunger states since they are unable to tell the difference between these states (Canetti et al., 2002). The ability to accurately identify internal states has been defined as interoceptive awareness and this has been suggested to be deficient in obesity (Koch & Pollatos, 2014). For this reason, vulnerable individuals tend to depend upon external cues to eat and for appropriate portion sizes (Canetti et al., 2002). Eating in response to emotional states may increase the urgency of individuals' need to consume food, to modulate emotional states and, hence, increase the value of quick food.

Overeating resulting from emotional states in obesity has been reported in a number of studies, providing support for the argument that obese people are more affected by emotional states than non-obese people (Ganley, 1989; Patel & Schlundt, 2001). Individuals seeking weight loss treatment reported high levels of emotional eating (Ganley, 1989). In addition, Patel and Schlundt (2001) reported that obese individuals consumed larger portion sizes while in negative or positive emotional states, compared to when they reported being in a neutral mood.

Overall, ideas about emotional eating complement theories of restraint and externality (Canetti et al., 2002). Evidence suggests that emotional eating is reported frequently in obesity (Ganley, 1989; Patel &

Schlundt, 2001; Turner et al., 2010) and may be an underlying mechanism of overeating and consequential weight gain. Emotional eating may affect individuals' food-scheduling choices to obtain food as quickly as possible in order to reflect or help alleviate negative emotional states.

2.2.3. Uncontrolled and disinhibited eating

Variation in individuals' food-scheduling behaviours may also express vulnerability to loss of control over eating. Uncontrolled eating is closely linked to external eating, emotional eating and cognitive restraint (discussed above) and is defined as the tendency to overeat in the absence of hunger; in response to external stimuli; or the availability of food (Anglé et al., 2009). Uncontrolled eating has been measured alongside the constructs of restraint (Konttinen, Haukkala, Sarlio-Lahteenkorva, Silventoinen, & Jousilahti, 2009) and emotional eating (Turner et al., 2010). For example, uncontrolled eaters consume a larger number of cookies after a positive mood induction compared to individuals not exposed to a positive mood induction, showing the relationship between uncontrolled eating and emotional eating (Turner et al., 2010).

Disinhibition is defined as overeating as a result of emotional distress or exposure to external stimuli such as palatable foods (Hays & Roberts, 2008). This construct was previously split into emotional eating and weight lability subscales (Ganley, 1988). However, the

original Three Factor Eating Questionnaire has weak validity, being revised to form the TFEQ-R (Karlsson, Persson, SjoÈstroÈm, & Sullivan, 2000). The emotional and uncontrolled eating subscales of the TFEQ-R approximately map on to the disinhibition and hunger subscales of the previous version. There are links between disinhibited eating and BMI (Hays & Roberts, 2008) and impulsivity and uncontrolled eating (Kuijer et al., 2008), as well as impulsivity and disinhibited eating, where disinhibited eaters did not take time to gather all the relevant information on a decision-making task (Leitch, Morgan, & Yeomans, 2013).

2.2.4. External eating

Our eating behaviour can be determined by internal or external cues in the environment (Schachter, 1971). Internal cues, such as hunger or satiety, and external cues, such as the visible presence of food or its aroma, influence consumption. Evidence suggests that lean individuals ignore external cues when internal cues (such as hunger) are not present. However, obese individuals will eat in the presence of external cues, regardless of their internal state (feelings of hunger/satiety) (Schachter, 1971; Wansink, 2004).

In addition, people who are vulnerable to external eating tend to show greater cravings and higher BMI (Burton et al., 2007). This suggests that food cravings arise from increased salience of food cues in the environment (i.e. the aroma of food), and that individuals who are

more influenced by external cues will experience more cravings. Individuals with increased cravings, in turn, were more likely to have a higher BMI (Burton et al., 2007). However, this contrasts with findings that there is no relationship between BMI and external eating (van Strien, Herman, & Verheijden, 2009).

The Sensory-Normative model suggests that individuals respond to normative cues, such as portion size, and sensory cues, such as the palatability of food (Herman & Polivy, 2008). This model proposes that normative cues influence consumption independent of an individual's weight. However, sensory cues affect some individuals to a greater extent than others (i.e. dieters or restrained eaters, or individuals who are obese) (Herman & Polivy, 2008), promoting overconsumption and weight gain (Boswell & Kober, 2016).

External cues in the environment may also influence decisions about when we schedule our food intake. For example, if environmental cues are present that signal the availability of food, given our inherited food seeking strategies to obtain food as soon as it is available, this may result in the immediate consumption of food. In Experiment 2, I examine the influence of external cues and priming on consumption and food-scheduling decisions: in this case, a food aroma that might also prime consumption. Priming is said to occur when a cue or a stimulus biases the processing of, and responses to, a second stimulus (Janiszewski & Wyer Jr., 2014). There are many different types of

priming (semantic priming, goal priming, affective priming and behavioural priming) (Cornell et al., 1989; Gaillet, Sulmont-Rossé, Issanchou, Chabanet, & Chambaron, 2013; Janiszewski & Wyer Jr., 2014; Knasko, 1995; Papies & Hamstra, 2010).

A number of different types of stimuli are often used to prime food-related behaviours. Viewing images of food items resulted in reduced inhibitory control in highly impulsive individuals (Lattimore & Mead, 2015). The taste of food items primed further consumption of specific foods (Cornell et al., 1989; Herman & Mack, 1975). Exposure to the aroma of food items (olfactory cues) influenced food choice (Gaillet-Torrent, Sulmont-Rossé, Issanchou, Chabanet, & Chambaron, 2014) and consumption (Fedoroff et al., 1997, 2003). Olfactory priming has been argued to be a unique form of priming for many reasons- unlike any other form of prime, odours can be perceived at a level below conscious awareness; aromas have the ability to trigger specific memories and guide judgement decisions (Smeets & Dijksterhuis, 2014).

At their most effective, olfactory cues will be congruent to the target to be primed. This has been shown in a number of environments. In a marketing context, odours congruent to the target brands being primed resulted in consumers spending more time considering options of different products and seeking a wider variety of options than individuals exposed to incongruent odours (Mitchell, Kahn, & Knasko,

1995). Congruent olfactory cues have also been shown to have an effect on food choice. Individuals exposed to the aroma of melon or pears made choices containing or relating to these items on a menu task (Gaillet et al., 2013; Gaillet-Torrent et al., 2014). This evidence suggests that for olfactory cues to be effective, they should be congruent to the target they are priming. In Experiment 2, I use a chocolate aroma, that is congruent with the food reward (chocolate pieces), to investigate the effect of an environmental cue on food-scheduling behaviours.

3. Impulsivity

Along with the psychological factors discussed previously, impulsivity may contribute to food scheduling behaviours, as impulsive individuals will show preferences for rewards received quickly. Impulsivity is a multi-faceted construct with a broad range of definitions (Evenden, 1999) including difficulties in inhibition of actions, and reduced ability to tolerate delay (de Wit, 2008). These are characteristic of many psychological disorders (de Wit, 2008), such as gambling problems (Madden, Francisco, Brewer, & Stein, 2011), alcohol dependence and substance use disorders (de Wit, 2008). Impulsiveness can be assessed in a number of different psychometric scales and laboratory tasks, such as the Barratt Impulsiveness Scale (Patton, Stanford, & Barratt, 1995) and Balloon Analogue Risk Task (Lejuez et al., 2002). However, in the context of my thesis, impulsivity as delay discounting is the most relevant (Mazur, 1987). Delay discounting is defined as the reduction in subjective value of a reward, as a function of time or delays until its receipt. It taps into the tendency to prefer smaller immediate rewards rather than receiving larger

more valuable rewards later in time (Odum, 2011a). Low discounting rates and the ability to delay gratification has been suggested to be an index of self-control (Rachlin & Green, 1972); high discounting rates is then taken as a measure of impulsivity (Madden, Begotka, Raiff, & Kastern, 2003).

In delay discounting assessments, participants choose between smaller, sooner rewards and larger, later rewards. The point in time at which an individual values equally the larger delayed reward and the smaller immediate reward is termed the indifference point (Mazur, 1987). These indifference points represent reductions in the subjective value of rewards over time and can be described in exponential form or hyperbolic form, quasi-hyperbolic form (Madden et al., 2003). However, the usual form is hyperbolic as:

$$V = \frac{A}{1 + kD}$$

Eq (1.1).

where V is the subjective value of the reward, A is the amount of reward received, k is an individual's discount rate and D is the delay until the reward is received (Mazur, 1987). The steepness of this curve varies dependent on the value of k – individuals with higher k values are more sensitive to delay, so will discount delayed options more quickly, reflecting impulsivity (Odum, 2011a). A hyperbolic curve plotted with a high k value shows a steeper profile, i.e. there is less area under the curve than curves formed from lower k values (which would show a shallower decline). Discounting curves, or their k-values, illustrate differences in individuals' discounting rates, which could indicate the amount an individual values an item (i.e. cigarettes, alcohol, food) (Odum & Baumann, 2007).

The relationship between the reduced ability to delay gratification and increased obesity has mostly been examined in women (Nederkoorn et al., 2006; Weller, Cook, Avsar, & Cox, 2008), and individuals with Binge Eating Disorder (BED; Manwaring et al., 2011). Hypothetical delay discounting and probability discounting tasks have been used to examine differences in discounting of different types of reward (money, food, preferred sedentary activity, and massage time) in obese women with and without BED and non-obese women without BED (Manwaring et al., 2011). Probability discounting tasks measure the degree to which individuals value larger more improbable rewards (that are less likely to be received) compared to smaller more probable rewards (that are more likely to be received) (Green & Myerson, 2010). Individuals with BED discounted all rewards more steeply than both obese and healthy weight controls without BED (Manwaring et al., 2011).

On delay discounting tasks, the food rewards tend to be discounted the most steeply, and monetary rewards discounted least compared to other rewards. Delayed food rewards specifically are discounted more quickly by obese compared to non-obese individuals (Manwaring et al., 2011). On the probability discounting tasks, obese individuals also discounted all rewards more steeply than non-obese individuals without BED. Specifically, obese individuals with BED showed steeper discounting in all four reward conditions compared to obese individuals and non-obese individuals without BED. Similar to delay discounting tasks, food rewards were discounted most steeply in the probabilistic task, with obese individuals with BED discounting food more quickly than obese and non-obese individuals without BED (Manwaring et al., 2011). These findings suggest that obese individuals with BED

are more impulsive than individuals without BED suggesting that BED is associated with additional impulsiveness that might contribute to episodic losses of control over eating behaviour (Manwaring et al., 2011).

Showing a similar pattern of results, obese individuals with and without BED were shown to discount delayed monetary rewards more steeply than healthy weight individuals (Davis, Patte, Curtis, & Reid, 2010). The greatest difference in discounting rates between obese and healthy weight individuals were shown when the magnitude of reward was increased (Weller et al., 2008). To further extend these findings, the addition of percentage body fat (PBF) measurements showed that individuals with high PBF discounted the value of food rewards more rapidly than monetary rewards on both hypothetical delay and probability discounting tasks (Rasmussen, Lawyer, & Reilly, 2010).

Overall, studies show mixed effect sizes but, in general, provide evidence of higher discounting rates in obese individuals, even when accounting for study design, mixed or female only samples, age range of child versus adult participants, and type of reward used (Amlung, Petker, Jackson, Balodis, & MacKillop, 2016). Although research has demonstrated greater impulsivity in women with BED, and/or high BMI, across a range of different reward types (Manwaring et al., 2011; Rasmussen et al., 2010; Weller et al., 2008), no research has examined the relationship between obesity and delay discounting using directly consumable rewards. My thesis will investigate the relationship between delay discounting and food-scheduling behaviours using directly consumable rewards, and explore its potential for future work in these populations.

4. Food addiction

Food addiction is proposed as an underlying factor of obesity and overeating (Ziauddeen, Farooqi, & Fletcher, 2012b). There are five strands of research that propose similarities between food addiction and the DSM-IV criteria for substance dependence. These include: clinical overlap; shared vulnerabilities between obesity and drug dependence; evidence from animal models of tolerance; withdrawal and compulsive food-seeking behaviours; decreased striatal dopamine receptor densities; and changes in functional brain responses following exposure to food related stimuli (Ziauddeen et al., 2012b). However, both Ziauddeen, Farooqi, and Fletcher (2012a) and Avena, Gearhardt, Gold, Wang, and Potenza (2012) propose that further research to identify, describe and evaluate the concept of food addiction is needed before it is accepted or rejected as part of the scientific literature. Thus far, the concept of food addiction is not supported by neuroscientific evidence (Ziauddeen et al., 2012a, 2012b). Additionally, the definition of obesity includes a heterogeneous group of individuals, who might not all be accurately identified by the category of food addiction (Avena et al., 2012; Ziauddeen et al., 2012b).

Addictions result in behavioural changes, possibly affecting individuals' food-scheduling decisions. As suggested by Avena et al. (2012) and Ziauddeen et al. (2012a), it is currently premature to draw such conclusions relating to individuals' food-scheduling decisions and their relationship with food addiction and obesity, given so little is known about how the concept of food addiction fits with the criteria of obesity (Avena et al., 2012; Ziauddeen et al., 2012b).

4.1. Food wanting

Powerful desires for foods that motivate food-seeking behaviour can be explained in various ways, relating to either Drive Reduction Theory and Incentive Motivation theory (Toates, 1998), or Incentive Salience (Berridge, 2009). Drive Reduction Theory explains food-seeking and goal-directed behaviours (i.e. to enable consumption) as a means to decrease physiological imbalances (i.e. experienced as hunger) and to return the body to homeostasis (Pool, Sennwald, Delplanque, Brosch, & Sander, 2016). In contrast to this, Incentive Motivation Theory suggests that the amount of energy expended by an individual (e.g. to buy food) will be influenced by environmental stimuli that individuals associate with actions through previous learning (Toates, 1998). The stronger the associative strengths, the greater the elicited motivation and response. This means that an individual's motivation to obtain a particular reward will reflect, in part, the detection of associated cues in the environment. If the stimulus is perceived to have higher motivational value, the individual will expend more energy to obtain it. The more pleasurable the reward, the greater the energy invested to obtain the reward subsequent to exposure to the relevant cue (Pool et al., 2016).

Incentive salience perspectives posit that obesity reflects disrupted reward or food wanting (motivational value) (Berridge, 1996, 2009). Incentive salience (wanting) is captured by the reward value and cues signalling their availability (Berridge, 2009). Many studies have used the amount of energy, or response rate, expended to obtain a reward as a proxy for measuring wanting of rewards

(Pool et al., 2016). Evidence has been presented that liking and wanting can occur together, or independently (Pool et al., 2016). However, Havermans (2011, 2012) argues that, in the context of human food behaviours, here two concepts of wanting and liking are interlinked and they cannot be disentangled operationally to measure the difference between them (Finlayson & Dalton, 2012). One difficulty is that research has demonstrated that there are circumstances when liking and wanting are linked (Havermans, Janssen, Giesen, Roefs, & Jansen, 2009) and circumstances when they are dissociated (Leyton, 2010). At present, it can be argued that there is no conclusive evidence for perturbed food wanting and/or liking in obesity (Finlayson & Dalton, 2012; Havermans, 2011, 2012). However, the mechanism of incentive salience underlies a number of factors addressed above, such as eating patterns and impulsivity, that contribute to weight gain and obesity.

5. Moving towards my experiments/foraging

Moving towards my experiments, my thesis will explore individuals' trade-offs between uncertainty or risk and the possibility of quick food. Animal models of food seeking and foraging behaviour can inform our understanding of obesity from an evolutionary perspective (Lieberman, 2006). Risk sensitivity governs animals' choices for obtaining food (Kacelnik & Bateson, 1997). When risk is measured in terms of delay (duration until reward is received), animals tend to show risk-prone behaviour. However, when risk is in terms of magnitude (amount of reward received), animals tend to show risk aversion (Kacelnik & Bateson, 1996). Risk sensitivity can reflect two mechanisms: daily energy budgets (Stephens, 1981) and Scalar Expectancy Theory (Marsh & Kacelnik, 2002).

Animals display different preferences when experiencing variability in amount or delay of food availability (Bateson & Kacelnik, 1995). These differences in choice can be explained by the daily energy budget rule (Stephens, 1981). When variability is in the amount of food that is available, animals behave in a manner that maximises their chances of obtaining enough food, and quickly enough to survive (reaching their energetic threshold) in line with their current energy budget (Stephens, 1981). This explains animals' choice of a highly variable reward when the animal has a negative energy budget, given the alternative reward of a fixed amount is not large enough in quantity to meet their necessary energy threshold for survival (Caraco, 1981; Kacelnik & Bateson, 1996; Stephens, 1981).

An additional explanation for animals' choice preference relates to how choices are represented in memory (Marsh & Kacelnik, 2002; Reboreda & Kacelnik, 1991) in so-called Scalar Expectancy Theory (Gibbon, 1977). Weber's Law states that discriminability of a signal depends upon its original or baseline value (Kacelnik & Brito-E-Abreu, 1998). The same is true for discriminating between delays in memory. Critically, the variability of estimates of delays retrieved from memory increases with their length, such that it is harder to discriminate between two longer delays that differ by, say 2s compared to 2 short delays that differ by the same amount (Kacelnik & Brito-E-Abreu, 1998).

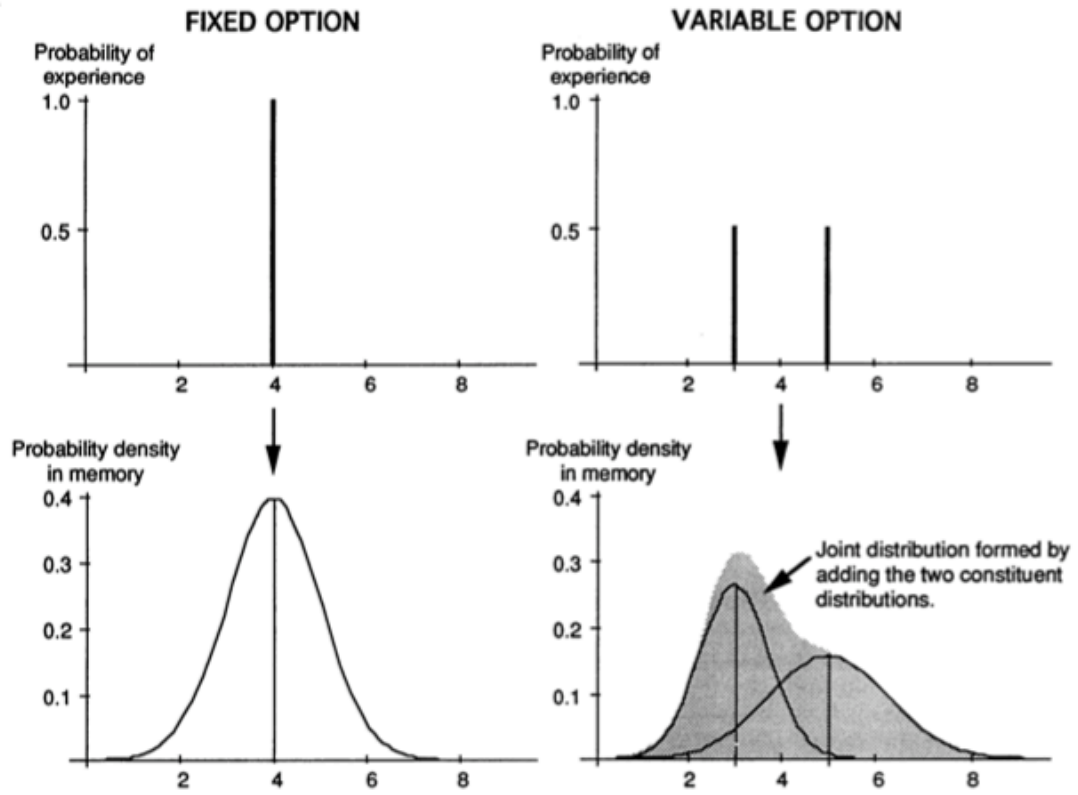


Figure 1.1. Adapted from Bateson and Kacelnik (1995). The top two panels show the experience distribution of outcomes for fixed and variable options. The bottom two panels show the distributions as they are represented in memory (Bateson & Kacelnik, 1995).

Consider two options, a variable delay option and a fixed delay option, as illustrated in Figure 1.1. Both offer the same mean reward but differ in the probabilities of delays before the reward are delivered. The fixed option gives a certain chance of receiving reward after four units of time. The variable option gives a 50% chance of receiving a reward after three units of time, and a 50% chance of receiving a reward after five units of time. If individuals retrieve a sample delay associated with each option (fixed and variable) in memory, the samples selected from the variable option will be of smaller value (shorter time), given the distribution and variability of the delays that are positively skewed. This suggests that the variable option will be

preferred because it will give shorter samples more than half of the time (Figure 1.1; Bateson & Kacelnik, 1995).

Here, I use preferences between variable vs fixed delays as a model to explore preference for quick food rewards. Inherited foraging strategies show that animals and individuals will show a preference for quick food rewards (Lieberman, 2006; Pinel et al., 2000). Studies from the animal literature use choices between fixed and variable delays prior to the delivery of rewards as a proxy measure for investigating preferences for quick food.

6. Fixed and variable delays to food reward

The animal operant literature offers a straightforward way to assess preferences for uncertain delays that offer the possibility of rewards delivered following very short or very long delays versus fixed intermediate delays. In an experiment, pigeons showed reliable preferences for variable intervals until water reward (Case, Nichols, & Fantino, 1995). Pigeons were given ample or restricted access to water, then given a series of choices between fixed or variable intervals until they could next obtain access to water. The fixed interval delivered access to water after a 15 second delay, the variable interval delivered access to water either immediately or after 30 seconds. Pigeons showed a preference for variable delays, independent of restricted or ample conditions where they had limited or unlimited access to water prior to completing the task (Case et al., 1995).

Instead of manipulating access to water, Caraco et al. (1990) manipulated Juncos' energy budgets using the temperature of the environment. Birds displayed a variable

delay preference, suggesting risk-proneness when they were in cold conditions, hence on a negative energy budget (as they required more energy to maintain their core temperature). Birds displayed a fixed delay preference, suggesting risk-aversion when they were on a positive energy budget in a warm environment (Caraco et al., 1990). These results add support to risk-sensitivity theory. There is also some evidence to suggest that dopamine receptor antagonists (eticlopride, D_2 but not D_1), and serotonin receptor agonists (8-OH-DPAT) reduce preference for variable delays in rats (Rogers, Wong, McKinnon, & Winstanley, 2013) and in humans (Campbell-Meiklejohn et al., 2011).

Findings also suggest that preferences for variable over fixed delays can be found in humans (Locey, Pietras, & Hackenberg, 2009). In these experiments, participants were presented with the choice between fixed intervals and variable intervals until they could watch desired videos as a reward. Overall, individuals showed robust preferences for the variable interval schedules compared to the fixed. Preferences for variable versus fixed intervals to directly consumable food rewards have not been investigated in humans. Hence, my research investigates individuals' preference for fixed versus variable delay schedules using directly consumable food rewards as a proxy measure for preference for quick food.

7. Thesis overview

Obesity is a growing problem in today's society; this is due to greater energy intake than expenditure: overeating versus decreased physical activity (Hill et al., 2012). There are a number of underlying factors for overeating (as explained above). However, from an evolutionary perspective, our inherited foraging strategies may

promote the over consumption of high-energy foods even in food-abundant environments.

Investigating how people schedule their food intake may tell us more about peoples' intertemporal preferences for food consumption and, possibly, how decisions about when to eat contribute to vulnerability to obesity and weight gain. To investigate food-scheduling behaviours (the choices people make about when to consume food) in a laboratory environment, I explored people's preferences for variable delay schedules (that offer the possibility of immediate food rewards or prolonged delays to food rewards) versus fixed intermediate delays to food rewards.

My first experiment sought to validate an experimental assessment of preferences for variable versus fixed delays to real food rewards and the relationships between the reinforcing effects of immediate food, weight (as BMI) and eating attitudes. My second experiment looked at how an environmental cue influences food-scheduling decisions, and if these decisions are influenced by olfactory primes. Picking up from the results of Experiment 1, the final experiment examines the relationship between participants' food-scheduling decisions and delay discounting rates to further investigate how impulsivity contributes to food-scheduling decisions. In each of these experiments, I conducted exploratory analyses to test how participants' preference for variable delays that might deliver rewards immediately or following longer delays, depend upon risk factors for weight gain including BMI, cognitive restraint (Fedoroff et al., 1997), external eating (Burton et al., 2007) and trait impulsiveness as discounting rates (Odum, 2011b).

Chapter 2: Food-scheduling behaviours

Review of the available literature in Chapter 1 indicates a significant gap in the experimental basis for linking weight gain and obesity to inherited, but now-unhealthy food-seeking strategies. Specifically, while evolutionary perspectives posit that the current population prevalence of weight gain and obesity reflects, in part, a mismatch between inherited food-seeking strategies that favour the over-consumption of energy-dense foods and today's obesogenic environment (Lieberman, 2006; Pinel et al., 2000), there has been surprisingly little experimentation into people's food-seeking strategies and relationships with risk factors for longer-term weight gain. In this first experiment, I introduce and test an exploratory model for investigating individuals' food-seeking strategies in terms of their inter-temporal preferences for high-value edible food rewards; and the way that people schedule food intake over brief time intervals.

Foraging research demonstrates that animals tend to make risk-averse selections of small certain food rewards over high-value but uncertain food rewards, yet risk-seeking selections of foods that might be available after either very brief or very long delays (Bateson & Kacelnik, 1997; Marsh & Kacelnik, 2002). For example, starlings show (marginal) preferences for fixed magnitude over variable magnitude food rewards delivered following the same delays (risk-aversion) but marked preferences for variable delays to food rewards of the same magnitude (risk-proneness) (Bateson & Kacelnik, 1995, 1997). Notwithstanding the debate about whether these foraging biases reflect fluctuating (and negative) energy budgets (according to Risk-Sensitivity-Theory) (Caraco et al., 1990; Shafir, 2000; Stephens, 1981) or unreliable internal representations of longer time intervals compared to shorter time intervals in

memory (as in Scalar Expectancy Theory) (Kacelnik & Bateson, 1996), animals' foraging behaviours typically place a premium on obtaining food quickly that outweighs the costs of sometimes sustaining longer delays to food.

Within operant settings too, animals exhibit biased responding towards variable interval (VI) over fixed interval (FI) reinforcement schedules (Case et al., 1995; Herrnstein, 1964; Killeen, 1968). At a neurobiological level, Rogers and colleagues demonstrated, using a discrete choice method, that preferences for variable delays to food rewards are mediated by corticolimbic circuitry (Tremblay et al., 2014) and its monoamine neuromodulation (Rogers et al., 2013). In humans, preference for variable delays over fixed delays have been reported for non-food rewards, such as video clips, and to reflect the relative probability (i.e. distribution) of shorter over longer delays (Locey et al., 2009). However, there has been no test of choices between variable and fixed delays to edible rewards that human subjects have the opportunity to eat in situ.

In a clinical context, investigations of choices involving delays to food rewards have focused upon delay discounting; and the observation that for humans, like animals, delayed rewards tend to be less valuable than immediate rewards (Bickel, Jarmolowicz, Mueller, Koffarnus, & Gatchalian, 2012). The rate at which delayed rewards are discounted with increasing delays is probably higher in individuals with greater compared to smaller percentage body fat (indicating overweight/obesity) (Appelhans et al., 2012; Kishinevsky et al., 2012; Rasmussen et al., 2010; Weller et al., 2008), and in clinically obese individuals with diagnoses of DSM-IV Binge Eating Disorder (Manwaring et al., 2011). Further studies have demonstrated links between obesity and excessive delay discounting using interventions such as episodic future

thinking (Daniel, Stanton, & Epstein, 2013) and mindful eating training (Hendrickson & Rasmussen, 2013) to decrease rates of delay discounting in obese individuals. However, despite these findings, the reported effects are often small, ranging between 0.11 and 0.25 (Bickel et al., 2014).

While studies of delay discounting highlight associations between weight gain and impulsivity, they do not tell us much about how people's inter-temporal preferences for variable over fixed delays vary as a function of high-value food edibles consumed immediately or as a function of other risk factors, such as body mass index, eating attitudes and behaviours. Understanding how people choose to schedule their food intake might help explain how our inherited food-seeking strategies contribute to weight gain and obesity. This could lead to future research to target maladaptive eating patterns and possible pharmacological interventions to manage these behaviours.

In Experiment 1, I carried out an exploratory analysis to investigate food-scheduling behaviours, as indicated by preferences for edible foods delivered following variable or fixed delays in 60 young healthy-weight females; and their relationships with anthropometric and eating-related factors. Adapting the discrete choice model of Rogers et al. (2013) participants made a series of binary selections between simple motor, touchscreen responses associated with variable delays (0s vs 30s) vs fixed delays (15s) to the delivery of pre-selected preferred treats. My results show inter-temporal preferences for edibles delivered following variable delays reflect the value of quick (i.e. immediate) foods and is modulated in opposing ways by risk-factors for longer-term weight-gain, BMI, emotional eating and restrained eating.

Method

The experiment was approved by Bangor University (School of Psychology) Ethics Committee (Application: #2015-15249). All participants provided informed consent (Appendix A1 & A2).

Participants

Sixty healthy female volunteers (Mean age: 25yrs±1.4) took part. Fifty participants were recruited from the School of Psychology student participant panel and through word-of- mouth, and were compensated with course credits. Ten participants were recruited through a local community panel and received £15 payment for their time.

Exclusion criteria included (i) severe obesity as a Body Mass Index (BMI) of 40 or more; (ii) moderate depressive symptoms as indicated by scores of 19 or more on the Beck Depression Inventory II (Beck, Steer, & Brown, 1996; Appendix B); and (iii) 'caseness' for DSM-IV eating disorders indicated by scores of 4 or more on any sub-scale of the Eating Disorders Examination-Questionnaire (Fairburn & Beglin, 1994; Luce, Crowther, & Pole, 2008; Mond, Hay, Rodgers, Owen, & Beumont, 2004; Appendix C).

Psychometric questionnaires

Participants completed self-report measures and psychometric assessments of state positive and negative affect, eating attitudes and behaviours, impulsiveness and cognitive ability. These assessments included the Positive and Negative Affect Scale-State version (PANAS; Watson, Clark, & Tellegen, 1988; Appendix D), Three Factor

Eating Questionnaire-Revised (TFEQ; Karlsson et al., 2000; Appendix E) and Barratt Impulsiveness Scale (BIS-II; Patton et al., 1995; Appendix F). The measures were chosen to describe related traits in our sample.

The PANAS comprises two subscales to measure positive and negative state affect, and includes 20 items scored on a 5-point Likert scale from 'Very slightly/Not at all' to 'Extremely'. Watson et al. (1988) reported Cronbach-α scores of 0.89 for the positive state affect subscale and 0.84 for the negative state affect subscale, indicating good internal reliability. These values were reflected in my sample, with Cronbach-α scores of 0.86 and 0.63 for positive affect and negative affect respectively. The Three Factor Eating Questionnaire-Revised (Karlsson et al., 2000) was included to assess eating attitudes and behaviours. It is comprised of 18 items, with separate subscales for cognitive restraint, uncontrolled eating and emotional eating. de Lauzon et al. (2004) report Cronbach-α values for these subscales as 0.84, 0.83 and 0.87, respectively. The Cronbach-α values in this sample were 0.74, 0.73, and 0.84, also showing a high degree of reliability for the cognitive restraint, uncontrolled eating and emotional eating subscales.

The Barratt Impulsiveness Scale (Patton et al., 1995) provides a measure of trait impulsivity. It includes 30 items measured on a 4-point Likert scale from 'Rarely/Never' to 'Almost always/Always'. Three primary subscales include attentional, motor and non-planning impulsivity. Only total scores were used here; for these scores, Patton et al. (1995) report Cronbach-αs between 0.79 and 0.82. The Cronbach-α value for BIS total scores in this sample was 0.75.

The Ravens Matrices-Short Form (Arthur & Day, 1994; Appendix G) is a quick measure of (non-verbal) cognitive ability. This measure includes 12 items selected from the Advanced Progressive Matrices (APM; Raven, Court, & Raven, 1985). Arthur and Day (1994) report Cronbach's αs of 0.72 for the short form used here; with scores being strongly associated with those from the APM, $r = .90$, $p < .001$.

Finally, participants answered a series of questions about their awareness of the box contingencies from the task (Appendix H). These questions included, ′Which box was your favourite′ (favourite box), ′On average, how many seconds do you think you had to wait before receiving a treat after pressing the green/blue box?′ (the estimated delay risky/fixed), ′How many treats do you think you received?′ (estimated treats), and ′What percentage of your presses were on the green box?′ (estimated risky choice).

Food-scheduling task

Participants completed a series of 39 selections involving preferred food rewards or 'treats'. On each selection, participants were presented with 1 green and 1 blue box side-by-side on a standard touch-sensitive display (Figure 2.1). The dimensions of the boxes were 40mm x 40mm and the boxes were positioned 40mm apart on the display, subtending a visual angle of approximately 7.26° at a rough viewing distance of 630mm.

Touching one of the boxes (e.g. green), with the index finger of the preferred hand, delivered a single treat following variable delays of 0s or 30s (each scheduled with probabilities of 0.5); while touching the other box (e.g. blue) delivered a single treat following a fixed delay of 15s. Treats were delivered by a bespoke motorised food-

dispenser into a plastic 'hopper' positioned within easy reach of the participants' right-hand side. Following delivery, a randomly jittered interval of 20s to 30s allowed participants sufficient time to consume each treat before the following selection.

The variable delay (e.g. green) and the fixed delay (e.g. blue) boxes appeared randomly on the left- or the right-hand side of the display over successive selections. The assignment of colour of box (either green or blue) to the variable or fixed delays was counterbalanced across the 60 participants of the sample.

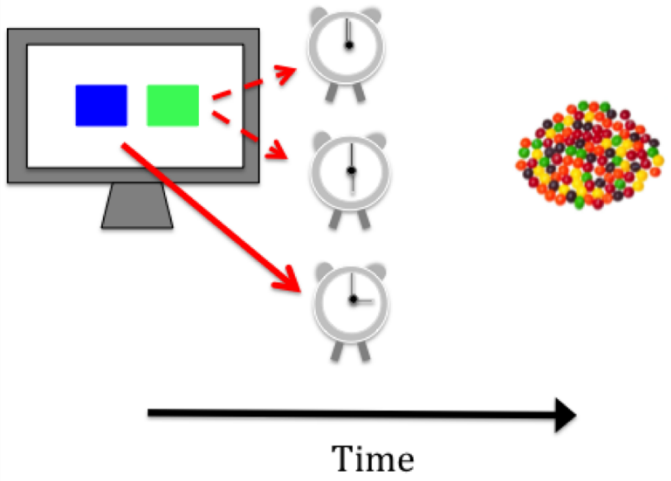


Figure 2.1. Schematic representation of selection options and sequence of events in the food-scheduling task. On each selection, participants were presented with a green and a blue box, side by side on computer display. Touch-responses on 1 box (e.g. green) delivered food rewards either immediately (0s) or following long delays (30s). Touching the other box (e.g. blue) delivered food rewards following fixed intermediate delays (15s). Participants made 39 such selections.

Procedure

Participants were asked to fast for at least 2hrs following breakfast or lunch prior to testing sessions scheduled for 11am or 4pm. On arrival at the lab, participants provided informed consent, and completed assessments of personality, impulsivity, mood, eating behaviours and cognitive ability. Height and weight (to the nearest 0.1cm/kg) were measured in light clothing without shoes for calculation of Body

Mass Index (BMI)**:** (weight (kg))/(height(cm))^2. Participants provided ratings of hungry using a 7-point Likert scale from 'Not at all hungry' to 'Extremely hungry'.

Next, participants were shown small paper dishes of 5 sweet (*Maltesers, Minstrels, Jelly Beans, Skittles* and *Revels*) and 5 savoury (*Hula Hoops Original, Cheese Puffs, Cheese Savouries, Pretzels* and *Twiglets*) food rewards, and asked to rank them in order of preference from 1 to 5 for each category. Participants chose between their highest-ranking sweet and highest-ranking savoury to select their preferred food reward for the experiment; and 39 of these treats were loaded into the food dispenser. Task instructions were presented on screen and read aloud to the participant:

"On each go, a green box and a blue box will appear side-by-side on the screen.
Touching either of them will produce your favourite treat in the plastic tray here.
You may need to wait a while for the treat to be delivered.
Sometimes the green box will appear on the left and the blue box on the right; sometimes the boxes will appear the other way around. But this will be random.
Once you've eaten (and enjoyed) the treat, the green and blue boxes will reappear and you can then obtain another treat.
That's all you have to do.
At the end we'll ask you some questions. But for now, enjoy."

Participants were then left alone to complete the food-scheduling task in their own time. On its completion, participants were asked to rate again how hungry they felt using the 7-point Likert scale (Appendix I), and answer questions on their awareness of the contingencies of each of the boxes. They were then paid and free to leave.

Data analysis

Binary choice of the variable delay vs the fixed delay schedules. Participants' choice between variable (or 'risky') and fixed delay options were analysed with multi-level binomial logistic models, with participant and selection (1 through 39) included in the intercept as random effects. These models yielded β-coefficients and standard errors; dividing the former by the latter produces Z-scores, allowing convenient significance tests ($p < .05$). All regression models were computed using RStudio (RStudio, 2015). Descriptive statistics were computed using IBM SPSS Statistics (IBM, 2013).

In Model 1, I tested an initial set of binary/categorical ′control′ predictors that included (i) colour assigned as the variable delay box ('blue' as the referent); (ii) side of the display that the variable delay box appeared on each selection (with 'right' as the referent); (iii) time of day ('afternoon' as the referent); (iv) food type (i.e. 'savoury' with 'sweet' as the referent); and (v) the interaction between (iii) time of day and (iv) food type. None of the predictors (i) through (v) were statistically significant and were removed from subsequent models (see Table 2.2).

Next, in Model 2, I included predictors for (vi) the delay before the treat was delivered on the previous selection (with 0s and 30s entered as categorical predictors and 15s as the ′referent′; ′last delay′). In Model 3, I added (vii) BMI; (viii) TFEQ-R cognitive restraint subscale scores, (ix) TFEQ-R emotional eating subscale scores, and (x) TFEQ-R uncontrolled eating subscale scores; and (xi) hunger ratings before completion of the food-scheduling task, all as continuous variables. Finally, in Model 4, I added the interaction between (xii) the delay before food reward delivery on the

previous selection and BMI; (xiii) the interaction between the delay before food reward delivery on the previous selection and the cognitive restraint subscale scores, (xiv) the interaction between the delay before food reward delivery on the previous selection and emotional eating subscale scores, and (xv) the interaction between the delay before food reward delivery on the previous selection and uncontrolled eating subscales; and finally (xvi) the interaction between the delay before food reward delivery on the previous selection and hunger ratings.

Choice selection times. Participants' latencies to select between the variable and fixed delay schedules were analysed using normal-distribution regression models. These models included the same sets of predictors, entered in the same sequence as the models for the logistic choice models, yielding β-coefficients and standard errors but then t-statistics that could be tested against estimated degrees of freedom (at $p <$ .05).

In a series of control models for both the binary choice and choice latencies, I also tested whether variable vs fixed delay preferences were moderated by participants' method of recruitment (student or community participant sample); as well as participants' age, cognitive ability (measured by the Raven's Matrices Short-Form) (Arthur & Day, 1994), depressive mood (measured by the BDI-II; Beck et al., 1996), symptoms of eating disorders (measured by the EDE-Q; Fairburn & Beglin, 1994), impulsivity (measured as total score of the Barratt Impulsivity Scale; Patton et al., 1995). However, associations between binary choice and choice times measures and these variables were weak and are not discussed further.

Finally, I also tested whether participants′ food-scheduling choices were moderated by their awareness of the variable vs fixed delay contingencies for both proportionate choice of variable delays and choice selection times. These models included (i) the delay prior to the food reward on the previous selection and then, in separate models, (ii) participants′ estimated risky choice; (iii) participants′estimates of the fixed delay a; (iv) their estimate of the variable delay; (v) their favourite box. For each model, I then added the interactions between last delay and these predictors.

Results

Demographic and psychometric sample characteristics

Demographic information, and the mood and eating characteristics of the sample, are shown in Table 2.1. The mean BMI of the participants fell inside the healthy band of 18.5 to 25.0, with 1/3 scoring beyond this range. Participants were screened to ensure modest depressive symptoms scored with the BDI II (Beck et al., 1996) and minimal eating disorder symptoms scored with EDE-Q (Fairburn & Beglin, 1994).

	N	Mean (SE)
Age	60	24.78 (1.44)
BMI	60	23.38 (0.40)
TFEQ Cognitive restraint subscale	58	29.79 (1.83)
TFEQ Uncontrolled eating subscale	59	28.84 (1.61)
TFEQ Emotional eating subscale	60	32.92 (2.92)
Raven's scaled score	57	12.16 (0.47)
BIS-11 Total score	59	61.39 (1.14)
EDE-Q Restraint subscale	60	1.12 (0.14)
EDE-Q Eating concern subscale	60	0.57 (0.09)

EDE-Q Shape concern subscale	60	1.70 (0.14)
EDE-Q Weight concern subscale	60	1.24 (0.13)
BDI-II	60	6.59 (0.67)

Table 2.1. Mean (±standard errors), age, BMI and self-report scores for 60 females selecting between variable and fixed delays to edible food rewards. Three Factor Eating Questionnaire (Karlsson et al., 2000); Ravens Matrices - short form (Arthur & Day, 1994); BIS-11/Barratt Impulsiveness Scale (Patton et al., 1995); Eating Disorders Examination Questionnaire (Fairburn & Beglin, 1994) and Beck Depression Inventory II (Beck et al., 1996). 3 participants did not provide Raven's scores; 1 did not provide a BIS-11 score.

Unsurprisingly, therefore, participants reported slightly fewer concerns about eating, shape, weight or restrained eating compared to published unselected norms: 0.62±0.06 (eating); 2.15±0.10 (shape); 1.59±0.06 (weight) and1.25±0.09 (restraint) (Fairburn, Cooper, & O'Connor, 2008). Finally, participants reported normative levels of impulsive traits, identified with the BIS-11, as compared to the total scores of 63.32±0.61 of an undergraduate female sample (Patton et al., 1995). There were no differences in any demographics, other than age, between participants recruited from the local community and the student participant panel. Participants recruited from the local community were older (49.63 ± 4.66 years) compared to participants in the student sample (20.41 ± 0.23 years).

Predictor	Model 1	Model 2	Model 3	Model 4
Intercept	0.24 (0.29)	0.20 (0.14)	-0.13 (1.29)	1.89 (1.40)
Side of variable delay option	0.16 (0.09)	-	-	-
Colour of variable delay option	-0.23 (0.27)	-	-	-
Time of day	0.14 (0.37)	-	-	-
Treat type	-0.33 (0.38)	-	-	-
Time of day * treat type	0.35 (0.52)	-	-	-
Last delay 0s	-	0.23 (0.11)*	0.20 (0.12)	-3.79 (1.78)**
Last delay 30s	-	-0.27 (0.12)*	-0.30 (0.13)*	-4.42 (1.27)**
BMI	-	-	0.01 (0.04)	-0.09 (0.05)
TFEQ Restrained eating	-	-	-0.02 (0.01)*	-0.01 (0.01)
TFEQ Emotional eating	-	-	0.01 (0.01)	0.02 (0.01)*
TFEQ Uncontrolled eating	-	-	-0.02 (0.01)	-0.02 (0.01)†
Hunger	-	-	0.27 (0.11)*	0.18 (0.12)
BMI*Last delay 0s	-	-	-	0.17 (0.04)**
BMI*Last delay 30s	-	-	-	0.14 (0.04)**
TFEQ Restrained eating*Last delay 0s	-	-	-	-0.02 (0.01)*
TFEQ Restrained eating*Last delay 30s	-	-	-	0.01 (0.01)
TFEQ Emotional eating*Last delay 0s	-	-	-	-0.01 (0.01)
TFEQ Emotional eating*Last delay 30s	-	-	-	-0.02 (0.01)*
TFEQ Uncontrolled eating*Last delay 0s	-	-	-	0.00 (0.01)
TFEQ Uncontrolled eating*Last delay 30s	-	-	-	0.02 (0.01)†
Hunger*Last delay 0s	-	-	-	0.21 (0.11)†
Hunger*Last delay 30s	-	-	-	0.13 (0.11)
AIC	2874.1	2857.4	2705.4	2690.0
BIC	2919.9	2886.0	2762.1	2803.3

Table 2.2. *β*-coefficients (and standard errors) for 4 multi-level binomial regression models of proportionate choice of variable delays (0s vs 30s) over fixed delays (15s) to delivery of preferred edible treats. Dividing the *β*-coefficient by the standard error (SE) yields a Z-score. *$p < .05$; ** p

<.01; †denotes significance due to rounding. Note: 'Restrained eating'= 'Cognitive restraint' subscale of the Three Factor Eating Questionnaire-Revised (Karlsson et al., 2000). Akaike information criterion (AIC) and Bayesian information criterion (BIC) provide estimates of model fit.

Selections between variable and fixed delay schedules: preliminary analyses

Participants who chose sweet food rewards for the experiment and participants who chose savoury rewards showed almost identical proportionate choices of the variable over the fixed delay option (see Model 1 in Table 2.2) (0.55±0.04 vs 0.55±0.04; β= -0.33±0.38, Z= -0.87). Similarly, there were no significant differences in the proportion of variable delay choices made by participants seen in the morning compared to those seen in the afternoon testing sessions (0.57±0.03vs 0.53±0.04; β= 0.14±0.37, Z= 0.38). Finally, there were no marked differences in the number of variable delay selections when the box assigned to the variable delays was green rather than blue (0.53±0.03 vs 0.56±0.04, β= -0.23±0.27, Z= -0.85) or presented on the left-hand side of the display compared to the right (0.53±0.03 vs 0.57±0.03, β= 0.16±0.09, Z= 1.76).

Selections between variable and fixed delay schedules: effects of delay to food rewards on previous food-scheduling selections, BMI and eating behaviours

Overall, participants were significantly more likely to choose the variable delay option again if, having made the same choice on the previous selection, they received a treat immediately compared to having chosen the fixed delay option (see Model 2 in Table 2.2) (0.60±0.03 vs 0.55±0.03, β= 0.23±0.11, Z= 2.09, p< .05). By contrast, participants were less likely to choose the variable delay option, having made the same choice on the previous selection, if they received a treat only after the longer delay of 30s (0.49±0.03 vs 0.55±0.03, β= -0.27±0.12, Z= -2.25, p< .05). In addition, participants with higher ratings of state hunger at the start of the food-scheduling task tended to choose the variable delay option more frequently than those participants with lower ratings of hunger (see Model 3) (β= 0.27±0.11, Z= 2.45, p< .05).

Critically, the effects of the previous delays to food rewards on food-scheduling choices were moderated in opposite directions by BMI and restrained eating. Participants with high BMIs were more likely than participants with low BMIs to choose the variable delay option again if, having done so on the previous selection, they received an immediate treat (see Figure 2.2; Model 4 in Table 2.2) (β= 0.17±0.04, Z= 4.25; p< .01). Similarly, high BMI participants were also more likely than low BMI participants to choose the variable delay option having done so on the previous selection and received a delayed treat (β= 0.14±0.04, Z= 3.50; p< .01).

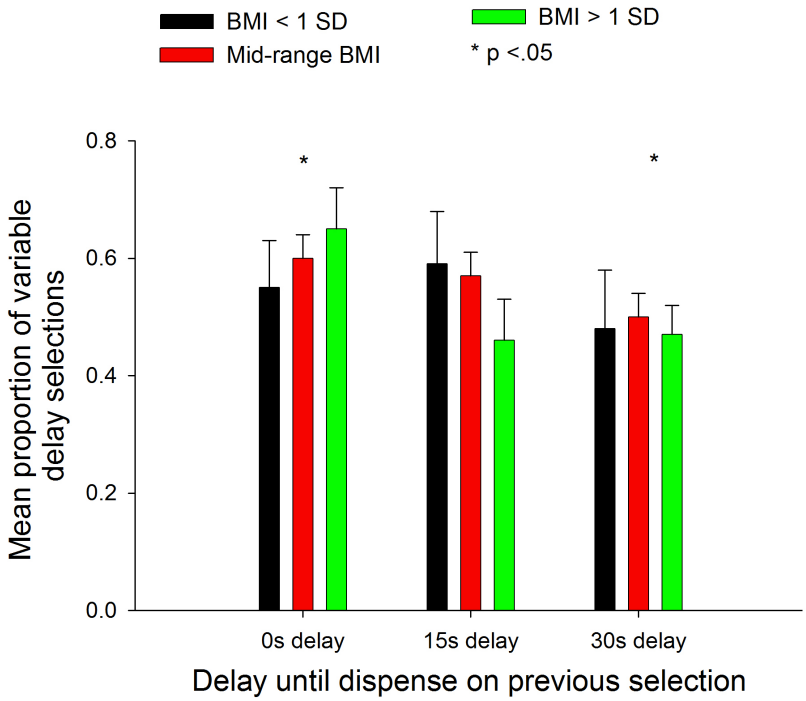


Figure 2.2. Mean proportion (and standard errors) of variable delay choices for low BMI participants (< 20.2; less than 1 SD less than the mean), mid-range BMI and high BMI participants (> 26.5; less than 1 SD greater than the mean) following delays of 0s (variable delay), 15s (fixed), or 30s (variable delay) on the previous selection.

In contrast to the effects of BMI on food-scheduling selections, those participants who reported high restraint in their eating patterns were significantly less likely than those participants who reported low restraint to choose the variable delay option if they had done so on the previous selection and received their food rewards immediately (see Figure 2.3 and Model 4 in Table 2.2) (β= -0.02±0.01, Z= -2.00, p< .05).

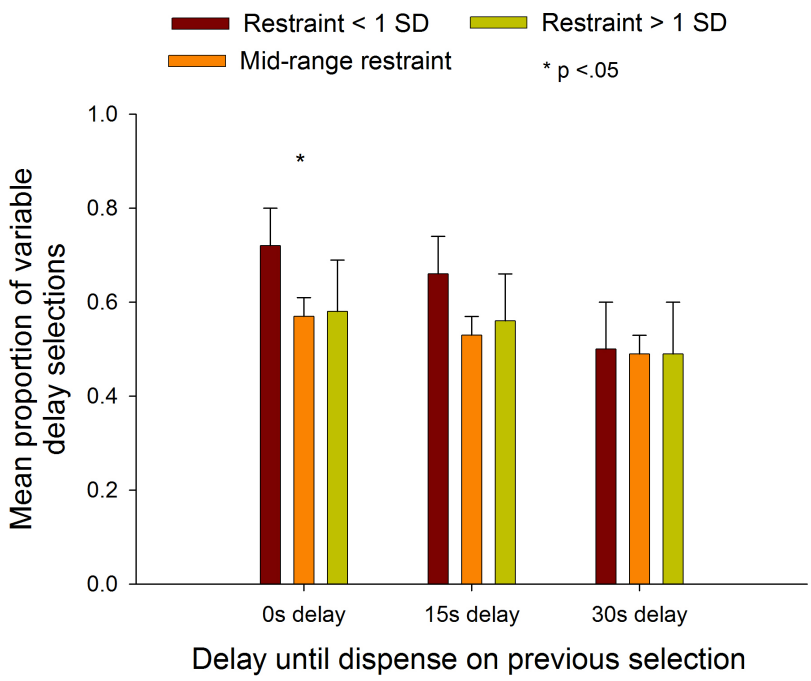


Figure 2.3. Mean proportion (and standard errors) of variable delay choices for low eating restraint participants (<16.05 less than 1 SD less than the mean), mid-range, and high cognitive restraint (>43.64; greater than 1 SD less than the mean) participants following delays of 0s (variable delay), 15s (fixed), or 30s (variable delay) on the previous selection.

Finally, participants who reported high levels of emotional eating were less likely than participants who reported low levels of emotional eating to choose the variable delay option if they received a treat following a long delay (30s) on the previous selection (β= -0.02±0.01, Z= -2.00, p< .05); they were also more likely to choose the variable delay following the fixed delay of 15s (see Figure 2.4).

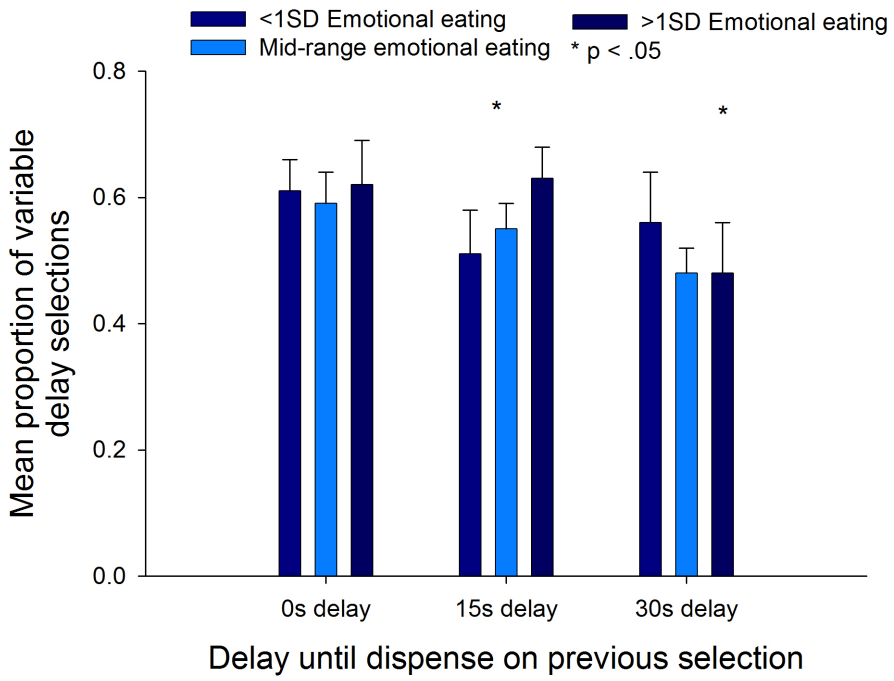


Figure 2.4. Mean proportion (and standard errors) of variable delay choices for low emotional eating participants (<11.05 less than 1 SD less than the mean), mid-range, and high emotional eating (>56.18; greater than 1 SD less than the mean) participants following delays of 0s (variable delay), 15s (fixed), or 30s (variable delay) on the previous selection.

Selections between variable and fixed delay schedules: self-reported food-scheduling behaviour and preferences

Unsurprisingly, participants who recalled making more variable delay selections made a corresponding higher proportion of such selections compared to those who reported fewer variable selections (β= 3.51±0.40, p< .01, Z = 8.77). Participants who estimated the (overall) variable delays as shorter were also more likely to have made a higher proportion of variable delay selections compared to participants who estimated the variable delays as longer (β= -0.04±0.02, p< .05, Z = 2.00). Additionally, participants who reported that the variable delay selection was their favourite of the two options made significantly more choices for the variable delay box (β= 1.17±0.23, p< .01, Z = 5.09). None of these variables showed any marked interactions with the delay prior to reward on the last selection (all 0.00< βs< -0.67). Finally, there were no significant associations between participants' self-reported food-

scheduling behaviour and BMI, cognitive restraint, or uncontrolled eating subscales of the TFEQ-R. However, participants whose favourite option was the variable delay schedule, rather than the fixed delay schedule, reported higher emotional eating scores on the TFEQ-R (see Figure 2.5) (24.45±3.38 vs 37.35±3.89 β= 12.71±0.97, $t(3569) = 13.14$, $p < .01$) There were no similar differences for either cognitive restraint or uncontrolled eating (see Figure 2.5. β= 2.11±3.84 and β=3.59±3.29, respectively).

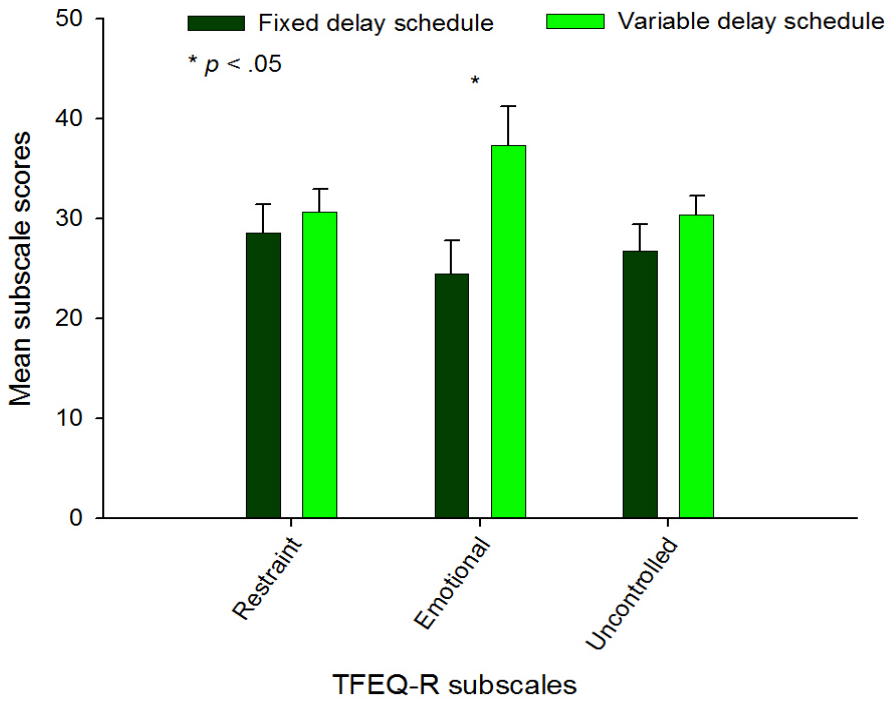


Figure 2.5. Mean subscale scores of TFEQ-R cognitive restraint, uncontrolled eating and emotional eating for participants who chose the fixed schedule as their favourite versus the variable schedule as their favourite.

Choice times between variable and fixed delay schedules: preliminary analyses

There were no reliable differences in the choice times of participants for whom the variable delays were assigned to the green box compared to blue box (2.17±0.04 vs 2.18±0.04; β= 0.13±0.35, $t(51.1)$= 0.38, *ns*) or when the variable delay box appeared on the left rather than right-hand side of the display (2.21±0.04 vs 2.13±0.04; β= 0.13±0.13, $t(2195)$= 1.00, *ns*). Preferences for sweet or savoury treats as the food rewards did not make any substantial difference to the time to choose between variable and fixed delay options (2.24±0.04s vs

2.11±0.04s; β= -0.12±0.49, t(51) = -0.25, *ns*). Similarly, overall, there were no marked differences in deliberation time between participants who chose savoury treats in the morning compared to the afternoon (2.09±0.05 vs 2.09±0.05; β= -0.36±0.68, t(51.3) = -0.53, *ns*).

Choice times between variable and fixed delay schedules: effects of delay to food rewards on previous food-scheduling selections, BMI and eating behaviours

Overall, participants were faster to make choices following delays of 0s on the previous selection, compared to choices made following 15s delays (0s: 2.09±0.09 vs 2.38±0.12, β= -0.44±0.16, t(2244.70) = -2.71, p< .05; 30s: 2.30±0.11 vs 2.38±0.12, β= -0.09±0.18, t(2240.70) = -0.50, *ns*). Participants with high BMIs who made variable delay choices on their last selection were no faster to respond to subsequent choices than participants with lower BMIs, both when they had received treats immediately (2.07±0.22 vs 1.95±0.18, β= 0.06±0.06, t(2109) = 1.00, *ns*) and following a longer 30s delay (β= -0.05±0.06, t(2103) = 0.76, *ns*).

Participants with high levels of restrained eating did not take substantially longer to make their choices compared to those who reported low levels of restraint following variable delay choices that delivered immediate treats (β= 0.01±0.01, t(2055) = 1.00, *ns*) or delayed treats (β= 0.01±0.01, t(2113) = 1.00, *ns*). Similarly, participants with high levels of emotional eating also did not differ in the time to make their choices compared to participants with low levels of emotional eating following immediate treats (β= -0.01±0.01, t(2114) = 1.00, *ns*). However, participants with high emotional eating who received a treat following a long delay were slower to make their choice on the subsequent trial (β= -0.02±0.01, t(2112) = 2.00; p< .05). Participants with high scores on the uncontrolled eating scale did not differ in time to

make their choices compared to participants who were lower in uncontrolled eating (0s: β = 0.03±0.02, $t(2110) = 1.50$, *ns*; 30s: β = 0.02±0.02, $t(2112) = 1.00$, *ns*).

Choice times between variable and fixed delay schedules: self-reported food-scheduling behaviour and preferences

Finally, participants' awareness of the box contingencies (estimated proportion of variable delay choices, estimated duration of fixed/variable delays, favourite box, or estimated number of treats) did not influence their choice reaction times on following trials (0.00±0.00 < β < 0.02±0.00).

Discussion

Evolutionary perspectives on obesity posit a mismatch between inherited food selection strategies that favour over-consumption of energy dense food and an obesogenic environment in which such foods are plentiful (Lieberman, 2006; Pinel et al., 2000). Foraging and operant theory highlights animals' preference for variable intervals to food rewards (Bateson & Kacelnik, 1995; Case et al., 1995); similar biases and have been reported in humans too for non-food rewards (Locey et al., 2009). To my knowledge, Experiment 1 is the first to demonstrate that human adults show robust preferences for variable over fixed delays to food rewards and that these preferences are strengthened by the delivery of quick foods but moderated in opposing directions by three significant risk factors for (longer-term) weight gain; namely, BMI, emotional eating and cognitive restraints over eating.

The design of Experimental 1 has several strengths. First, my participants were assessed to exclude individuals with histories of significant recent depressive symptoms (that can interfere with food and eating behaviours) (Blaine, 2008) and 'caseness' for eating disorders. Thus, this demonstration that individuals' preference for variable delays is strengthened by

the delivery of immediate food rewards on prior selections (i.e. as quick foods) and is moderated in different ways by BMIs, eating restraint and emotional eating, is unlikely to reflect co-occurring mood or eating-related psychopathology. Second, participants completed the food-scheduling task with preferred treats picked out of a menu of 5 confectionary and 5 savoury snacks, ensuring that a high-value edible was used for all participants, reflecting their individual differences in food preference. Further, there was no significant evidence that the pattern of participants' preferences for variable delays, their deliberation times, and their relationships with BMI and cognitive restraint, was specific to particular treats or time-of-day assessments.

Individuals' choices, and the increased choice of the variable delay schedule following immediate food rewards, were not markedly associated with participants′ estimates of the percentage of variable delay selections or their estimates of the duration of schedule delays. Similarly, there were only weak associations between self-reported food-scheduling behaviours (elicited after the protocol had been completed) and BMI, cognitive restraint and uncontrolled eating (as measured by the TFEQ-R) but one statistically significant increase in emotional eating amongst those who reported the variable schedule as their favourite. Collectively, the inter-temporal preferences, and their modulation by the most recent delays to high-value food-rewards, reported here are not systematically mirrored by their self-reported impressions about the reinforcement contingencies of food-scheduling assessment.

Finally, all participants completed my food-scheduling assessment while moderately hungry, having fasted for 2hrs after breakfast or lunch. The finding that state hunger just prior to completion of the food-scheduling task increased (albeit marginally) preference for the variable delay over the fixed delay choice options is at least consistent with other evidence

that foraging biases are sensitive to negative energy budgets (Caraco et al., 1990; Stephens, 1981) but, more importantly, validates the food-scheduling assessment as sensitive to (food-relevant) motivational state.

As discussed in the introduction, animals tend to be risk-averse in relation to reward magnitudes but risk-seeking in relation to delays to reward (Bateson & Kacelnik, 1995, 1997; Kacelnik & Bateson, 1996; Marsh & Kacelnik, 2002), reflecting the increased value of immediate over delayed foods in the face of possible starvation or predation (Bixter & Luhmann, 2013). Comparable biases are evident in operant contexts with pigeons and rats (Case et al., 1995; Herrnstein, 1964) and, possibly, in humans with non-food rewards (Locey et al., 2009). Individuals with anorexia, bulimia or obesity can experience problems with risky decision-making (Brogan, Hevey, & Pignatti, 2010), possibly mediating symptom severity (Davis et al., 2010; Manasse et al., 2015). Experiment 1 extends the above observations by demonstrating that, under some conditions at least, young healthy females show clear preference towards risk in the form of temporally uncertain over fixed delays for preferred foods. These data suggest that the delivery of quick food, possibly reflecting its augmented reward value, sustains this food-seeking strategy (and facilitates the speed of its selection) over subsequent selections. This is further validated by the finding of the current study that delivery of an immediate treat, results in faster selections between choice of variable/fixed delays on the following trial.

Obesity is associated with increased preferences for small immediate rewards (including, for example, money) at the expense of large delayed rewards, indicating a potential role for impulsivity in over-eating and weight-gain (Manwaring et al., 2011; Rasmussen et al., 2010; Rollins, Dearing, & Epstein, 2010; Weller et al., 2008). From this perspective, preferences

for variable over fixed delay options could reflect the higher combined value of immediate food rewards (at 0s) and heavily discounted food rewards (at 30s) compared to intermediately discounted food rewards (at 15s). Little is known about the relationship between preferences for variable over fixed delays to rewards and discounting rates (Madden et al., 2011). However, my observation that the immediate delivery of preferred foods sustained subsequent selections of the variable delay option in individuals with high BMI supports the working hypothesis that the consumption of quick food produces a transient increase in its relative reward value in individuals vulnerable to longer-term weight gain. Possibly, this leads to further over-weighting of the value of immediate over delayed foods, and increases the tolerance of risk or uncertainty in food-seeking behaviours. Additionally, this suggests that BMI is associated with an efficient 'behavioural set' to persist with variable delay options if they deliver quick food-rewards ('win-stay') but to switch rapidly to the fixed delay option ('lose-shift') if variable delay selections delivered only longer delayed rewards.

By contrast, my results show diminished preference for the variable delay option in participants with high levels of restrained eating, suggesting that the tendency to over-ride physiological signals of appetite counteracts the value of quick food. This is in line with the definition of restraint proposed by Fedoroff et al. (1997), "*as the deliberate effort to combat the physiologically-based urge to eat in order to lose weight or to maintain a reduced weight.*" (p. 34). This pattern of findings raises the possibility that cognitive restraint is associated with attempts to schedule or regulate the temporal patterning of their food intake, manifested here as preferences for the fixed delay option. Restrained eating is a risk factor for longer-term weight gain (Fedoroff et al., 1997; Polivy et al., 2005; Wallis & Hetherington, 2004). Therefore, these data suggest that attempts to regulate the timing of food intake through fixed delays indexes a countervailing strategy that can be over-ridden by those

factors that challenge restrained eating (e.g. preloads in people high in disinhibition (Ouwens, van Strien, & van der Staak, 2003; van Strien, Cleven, & Schippers, 2000)).

Previous findings have reported an association between emotional eating and a lack of patience (van Strien, Frijters, Roosen, Knuiman-Hijl, & Defares, 1985), and correlations with facets of negative affect and neuroticism (impulsiveness, anxiety, hostility, depression, self-consciousness and vulnerability; Elfhag & Morey, 2008) in samples of obese, and non-obese individuals. From this perspective, emotional eaters are motivated to eat in order to reduce feelings of anxiety and negative affect - Psychosomatic theory (Kaplan & Kaplan, 1957). Here, I found that individuals with high levels of emotional eating showed reduced choice of the variable schedule having previously chosen that schedule and received a treat following a long delay of 30s. Additionally, these individuals also demonstrated increased selections of the variable schedule following fixed schedule selections that produced treats following 15s. Possibly, participants with high scores on the TFEQ-R subscale for emotional eating evaluate the variable vs the fixed delay option on their basis of their relative aversion to long delays: 15s is worse than 0s and 30s is worse than 15s. Thus, participants with high levels of emotional eating will be motivated to switch to the variable option following fixed delays of 15s but then also motivated to switch to fixed delay options following the delays of 30s. Individuals who reported that the variable delay schedule was their favourite also reported higher scores for emotional eating than those whose favourite was the fixed delay schedule, suggesting that the availability of short delays to high-value food rewards is associated with affective responses that could reinforce action/operant preferences as a form of evaluative conditioning (Hofman, De Houwer, Perugini, Baeyens, & Crombez, 2010; Lebens et al., 2011).

These first results are subject to several qualifications. First, I included female but not male participants. Given gender-specific attitudes to risk (Warshawsky-Livne et al., 2014) and food (Carels, Konrad, & Harper, 2007), male adults may show distinct patterns of choices in our food-scheduling assessment. Second, the food rewards offered were small edible treats, and not delivered in the quantities associated with weight gain in vulnerable populations (Whybrow, Mayer, Kirk, Mazlan, & Stubbs, 2007). Third, impulsiveness, as measured by the BIS-11, did not predict choice of variable over fixed delay options. Possibly, this is because the BIS-11 (and its subscales) do not capture delay discounting (Patton et al., 1995) or that variation in food-scheduling choices depends, less upon failing cognitive/motor control, but more the stable inter-individual differences in food-seeking behaviours. Finally, individuals with high cognitive restraint may have shown a somewhat diminished preference for the variable ("risky") choice as a result of the weight measurement that occurred prior to the snacking task, given that this may have acted as a dietary cue (Papies & Hamstra, 2010).

Notwithstanding these uncertainties, Experiment 1 demonstrates that young, healthy female adults show preferences for varied compared to fixed delays to preferred food rewards, and that variation in BMI, emotional eating and restrained eating moderate food-scheduling strategies in opposing ways. Experiment 2 further explores the mechanism underlying food foraging strategies and individuals' vulnerability to weight gain by investigating if reward cues in the environment alter preferences for delays until food rewards.

Chapter 3: The effects of environmental reward cues on food-scheduling behaviour

Our current food environment affords opportunities to secure food easily and at very low energy costs (Lieberman, 2006; Malik, Willett, & Hu, 2013). This environment contains a plethora of food cues, or stimuli that signal to us the easy availability of food (Lieberman, 2006). However, these cues are more salient to some individuals (Schachter, 1971), or in certain situations or motivational states (such as deprivation; Polivy et al., 2005) than others. Experiment 2 sought to explore the possible influence of such cues upon preferences for fixed versus variable delay schedules. Experiment 1 demonstrated that moderately hungry people showed moderate but consistent preferences for variable delay food schedules but that these preferences were enhanced following the receipt of immediate food rewards on previous selections in healthy young female adults. The enhancement of variable schedule preferences following the quick delivery of high-value food rewards was more marked in individuals with high BMI but moderated by high levels of cognitive restraint and emotional eating. Collectively, these data suggest that the preferences for variable delay versus fixed delay schedules reflect the value of quick rewards but are sensitive to risk factors for weight gain and obesity. In Experiment 2, I investigated whether these preferences for immediate rewards can be manipulated by environmental cues.

Many different types of environmental cues influence eating behaviour. The two most common types of cues are visual stimuli and olfactory (processing of aromas). Visual food cues can take the form of words (text) (Papies, Stroebe, & Aarts, 2008) or real objects such as portion size (Wansink, Painter, & North, 2005). Some cues can be dynamic: for example, such as cartoons displaying overweight cartoon characters that consume a greater amount of calorie dense foods compared to children whose cartoons had not included overweight characters (Campbell, Manning, Leonard, & Manning, 2015). Other cues are linked to health

messaging or prescriptions: seeing a poster displaying a dieting cue was enough to limit consumption of meat snacks (Papies & Hamstra, 2010). In some cases, the sight of food is enough to increase consumption. In one simple example, when chocolates were placed visibly near participants, they ate two and a half times the amount than when they were not visible (Wansink, Painter, & Lee, 2006).

Olfactory cues both in general and particularly those that relate to eating can have powerful effects upon behaviour given its intimate connection with taste (Rouby, 2002). Olfactory cues are frequently used in marketing to entice consumers, persuade them to purchase particular food products (Spence, 2015), and to increase memory and recall of particular brands (Krishna, 2012). The aroma of food is often enough to stimulate increased consumption. This is particularly true in restrained eaters, who rely more upon environmental cues and less upon internal cues such as hunger, in order to regulate food intake and/or adhere to the demands of a diet (Herman et al., 1987), compared to unrestrained eaters. For example, restrained eaters consumed more pizza following exposure to a pizza aroma compared to unrestrained eaters (Fedoroff et al., 1997; Jansen & van den Hout, 1991).

Interestingly, Coelho, Polivy, Herman, and Pliner (2009) argue that increased consumption is only seen in restrained eaters when they are instructed to specifically attend to the food aromas, consistent with reports from Fishbach, Friedman, and Kruglanski (2003) that restrained eaters consume less food than unrestrained eaters following exposure to an olfactory food cue but only when unrestrained eaters are unaware of the olfactory cue. There is other evidence that specific food cues in the environment can influence eating behaviours. Participants exposed to a pear aroma chose more fruit desserts in comparison to participants not exposed to a pear aroma (Gaillet-Torrent et al., 2014). Additionally, olfactory food cues

can both increase or decrease consumption. An example of the use of olfactory cues to decrease consumption is where a cue is used to influence self-regulation behaviour in the case of dieting. After exposure to the smell of grilled chicken, participants exposed to a diet cue (a poster displaying a diet recipe) ate fewer meat snacks compared to restrained eaters in the control condition who were not exposed to a dieting cue (Papies & Hamstra, 2010). By contrast, in the case of using an olfactory cue to increase consumption, restrained eaters who were exposed to the aroma of cooked pizza or chocolate chip cookies, consumed more of the cued food than unrestrained eaters (Fedoroff et al., 2003). In order for environmental cues to prime behaviour, cues are most effective if they are congruent with the target stimulus (Schachter, 1971). For example, participants eat more food that is primed (for example, ice cream or pizza), in this case using a preload, than food that isn't primed (Cornell et al., 1989). Furthermore, an olfactory cue of a melon or pear scent facilitated lexical decisions for words related to this specific food reward (e.g. 'melon') (Gaillet et al., 2013).

In Experiment 2, I investigated whether intertemporal preferences for high-value food rewards (chocolate offered in variable delay and fixed delay schedules) are sensitive to (congruent) olfactory food cues in the environment. I wished to test the hypothesis that individuals who were exposed to a scent that signalled the availability of high value food rewards (i.e. chocolate scent), would make more variable delay selections than fixed delay selections compared to individuals who were not exposed, and that these preferences would be especially heightened following the delivery of immediate food rewards. I also sought to explore, as in Experiment 1, whether these preferences were moderated by BMI and other risk factors for weight gain.

Experiment 2 included a number of new design features. First, I used chocolate scent as the prime and Cadbury's milk chocolate pieces™ as the reward. In this experiment, pilot testing allowed me to establish a protocol in which the olfactory cue (chocolate scent) reached a discreet, discernible intensity that could be identified only when participants were aware of its presence. Second, Experiment 1 involved only female participants, whereas the sample in Experiment 2 comprised male and female participants. Men and women have been shown to demonstrate differences in their preferences towards food choices (Cornier, Salzberg, Endly, Bessesen, & Tregellas, 2010) and risk sensitivity more generally (Anbarci, Arin, Okten, & Zenker, 2016; Charness & Gneezy, 2012). This allowed me to further investigate food-scheduling behaviours in a mixed gender sample. Third, Experiment 1 included participants who were moderately hungry; however, food cues can sometimes promote eating behaviour even when people are sated (Cornell et al., 1989). Therefore, in Experiment 2, to explore the generality of intertemporal preferences, I allowed hunger and time of day of the testing session to vary freely. In addition to a measuring time to select between fixed and variable delays during the food-scheduling task, I also measured time for participants to collect their food rewards from the dispenser. This allowed me to examine if exposure to an olfactory cue had a similar impact on consummatory behaviours as in choices for variable versus fixed delays to rewards. Finally, I included the Pleasure Arousal Dominance scale (PAD; Mehrabian & Russell, 1974) and the Chocolate Habits Questionnaire (Gibson & Desmond, 1999). I included the Pleasure Arousal Dominance scale (Mehrabian & Russell, 1974) to account for differences in arousal across groups between participants who were exposed to the olfactory cue and those who were not, given that olfactory cues can influence levels of arousal (Mattila & Wirtz, 2001). The PAD scale has been used specifically in retail environments, to measure changes in consumers' behaviour in response to a number of environmental factors, called store atmospherics, such as the use of aromas in store to

influence shopping behaviour (Donovan, Rossiter, Marcoolyn, & Nesdale, 1994; Spence, Puccinelli, Grewal, & Roggeveen, 2014). I also included the Chocolate Habits Questionnaire (Gibson & Desmond, 1999) to measure and account for individual differences in chocolate liking and consumption.

Method

Ethical approval was granted by Bangor University School of Psychology Ethics committee (2015-15482). All participants have informed, written consent.

Participants

Seventy participants were recruited for a study of 'Snacking throughout the day'" from Bangor University online psychology student participant panel and were compensated with course credit. Participants' (Male = 25; Female = 45) mean age was 20.74±0.50 years (range = 18 to 39), with a mean BMI of 23.09±0.36 (range = 19 to 33.5). Exclusion criteria included food allergies and BMI above 40 indicating morbid obesity.

Measures

Psychometric questionnaires. Participants completed some of the same self-report assessments of eating behaviour, hunger, state affect, trait impulsivity and cognitive ability as in Chapter 2. First, I included the Three Factor Eating Questionnaire Revised (Karlsson et al., 2000); in my sample, the Cronbach's α were .82 for cognitive restraint, .76 for uncontrolled eating, and .84 for emotional eating in our sample.

Participants also completed the Food Craving Questionnaire – State version (Cepeda-Benito, Gleaves, Williams, & Erath, 2000; Appendix J) to measure state food craving for sweet and

savoury items. This scale consists of 30 items using a 7-point Likert scale. Cepeda-Benito et al. (2000), reported Cronbach's αs of .82 and .84 for each of the subscales and .94 overall. Here, in Experiment 2's sample, the Cronbach's αs for the savoury scale and the savoury scale were .93, and .92 respectively, with an overall value of .96.

Other measures included the Eating Disorders Examination Questionnaire (Fairburn & Beglin, 1994), the Beck Depression Inventory (BDI-II; Beck et al., 1996), the Positive and Negative Affect Scale (PANAS; Watson et al., 1988), the Barratt Impulsiveness Scale (BIS-II; Patton et al., 1995) and the Raven's Matrices short form (Arthur & Day, 1994). These are described briefly below; for further detail, please refer to p.47-49 Chapter 2.

The Eating Disorders Examination Questionnaire (Fairburn & Beglin, 1994) was used to assess participants' eating disorder concerns and symptoms. Experiment 2's sample showed Cronbach's αs of .71 for the eating concern subscale, .89 for the shape concern subscale, .82 for the weight concern subscale and .85 for the restraint subscale. To measure dysphoric mood, participants completed the Beck Depression Inventory (Beck et al., 1996). The Cronbach's α for this sample was .88.

The PANAS (Watson et al., 1988) was included to assess participants' current mood during the testing session. My sample showed Cronbach's αs of .86 for positive affect and .81 for negative affect subscales. The Barratt Impulsiveness Scale (Patton et al., 1995) was included to measure participants' levels of impulsivity. My sample showed Cronbach's αs of .72, .52, and .75 for the attention, motor and nonplanning subscales respectively. The Raven's Matrices short form (Arthur & Day, 1994) was included as a measure of non-verbal cognitive ability. This scale consists of twelve items with a reported Cronbach's α of .72, which

correlates highly with the scores from the Advanced Progressive Matrices as reported previously (please refer to p.49 Chapter 2).

In order to assess and control for any differences in participants' levels of arousal dependent on scent exposure compared to non-exposure, participants completed the Pleasure Arousal Dominance scale (Mehrabian & Russell, 1974; Appendix K). This scale consists of 18 items, with each of the three subscales consisting of 6 items. Each item is presented on a continuum (i.e., happy/unhappy), measured on a 5 point Likert scale, with higher scores reflecting higher amounts of the trait.

The Chocolate Habits Questionnaire (Gibson & Desmond, 1999; Appendix L) was included to assess individuals' preference and attitudes towards chocolate and whether these influenced participants' intertemporal preferences for chocolate rewards. The questionnaire comprises 16 items, scored on a 5-point Likert scale. This scale has previously been used to measure chocolate consumption in cravers and non-cravers following repeated consumption of chocolate in differing motivational states (Gibson & Desmond, 1999). The sample for Experiment 2 showed a Cronbach's α of .84 for the overall scale.

Olfactory primes. Thirty-five participants were exposed to a subtle non-identifiable chocolate aroma or scent. This prime was delivered in a small waiting room next door to the room in which the food-scheduling task was completed. To deliver the prime, I used a chocolate scented cartridge from ScentAir UK (www.scentair.co.uk), and a small desk fan. Extensive pilot testing (n= 20) indicated that optimal exposure involved leaving the fan to disperse the scent for 65s, followed by a dispersal interval 3mins before the participants entered the room. Under these conditions, participants were able to identify that an aroma

was present but were not able to identify reliably the aroma as chocolate in free recall. However, when given the forced-choice of chocolate, Haribo, toffee or cinnamon, participants tended to identify chocolate reliably (see Manipulation check section below). Participants remained in the scented room for 6min to allow enough time to complete the PAD (to measure arousal), PANAS (to measure state affect) and the BIS questionnaires.

Food-scheduling task. The food-scheduling task was the same as reported in Experiment 1 (please refer to p. 49, Chapter 2). However, rather than being allowed to select their preferred food rewards from a menu of sweet confectionary and savouries, all participants completed the task using half-squares of Cadbury's Dairy Milk chocolate (to be congruent with the scent prime). Additionally, I collected latencies for the time it took participants to reach for and retrieve the chocolate rewards by means of a light-sensitive (infra-red) diode positioned just inside the mouth of the food hopper.

Procedure

On arrival at the laboratory, participants completed the EDE-Q (Fairburn & Beglin, 1994), FCQ (Cepeda-Benito et al., 2000), TFEQ-R (Karlsson et al., 2000), BDI (Beck et al., 1996), Ravens short form (Arthur & Day, 1994) and a single rating of their current hunger using a 7-point Likert scale with anchor points "not at all hungry" to "extremely hungry". Anthropometric measurements of height and weight were taken to the nearest 0.1cm/kg without shoes in light clothing to allow calculation of BMI (weight (kg))/(height(cm))^2. Next, participants were taken to the room that had been scented with a chocolate aroma where they were exposed to the prime for 6mins while completing the PANAS (Watson et al., 1988), PAD (Mehrabian & Russell, 1974) and BIS (Patton et al., 1995) questionnaires. Participants in the control condition followed exactly the same procedure, except the room where they

completed the PANAS, PAD and BIS questionnaires had not been scented with a chocolate aroma.

Following this, participants were moved to the testing room next door (that had not been filled with a chocolate aroma for either condition) and seated in front of a touch screen monitor and immediately completed the food-scheduling assessment as described in Chapter 2 (p. 49, Chapter 2). Participants started the assessment as soon as they were ready and the experimenter exited the room. On completion of the food-scheduling task, participants provided a second hunger rating and answered the same questions about the contingencies of the intertemporal preferences (as reported in Ch. 2, p.49). Participants also answered questions about their awareness of the scents/olfactory cues during exposure to the prime (see Manipulation check section) below.

Manipulation check. I assessed participants' awareness of the chocolate scent once the food-scheduling assessment had been completed. First, I asked participants if they could smell anything (coded as a categorical variable, with 'yes' and 'no' responses), and then to make a forced selection from a choice of four scents (chocolate, Haribo, toffee, or cinnamon) which they thought best described the scent they could smell.

Data analysis

Group-matching was assessed with linear regressions to test for differences between groups on each of the psychometric questionnaires, BMI and age.

Multilevel regressions of binary choice of the variable delay selections (with logistic models), choice latencies and food-collection latencies were run to analyse associations with scent

condition and participant characteristics. Participant and trial (1 through 38) were included in the intercept as random effects.

To investigate the effects of gender and state hunger, I ran a set of preliminary models. These tested for the effects of gender, delay on the previous selection and the interaction between gender and delay (Model 1 Gender), scent ('scent-present' vs 'scent-absent' as the referent) and the interaction between gender and scent (Model 2 Gender), and, finally, the three-way interaction between gender, delay on the previous trial and scent (Model 3 Gender). Next, I repeated this sequence replacing gender with state hunger (Model 1 Hunger; Model 2 Hunger and Model 3 Hunger). Neither set of models showed systematic effects (see below: Section Gender and Hunger models for details). Therefore, I constructed the following sequence of models to test the effects of the olfactory cues, BMI and eating attitudes as scored by the TFEQ on food-scheduling behaviour.

Initial predictors entered into Model 1 were (i) side of the variable box (right as the referent); (ii) colour assigned to the variable option (blue as referent); (iii) time of day (lunchtime, and afternoon (after 3pm) with 11am as the referent); (iv) state hunger; (v) gender (male as referent), and (vi) chocolate habit score (Model 1). Of these, (i) side of the variable box was retained in all subsequent models. Next, I tested the main effects of (vii) scent (′scent-present′ vs ′scent-absent′/control as referent); (viii) delay before food delivery on the previous selection (last delay; fixed/15s as referent); (ix) BMI and (x-xii) the subscales of the TFEQ-R (Model 2). In Model 3, I added (xiii) the interaction between last delay and BMI and (xiv-xvi) last delay and the subscales of the TFEQ. In Model 4, I dropped the interaction between BMI and last delay, and the TFEQ-R and last delay, and entered the interaction between (xvii) condition and last delay. In Model 5, I re-entered the interactions between (xiii) last

delay and BMI; and added (xvii) condition and BMI and (xviii) condition, last delay and BMI. Finally, in Model 6, I included the interactions between (xix-xvii) last delay and the subscales of the TFEQ-R; (xviii) condition and last delay; (xix-xxi) condition and the subscales of the TFEQ; and the three-way interaction between (xxii-xiv) condition, last delay and TEFQ-R subscales.

Results

Demographic and psychometric sample characteristics

Participants' demographic and psychometric data is displayed in Table 3.1. All participants were aged between 19 to 39 years; 19 participants had a BMI outside the healthy range (18.5-24.9), and one participant was obese (BMI 33.50).

	N	Mean (SE)	Control (n = 35) Mean (SE)	Experimental (n = 35) Mean (SE)	β±SE
Gender	70	M = 25; F = 45	M = 15; F = 20	M = 10; F = 25	0.63 ±0.51
Age	70	20.74 (0.50)	20.80 (0.71)	20.69 (0.73)	-0.11 ±1.01
BMI	70	23.09 (0.36)	23.09 (0.57)	23.09 (0.44)	-0.01 ±0.72
TFEQ Cognitive restraint	64	25.26 (1.96)	26.30 (3.12)	24.22 (2.40)	-2.08 ± 3.93
TFEQ Uncontrolled eating	70	29.76 (2.16)	28.09 (3.07)	31.43 (3.08)	3.33 ± 4.35
TFEQ Emotional eating	69	29.71 (1.61)	30.56 (2.51)	28.84 (2.03)	-1.72 ± 3.24
Raven's scaled score	69	11.68 (0.30)	11.44 (0.46)	11.91 (0.39)	0.47 ± 0.60
BIS-11 Total score	59	64.05 (1.30)	64.93 (2.00)	63.20 (1.60)	-1.73 ± 2.55
EDE-Q Restraint	70	0.69 (0.13)	0.73 (0.20)	0.66 (0.16)	-0.07 ± 0.26
EDE-Q Eating concern	70	0.63 (0.09)	0.72 (0.15)	0.54 (0.11)	-0.18 ± 0.18
EDE-Q Shape concern	69	1.71 (0.17)	1.85 (0.27)	1.57 (0.21)	-0.28 ± 0.33
EDE-Q Weight concern	70	1.29 (0.15)	1.34 (0.23)	1.23 (0.18)	-0.10 ± 0.29
BDI-II	70	8.27 (0.79)	8.69 (1.18)	7.86 (1.06)	-0.83 ± 1.59
FCQ sweet	63	2.78 (0.13)	2.63 (0.20)	2.93 (0.17)	0.31

FCQ savoury	62	3.01 (0.14)	2.89 (0.20)	3.13 (0.21)	± 0.27 0.24 ± 0.29

Table 3.1. Means and standard errors for participants' overall scores and in each condition. β and standard errors for differences between conditions for each demographic variable.

As expected, participants' mean scores on the EDE-Q and BDI-II indicated few eating or mood concerns overall (Beck et al., 1996; Fairburn & Beglin, 1994). There were no significant differences between scent-present and scent-absent participants in any of the above characteristics prior to the prime being delivered (all $-2.08 \pm 3.93 < \beta < 3.33 \pm 4.35$; Table 3.1). Groups also showed no consistent differences in hunger ratings prior to the snacking task.

Manipulation checks for awareness of prime

22 out of 35 (63%) of the scent-present participants reported that they detected an aroma in the waiting room prior to the food-scheduling assessment compared to 5 out of 35 participants (15%) of the control, scent-absent participants (as probed by the question "Could you smell anything?", a significant difference $\chi^2(1) = 16.79$, $p < .001$).

As shown in Table 3.2, participants reported a greater frequency of smelling chocolate compared to the other aromas in both scent-absent ($\chi^2(3) = 8.31$, $p = .04$) and scent-present conditions ($\chi^2(3) = 40.31$, $p < .001$). However, while the number of participants reporting the chocolate aroma in the scent-present group was elevated in comparison to the scent-absent group (25 vs 16), this difference was not significant ($\chi^2(3) = 4.89$, $p = .18$).

	Scent-absent	Scent-present	Total
Chocolate	16	25	41
Haribo	7	3	10
Toffee	7	4	11
Cinnamon	5	3	8
Total	35	35	70

Table 3.2. Number of responses for each scent reported from the questions asked to check the awareness of the prime in each condition.

Finally, the scent-absent and the scent-present groups showed no significant differences in their state arousal (18.51±0.63 vs 17.68±0.52; β= 0.84±0.82 $t(67) = 1.03$).

Selections between variable and fixed delay schedules: gender and hunger

A preliminary test of gender showed that there were no reliable differences between males and females in terms of the proportions of variable delay selections following 0s or 30s delays to rewards as compared to fixed delays (0s vs 15s: β= 0.02±0.21; 30s vs 15s: β= 0.09±0.22; Model 1 Gender; see Table 3.3) or differentially following exposure to the chocolate scent (β= -0.19±0.41; Model 2 Gender, Table 3.3). Neither were variable delay schedule selections altered differently in the males and females in the scent-absent compared to the scent-present condition following 0s or 30s delays (0s: β= 0.71±0.43; 30s: β= 0.55±0.46; Model 3 Gender, Table 3.3).

	Scent-absent		Scent-present		Overall	
	Male	Female	Male	Female	Male	Female
0s delay	0.60 (0.08)	0.61 (0.05)	0.62 (0.07)	0.58 (0.06)	0.61 (0.06)	0.59 (0.04)
15s delay	0.51 (0.06)	0.57 (0.04)	0.54 (0.08)	0.50 (0.06)	0.52 (0.05)	0.53 (0.04)
30s delay	0.44 (0.06)	0.42 (0.05)	0.49 (0.06)	0.53 (0.06)	0.46 (0.04)	0.48 (0.04)
Overall	0.51 (0.05)	0.55 (0.03)	0.52 (0.05)	0.52 (0.04)	0.52 (0.04)	0.53 (0.03)

Table 3.3. Means and standard errors for proportion of variable delay choices following 0s, 15s and 30s delays on the previous selection male and female participants in the scent-absent and scent-present conditions.

In contrast to Experiment 1, preference for the variable delay schedule was associated with increased hunger only following 30s delays (β= 0.31±0.08, Z = 3.88; Model 1 Hunger, see Table 3.4). There was no significant change in variable delay versus fixed delay schedule selections in relation to state hunger following exposure to the chocolate scent (β= 0.07±0.14; Model 2 Hunger, see Table 3.4), or in the scent-present compared to scent-absent conditions following delays of 0s or 30s (0s vs 15s: β= 0.23±0.15; 30s vs 15s: β= 0.17±0.15; Model 3 Hunger, Table 3.4). Overall, these preliminary tests demonstrate that preference for the variable delay schedules is only marginally influenced by gender and state hunger.

	Scent-absent			Scent-present			Overall		
	Hunger <1SD	Mid-range hunger	Hunger >1SD	Hunger <1SD	Mid-range hunger	Hunger >1SD	Hunger <1SD	Mid-range hunger	Hunger >1SD
0s delay	0.61 (0.07)	0.62 (0.07)	0.56 (0.07)	0.48 (0.14)	0.64 (0.05)	0.48 (0.16)	0.57 (0.07)	0.63 (0.04)	0.52 (0.09)
15s delay	0.59 (0.08)	0.49 (0.05)	0.66 (0.09)	0.47 (0.12)	0.54 (0.06)	0.43 (0.12)	0.55 (0.07)	0.52 (0.04)	0.54 (0.08)
30s delay	0.31 (0.05)	0.47 (0.05)	0.48 (0.10)	0.42 (0.09)	0.51 (0.06)	0.63 (0.10)	0.35 (0.04)	0.49 (0.04)	0.56 (0.07)
Overall	0.54 (0.06)	0.52 (0.04)	0.57 (0.06)	0.45 (0.08)	0.54 (0.04)	0.49 (0.07)	0.51 (0.05)	0.53 (0.03)	0.53 (0.04)

Table 3.4. Means and standard errors for proportion of variable delay choices following 0s, 15s and 30s delays on the previous selection in each condition, for individuals with low, mid-range and high self-reported hunger.

Variable and fixed delay selections

Participants were more likely to select the variable option when it was presented on the right-hand side of the computer display compared to the left-hand side (0.55±0.01 vs 0.51±0.01; β= 0.21±0.08; Z = 2.43; Model 1, see Table 3.5). There was no significant difference in participants′ selections depending upon the colour of box assigned to the variable delay schedule (0.50±0.03 vs 0.55±0.03, β= 0.23 ± 0.21; Model 1, Table 3.5). Similarly, preferences for the variable option were not markedly related to the time of day of the testing session compared to participants tested during the 11.00am session (midday: β= 0.08±0.25; afternoon: β= -0.10±0.25; evening: β= 0.75±0.85; Model 1, Table 3.5).

Variable and fixed delay selections: olfactory cues

As I found in Experiment 1, participants were more likely to choose the variable delay schedule when they had received rewards immediately on previous selections (0.60±0.03 vs 0.53±0.03; β= 0.57±0.11; Z = 5.18; Model 2, Table 3.5). Exposure to the chocolate aroma did not affect overall preference for the variable over the fixed delay schedules (0.53±0.02 vs 0.52±0.03; β= -0.06±0.91; Model 2). However, participants in the scent-present group were significantly more likely to select the variable delay schedule if they received rewards following 30s delays compared to 15s delays on previous selections (0.52±0.04 vs 0.51±0.05, β= 0.82±0.23, Z = 3.57, Model 4, see Fig 3.1, Table 3.5). There was no difference in proportion of variable delay selections following immediate rewards in the scent-present participants compared to the scent-absent participants (0.59±0.05 vs 0.61±0.04, β= 0.36±0.22, Model 4, Fig 3.1, Table 3.5).

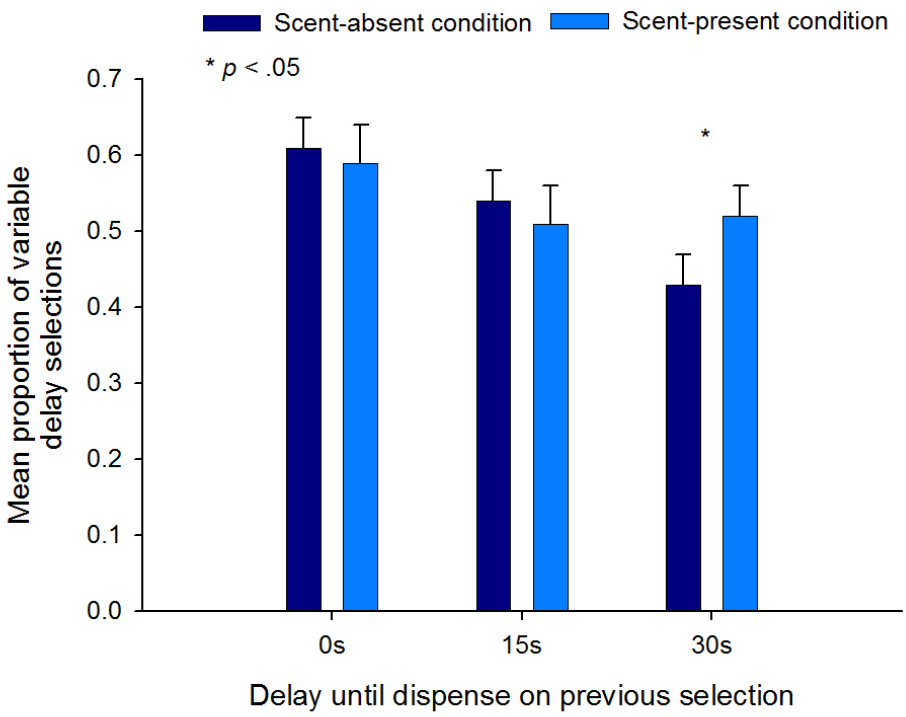


Figure 3.1. Mean proportion (and standard errors) of variable delay choices for participants in scent-absent (controls) and scent-present (experimental) groups following 0s, 15s or 30s delays on the previous trial.

Variable and fixed delay selections: olfactory cues and BMI

As in Experiment 1, participants with a high BMI were more likely to select the variable delay schedule more frequently if they received rewards following 0s delays (0.54±0.07 vs 0.49±0.06, β= 0.08±0.04; Z = 2.00; Model 3, Table 3.5). However, these preferences were modulated at least to some degree by exposure to the chocolate scent. In the scent-absent group, choice of the variable schedule following rewards delivered after fixed delays of 15s were reduced in participants with high BMIs (0.42±0.06, β= -0.31±0.11, Z = 2.82, Model 5, Table 3.5), but not following delays of 0s (0s vs 15s: 0.54±0.07 vs 0.64±0.04; β= 0.42 ± 0.11; Z = 3.82; Model 5; Table 3.5) or following delays of 30s (30s vs 15s: 0.40±0.06 vs 0.50±0.04 β= 0.50±0.11; Z = 4.55 Model 5, Fig 3.2 a&b).

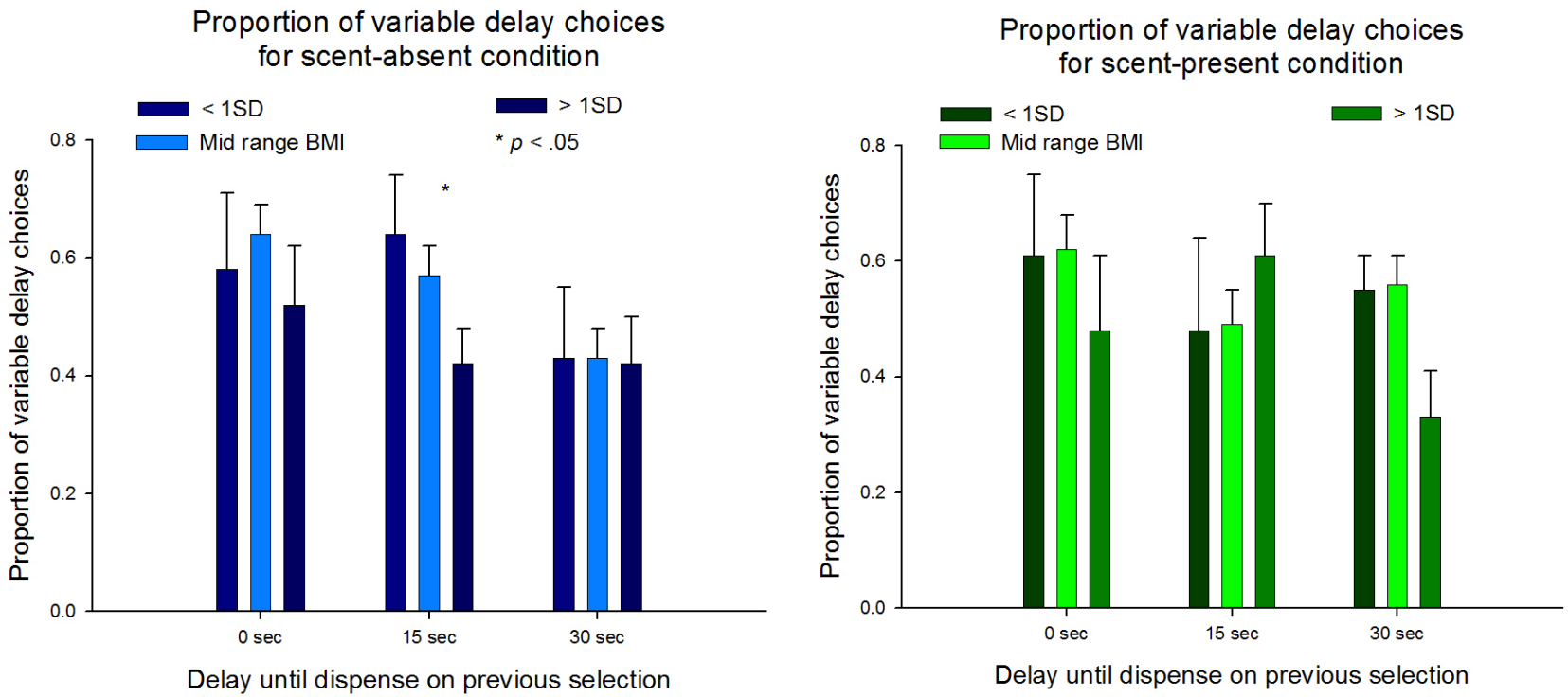


Figure 3.2a&b. Mean proportion (and standard errors) for low BMI participants (< 20.11; less than 1 SD less than the mean), mid-range BMI and high BMI participants (> 26.07; greater than 1 SD greater than the mean) following delays of 0s (variable delay), 15s (fixed), or 30s (variable delay) on the previous selection in the scent-absent condition (control) and scent-present (experimental) groups.

By contrast, in the scent-present group, choice of the variable delay schedules tended to be slightly increased in participants with a high BMI following fixed delays of 15s (0.61±0.09, β= 0.20±0.07, Z = 2.86, Model 5, Table 3.5) but, by comparison, were reduced following immediate rewards (0.48±0.13, β= -0.25±0.08; Z = -3.13; Model 5, Table 3.5) and indeed following delays of 30s (0.33±0.08, β= -0.34±0.08; Z = -4.25; Model 5, Table 3.5; Figs 3.2 a and b).

Variable and fixed delay selections: olfactory cues and eating behaviours

In contrast to Experiment 1, participants' preferences of the variable delay schedule were not modulated by cognitive restraint after receiving rewards following a 0s delay or a 30s delay on the previous trial (0s vs 15s: 0.64±0.04 vs 0.52±0.05; β= 0.01 ± 0.01; 30s vs 15s: 0.47±0.04 vs 0.52±0.05, β= -0.01 ± 0.01; Model 3, Table 3.5). However, as Figure 3.3 shows, selections of variable delay schedules were influenced by cognitive restraint in different ways in the scent-absent compared to scent-present participants. In the scent-absent control group, variable delay selections tended to be increased (non-significantly) in participants with high restraint scores following fixed delays of 15s (β=-0.00±0.02; Model 6) but, by comparison, not following rewards delivered after 0s (0s vs 15s: 0.61±0.07 vs 0.59±0.07, β=-0.07±0.02, Z = -3.50) and were actually diminished following delays of 30s (30s vs 15s: 0.45±0.04 vs 0.59±0.07, β= 0.04±0.02, Z = 2.00, Model 6, Table 3.5). By contrast, in the scent-present group, variable delay selections were markedly increased in high restraint participants following the delivery of immediate rewards compared to fixed delays of 15s (0.82±0.05, β= 0.05±0.01; Z = 5.00; Model 6, Table 3.5; Fig 3.3 a & b), and to a lesser extent following delays of 30s (0.60±0.09 vs 0.53±0.13, β= 0.03±0.02; Model 6, Table 3.5; Fig 3.3 a and b).

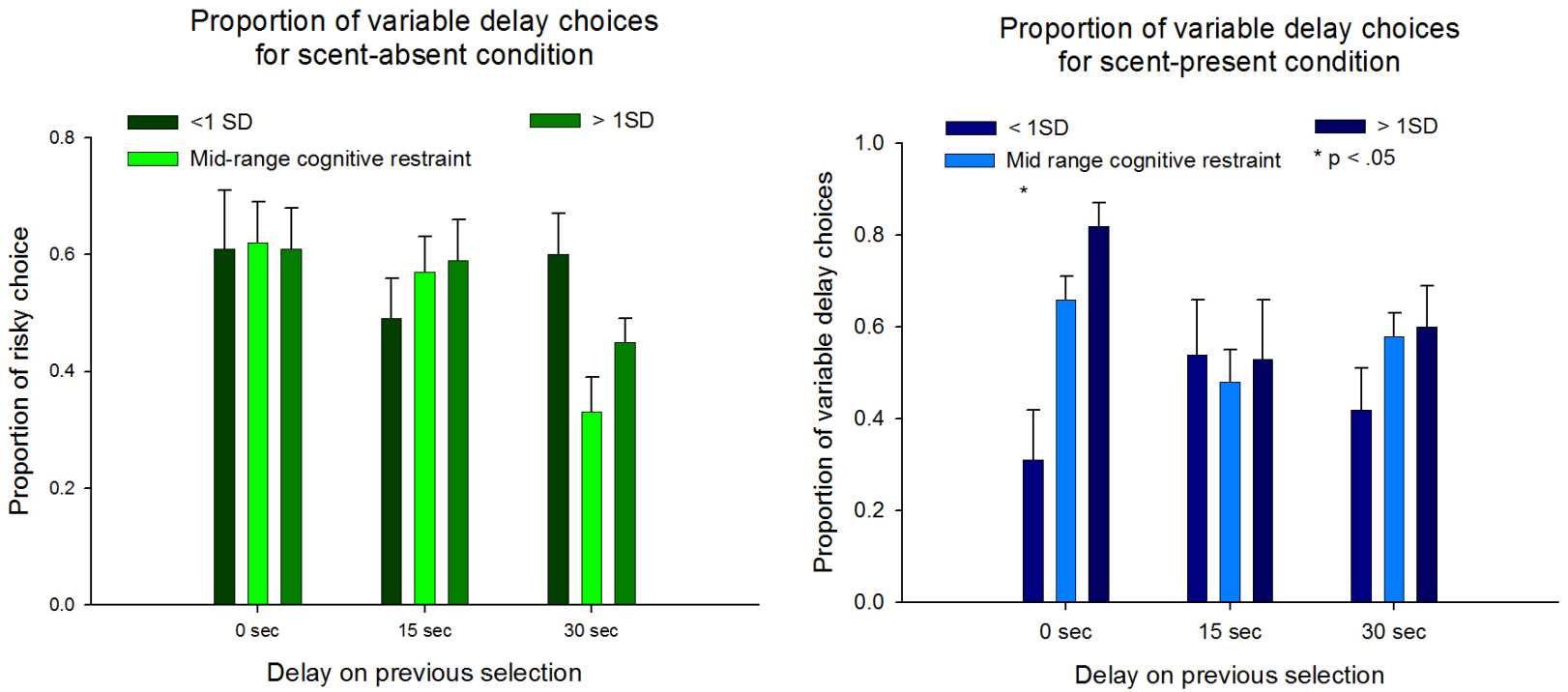


Figure 3.3a&b. Mean proportion (and standard errors) of variable delay choices for low eating restraint participants (<9.62 less than 1 SD less than the mean), mid-range, and high cognitive restraint (>40.90; greater than 1 SD less than the mean) participants in the scent absent (control) and scent-present (experimental) groups following delays of 0s (variable delay), 15s (fixed), or 30s (variable delay) on the previous selection.

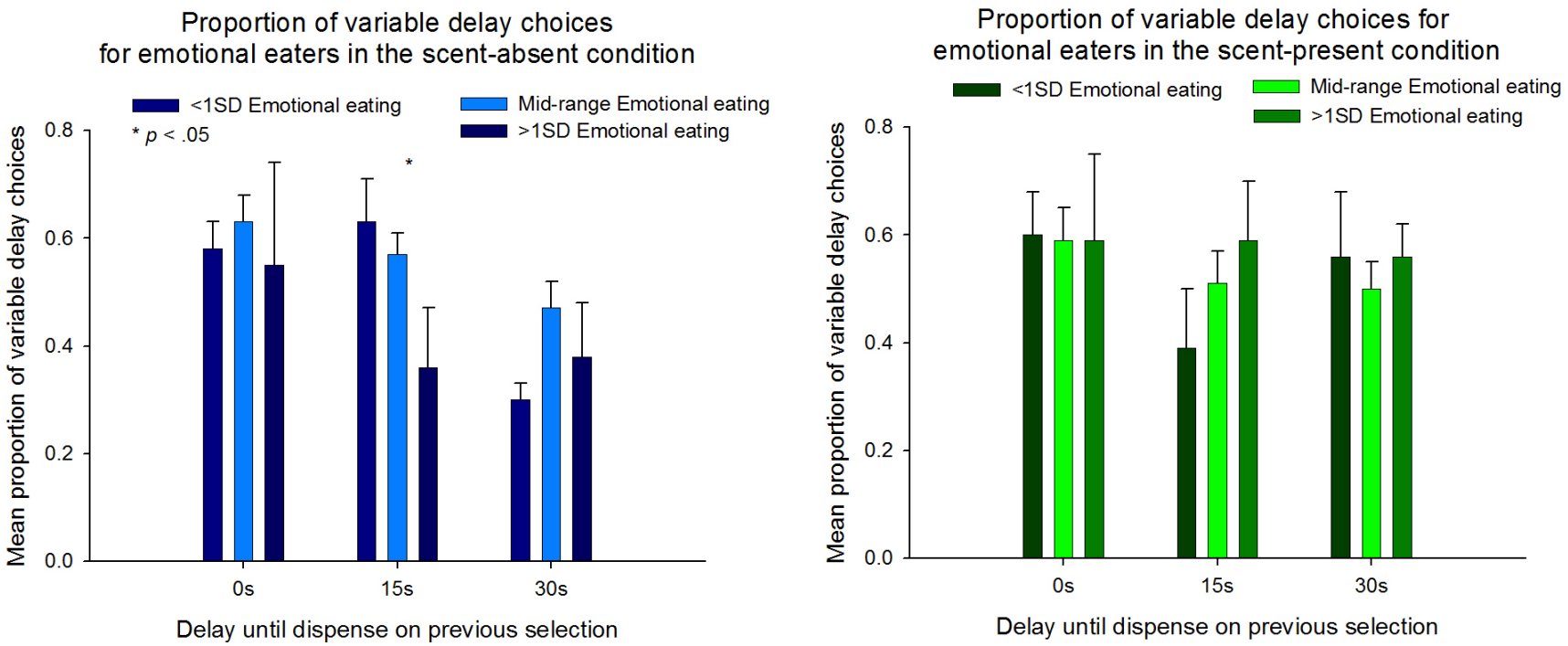


Figure 3.4 a&b. Mean proportion (and standard errors) of variable delay choices for low emotional eating participants (<16.03 less than 1 SD less than the mean), mid-range, and high emotional eating (>43.09; greater than 1 SD less than the mean) participants in the scent-absent (control) and scent-present (experimental) groups following delays of 0s (variable delay), 15s (fixed), or 30s (variable delay) on the previous selection.

Selections of the variable delay schedule as a function of varying emotional eating were expressed differently in the scent-absent compared to the scent-present groups. In the scent-absent participants, selections of the variable schedule were reliably diminished after fixed delays of 15s in participants with high emotional eating scores (0.36±0.11, β= -0.06±0.02, Z = -3.00, Model 6, Table 3.5, Fig 3.4) but not following rewards delivered immediately (β= 0.06±0.02, Z = 3.00, Model 6) or following delays of 30s (β= 0.08±0.03, Z = 2.67, Model 6, Table 3.5). By contrast, in the scent-present participants, choices of the variable schedule were only non-significantly increased with higher emotional eating scores after fixed delays of 15s (β= 0.03±0.02, Model 6, Table 3.5) and were unchanged following rewards delivered either immediately (β= -0.04±0.02, Z = -2.00, Model 6, Table 3.5) or following delays of 30s in previous selections (β= -0.04±0.02, Z = -2.00, Model 6, Table 3.5. Fig 3.4).

Finally, as I found in Experiment 1, preferences for the variable delay option were not influenced by the uncontrolled eating subscale of the TFEQ-R overall (uncontrolled eating >1SD: 0.60±0.04, mid-range uncontrolled eating: 0.50±0.03, uncontrolled eating <1SD: 0.51±0.04; β= 0.00 ± 0.01; Model 2). For participants in the scent-absent group, choice of the variable delay schedule was not related to uncontrolled eating scores following 0s or 30s delays (0s vs 15s: β= 0.03 ± 0.02; 30s vs 15s: β= 0.01 ± 0.02; Model 6). Similarly, in the scent-present group, participants' choice of the variable delay schedule was not affected by delays of 0s or 30s for uncontrolled eaters (0s vs 15s: β= -0.01 ± 0.01; 30s vs 15s: β= -0.01 ± 0.01; Model 6, Table 3.5).

Predictor	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Intercept	0.14 (0.55)	0.17 (0.83)	1.14 (0.93)	0.69 (0.83)	7.66 (2.49)**	2.68 (1.17)*
Side of variable delay option	0.21 (0.08)*	0.20 (0.09)*	0.20 (0.09)*	0.20 (0.09)*	0.22 (0.09)*	0.20 (0.09)*
Colour of variable delay option	0.23 (0.21)	-	-	-	-	-
Time of day - midday	0.08 (0.25)	-	-	-	-	-
Time of day – afternoon	-0.10 (0.25)	-	-	-	-	-
Time of day - evening	0.75 (0.85)	-	-	-	-	-
Hunger	-0.04 (0.07)	-	-	-	-	-
Gender	0.05 (0.21)	-	-	-	-	-
Chocolate habits	-0.00 (0.01)	-	-	-	-	-
Condition	-	-0.06 (0.19)	-0.07 (0.19)	-0.36 (0.21)	-4.99 (1.70)**	-1.47 (0.59)*
Last delay 0s	-	0.57 (0.11)**	-1.60 (0.91)	0.03 (0.33)	-9.64 (2.58)**	-0.68 (0.95)
Last delay 30s	-	-0.10 (0.11)	-1.50 (0.91)	-1.32 (0.36)**	-12.83 (2.63)**	-3.02 (0.97)**
BMI	-	-0.01 (0.03)	-0.04 (0.04)	-0.01 (0.03)	-0.31 (0.11)**	-0.02 (0.03)
TFEQ Cognitive restraint	-	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.00 (0.02)
TFEQ Emotional eating		-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)	-0.06 (0.02)**
TFEQ Uncontrolled eating		0.00 (0.01)	0.00 (0.01)	0.00 (0.01)	0.00 (0.01)	0.00 (0.02)
Last delay 0s * BMI	-	-	0.08 (0.04)*	-	0.42 (0.11)**	-
Last delay 30s * BMI	-	-	0.04 (0.04)	-	0.50 (0.11)**	-
Last delay 0s * Restraint	-	-	0.01 (0.01)	-	-	-0.07 (0.02)**
Last delay 30s * Restraint	-	-	-0.01 (0.01)	-	-	-0.04 (0.02)†
Last delay 0s * Emotional Eating	-	-	0.00 (0.01)	-	-	0.06 (0.02)*
Last delay 30s * Emotional Eating	-	-	0.02 (0.01)*	-	-	0.08 (0.03)*
Last delay 0s * Uncontrolled Eating	-	-	0.00 (0.01)	-	-	0.03 (0.02)
Last delay 30s * Uncontrolled Eating	-	-	0.00 (0.01)	-	-	0.01 (0.02)

Condition * Last delay 0s	-	-	-	0.36 (0.22)	6.14 (1.78)**	0.56 (0.65)
Condition * Last delay 30s	-	-	-	0.82 (0.23)**	8.68 (1.80)**	1.67 (0.65)*
Condition * BMI	-	-	-	-	0.20 (0.07)**	-
Condition * Restraint	-	-	-	-	-	0.00 (0.01)
Condition * Emo eating	-	-	-	-	-	0.03 (0.02)
Condition * Unc eating	-	-	-	-	-	0.00 (0.01)
Condition*Last delay 0s*BMI	-	-	-	-	-0.25 (0.08)**	-
Condition*Last delay 30s*BMI	-	-	-	-	-0.34 (0.08)**	-
Condition*Last delay 0s*Rest	-	-	-	-	-	0.05 (0.01)**
Condition*Last delay 30s*Rest	-	-	-	-	-	0.03 (0.02)
Condition*Last delay 0s*Emo	-	-	-	-	-	-0.04 (0.02)*
Condition*Last delay 30s*Emo	-	-	-	-	-	-0.04 (0.02)*
Condition*Last delay 0s*Unc	-	-	-	-	-	-0.01 (0.01)
Condition*Last delay 30s*Unc	-	-	-	-	-	-0.01 (0.01)
AIC	3404.20	3084.60	3088.00	3075.20	3056.50	3070.30
BIC	3468.60	3148.10	3197.10	3150.20	3160.40	3231.80

Table 3.5. β-coefficients (and standard errors) for 5 multi-level binomial regression models of proportionate choice of variable delays (0s vs 30s) over fixed delays (15s) to delivery of preferred edible rewards. Dividing the β-coefficient by the standard error (SE) yields a Z-score. *p< .05; **p <0.01. Akaike information criterion (AIC) and Bayesian information criterion (BIC) provide estimates of model fit

Choice times between variable and fixed delay schedules: olfactory cues

As in Experiment 1, participants made faster selections when they received a reward following a variable delay of 0s or 30s compared to 15s on the previous trial (0s vs 15s: 2.31±0.14 vs 2.86±0.20, β= -0.51±0.15, t(2346)= -3.47, $p < .05$; 30s: 2.42±0.13 vs 2.86±0.14, β= -0.34±0.16, t(2331)= -2.13, $p < .05$, Model 2). However, selection times were not significantly affected by the variable delays on the previous selection for participants either in the scent-absent participant group (0s vs 15s: 2.38±0.17 vs 2.72±0.22; β= 0.17±0.46, t(2344)= 0.37, $p > .05$; 30s vs 15s: 2.49±0.21 vs 2.72±0.22; β= 0.39±0.49, t(2336)= 0.80, $p > .05$, Model 4. Fig 3.5); or in the scent-present group (0s vs 15s: 2.26±0.22 vs 2.98±0.33; β= -0.46±0.29, t(2349)= -1.59, $p > .05$; 30s vs 15s: 2.19±0.16 vs 2.98±0.33, β= -0.49±0.31, t(2342)= -1.58, $p > .05$, Model 4, Fig 3.5).

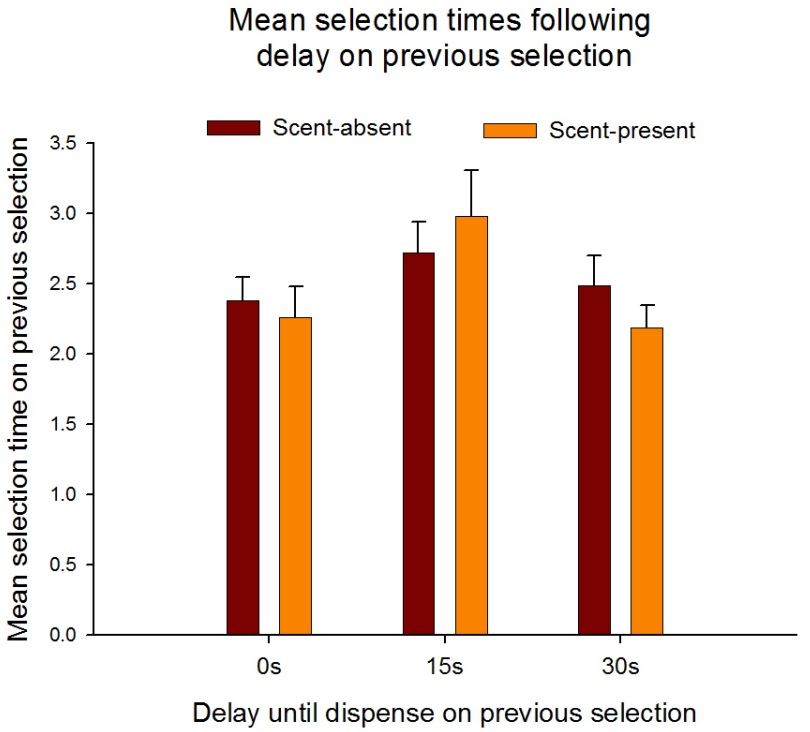


Figure 3.5. Mean choice time (and standard errors) of variable versus fixed delay choices for participants in the scent-present (experimental) and scent-absent (control) groups following delays of 0s (variable delay), 15s (fixed), or 30s (variable delay) on the previous selection.

Choice times between variable and fixed delay schedules: olfactory cues, BMI and eating behaviours

In the scent-absent (control) group, speed of selection times following variable delays of 0s or 30s were not modulated by BMI (0s: β= -0.25±0.15, t(2342)= 1.67, p > .05; 30s: β= -0.26±0.15, t(2333)= 1.73, p > .05, Model 5). However, in the scent-present condition, selection times tended to be slower in participants with a high BMI following immediate rewards or following delays of 30s compared to 15s delays (0s: β= 0.26±0.10, t(2346)= 2.60, p < .05; 30s: β= 0.24±0.11, t(2338)= 2.18, p < .05). Selection times were faster in participants with high cognitive restraint in the scent-absent condition following a 0s compared to 15s delay (β= -0.11±0.03, t(2327.40)= -3.67, p < .05; Model 6) but there was no difference after rewards following 30s delays (β= -0.03±0.03, t(2318)= -1.00, p > .05, Model 6). In contrast, selection times were slower in participants in the scent-present condition following 0s delays as a function of cognitive restraint (β= 0.08±0.02, t(2334)= 4.00, p < .05*;* Model 6). However, selection times did not differ following 30s delays for participants in the scent-present condition as a function of cognitive restraint (β= 0.03±0.02, t(2319.50)= 1.50, p > .05*;* Model 6).

Finally, in the scent-absent participants, selection times were faster as a function of emotional eating following 0s delays but not following 30s delays compared to delays of 15s (0s: β= -0.11±0.03, t(2334.80)= -3.67, p < .05; 30s: β= -0.05±0.04, t(2333.20)= -1.25, p > .05, Model 6). Selection times were slightly speeded by higher uncontrolled eating following 0s delays for participants in the scent-present condition (β= -0.04±0.02, t(2325.20)= -2.00, p < .05; Model 6).

Collection times between variable and fixed delay schedules

Collection times for food rewards were not substantially different when the location of the variable delay schedule was to the left or the right hand side of the display (β= -0.06±0.04, t(1753)= 1.50). Food collection times were not affected by the colour associated with the variable delay schedule (β= -0.09±0.18, t(48.80)= 0.50), and were not significantly faster during testing sessions taking place at lunchtime, afternoon or evening, compared to the morning session (lunchtime: β=0.23±0.22, t(46.80)= 1.05; afternoon: β=0.16±0.21, t(46.70)= 0.76; evening: β= -0.74±0.64, t(46.50)= 1.16).

Participants were quicker to collect their reward on the selections following delays of 0s delays compared to delays of 15s (2.43±0.08 vs 2.65±0.09, β= -0.21±0.05, t(1654)= -4.20, $p < .05$). Collection time latencies were not affected by exposure to the chocolate scent compared to individuals who were not exposed to the chocolate scent (2.34±0.05 vs 2.39±0.05, β= -0.08±0.18, t(44.80)= -0.44, Model 2).

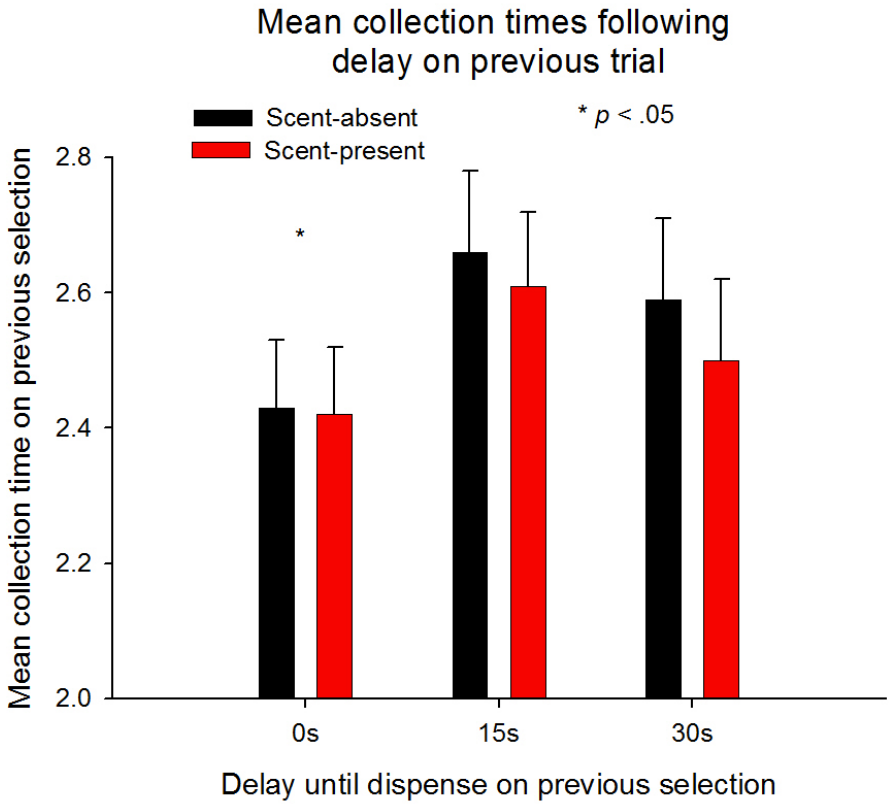


Figure 3.6. Mean collection times (and standard errors) following delay on previous selection for participants in the scent-absent and scent-present conditions.

Additionally, there was no significant change in collection times for individuals who were exposed to the chocolate scent compared to individuals who were not exposed to the scent following 0s or 30s delays (0s: β= 0.05±0.09, t(1658)= 0.55; 30s: β= -0.11±0.10, t(1660)= -1.10, Model 4, Fig 3.6). There were no additional associations between collection times, the delay for the last food reward, scent-present vs scent-absent, BMI or TFEQ-R subscale scores (-0.01±0.01 < β < 0.05±0.03).

Self-reported choice between variable and fixed delay schedules

As reported in Chapter 2, participants who estimated they had made a higher proportion of selections for the variable schedule were more likely to have chosen the variable delay schedule more frequently (estimated proportion of variable selections

>1SD: 0.67±0.05; mid-range estimated proportion of variable selections: 0.57±0.02; estimated proportion of variable selections <1SD: 0.31±0.05; β= 0.02±0.00; Z = 8.50, $p < .05$). Additionally, those who reported the variable schedule as their favourite box chose the variable delay schedule more frequently than the fixed delay schedule (0.60±0.02 vs 0.43±0.03, β= 0.75±0.17; Z = 4.50, $p < .05$). Choice of the variable delay schedule was not predicted by participants' estimations of either the duration of the variable versus fixed delays, or the number of rewards received (all 0.00±0.01 < βs < 0.02±0.01 (only significant due to rounding)). Participants who selected the variable schedule as their favourite box were less likely to choose the variable schedule following a delay of 30s compared to following a delay of 15s (0.48±0.03 vs 0.63±0.03, β= -0.95±0.22; Z = -4.32, $p < .05$). Participants were also less likely to select the variable delay on subsequent selections if they estimated a greater delay following a delay of 0s (β= -0.01±0.00; Z = -2.57, $p < .05$), or 30s (β= -0.02±0.01; Z = -2.00, $p < .05$).

Participants in the scent-absent condition were less likely to report the variable delay schedule as their favourite if they had higher amounts of cognitive restraint (measured by the TFEQ-R; β= -1.60±0.35; Z = -4.57, $p < .05$). However, participants in the scent-present condition were more likely to report the variable delay schedule as their favourite if they had high levels of cognitive restraint (measured by the TFEQ-R; β= 1.58±0.31; Z = 5.10, $p < .05$).

Discussion

Experiment 2 investigated the effects of environmental food cues, here operationalised as discernible but not readily identifiable chocolate aromas, on

intertemporal choice for high-value chocolate food rewards. I hypothesised that participants who were exposed to the scent of chocolate would show an increased preference for variable delay schedules compared to those who were not exposed to the chocolate aroma. My results show a greater proportion of selections for the variable delay schedule following the delivery of chocolate rewards in the scent-present participants compared to the scent-absent participants, but only after delays of 30s, showing specific impact of food cues upon intertemporal preferences. To my knowledge, this is the first study to report a link between preference for variable over fixed delays until food reward following exposure to an olfactory prime.

Broadly speaking, these results also replicate those of Experiment 1. Participants chose the variable delay schedules more frequently following the delivery of immediate food rewards on the previous selection, and they were faster to make their selection following immediate rewards. However, the associations between preferences for the variable delay schedules and cognitive restraint were less consistent (and robust) than in Experiment 1, possibly reflecting lower sample sizes and, perhaps, changes in my participant inclusion/exclusion criteria (see below). Participants in the scent-present group with higher BMIs were less likely to choose the variable delay schedule following delivery of rewards after delays of 30s. In addition, individuals with a high BMI in the scent-present condition were slower to make their choices than participants in the scent-absent condition. Cognitive restraint and BMI moderated these effects in opposing ways following exposure to the chocolate scent. Individuals with high cognitive restraint in the scent-present condition made a higher proportion of choices for the variable delay schedule following delivery of immediate rewards, compared to individuals with low cognitive

restraint, or individuals in the scent-absent group. Finally, examination of participants' collection time for the food rewards showed that, as in the selection times, participants were faster to retrieve and consume chocolate rewards, if they had been delivered immediately on previous selections compared to a delay of 15 or 30 seconds.

Experiment 2 had a number of strengths and extends the findings of Experiment 1 in several respects. First, pilot testing allowed me to achieve a prime intensity of the chocolate aroma where participants were aware of the scent, but were only able to identify it from a forced choice test of four options. Whereas 5/35 participants in the scent-absent condition reported being able to smell something, 22/35 of the scent-present participants reported they could smell something compared to the control condition. Further, participants in the latter group who were exposed to the aroma of chocolate, were more likely to correctly identify the aroma alongside 3 sweet aroma distractors. This demonstrates that, while the olfactory cue was identifiable to the level intended where participants were aware of the cue – in contrast to olfactory cues that are subthreshold (Hirsch, 1995) - it was not sufficiently strong to directly influence their selections in the food-scheduling assessment through conscious rumination about, or expectations of, chocolate as a powerful, high-value reward.

Second, the participants in the scent-present and –absent groups completed the PAD; an instrument that is used to assess pleasure, arousal and dominance in many different populations within the field of consumer psychology and marketing, particularly shopping behaviour (Donovan & Rossiter, 1982; Mattila & Wirtz, 2001; Mehrabian, 1996). Comparison of PAD ratings indicated that arousal was (more or less)

equivalent in the scent-present and scent-absent participants, and that the presence of an aroma did not differentially increase arousal in the former group. Therefore, preferences for the variable compared to fixed delay schedule could not be attributed to differences in arousal from exposure to the chocolate aroma in the scent-present (experimental) condition.

Two other factors of note are, Experiment 2 was single-blind not double-blind, so that the researcher (myself), but not the participants, was aware of the food cue conditions in operation during the food-scheduling assessment. This raises the concern that I, as the researcher, might have biased participants' behaviour. As an argument against this, I was absent from the room while participants completed the food-scheduling assessment, perhaps limiting any audience effects (Kniffin, Sigirci, & Wansink, 2015). Also, there were few differences between the demographic characteristics from each sample. The average age of the sample in Experiment 2 was slightly younger than that of Experiment 1, and the participants in Experiment 2 reported lower levels of eating restraint (measured by the EDE-Q), however these differences did not reach statistical significance. Conversely, there were no differences between the two samples in the eating concern, shape concern, or weight concern subscales of the EDEQ. There were no differences in any other sample characteristics, such as BMI, impulsivity (as measured by the BIS), cognitive restraint (measured by the TFEQ-R), low mood (measured by the BDI), or cognitive ability (measured by the Ravens short form).

Experiment 2 extends the findings of Experiment 1 by examining food-scheduling behaviours in a mixed sample of men and women, following exposure to an

environmental food cue. In addition, unlike in Experiment 1 in which testing took place at least 2hrs after participants′ last meal, participants' hunger was left uncontrolled to vary over testing assessments that might have occurred at any time of day. Nonetheless, I still replicated preferences for the variable over the fixed delay schedules. Other evidence suggests that exposure to the presentation of food cues can stimulate consumption in people who are sated (Cornell et al., 1989); these data indicate that, as with consumption, food-scheduling behaviours and their dependence upon immediate or delayed delivery of rewards are manifested in participants with variable levels of state hunger.

Experiment 2 was intended to investigate the effect of an environmental food cue on food-scheduling behaviour. Exposure to a chocolate scent increased preference for the variable delay schedule in the scent-present condition following delivery of a reward after 30s on the previous selection. This suggests that exposure to a reward cue in the environment increases the incentive-value of the cued reward (chocolate), and therefore the preferences for the variable delay. This is consistent with observations in animal models of delay discounting in which presence of a cue (CS+) that signals reward during delays can reduce discounting rates (following treatment with amphetamine) in comparison to when a CS+ is not presented to signal the availability of the delayed reinforce (Cardinal, Robbins, & Everitt, 2000; Winstanley, Dalley, Theobald, & Robbins, 2003). In a similar manner, here, the presence of the olfactory cue may have acted as a CS+ to sustain choice of the variable delay schedule following delays of 30s.

Individuals with high cognitive restraint (measured by the TFEQ-R) showed a reversal in preference for variable over fixed delays when exposed to an olfactory prime. High cognitive restraint participants who were not exposed to the chocolate scent were less likely to choose the variable delay option when they had received a reward immediately on the previous selection. By contrast, participants with high cognitive restraint who had been exposed to the chocolate scent were more likely to choose the variable delay schedule when they received a reward immediately on the previous selection. This is in line with previous observations that a food preload in restrained eaters leads to greater consumption, albeit in disinhibited eaters (Jansen & van den Hout, 1991). This finding also extends previous research by showing that not only do restrained eaters increase their consumption, breaking restraint as counter-regulation, following exposure to the scent of chocolate, but also promotes variable/immediate food-scheduling decisions. Experiment 2 suggests that counter-regulation of cognitive restraint influences the impact of high value but immediate food rewards in promoting food-seeking behaviours.

Experiment 1 demonstrated that individuals with high BMIs showed a strong preference for the variable delay schedule, specifically after receiving rewards immediately on previous selections. Possibly, this just reflects a smaller sample size and less carefully screened participants than in Experiment 1. Here, individuals with a high BMI in the scent-present condition, showed a reduced preference for the variable delay following a delay of 0s or 30s on the previous selection. Participants with a high BMI appear to show a greater degree of restraint in their decreased preference for immediate rewards in the scent-present condition. This pattern of findings is different to the pattern of results in individuals with higher cognitive restraint where those with

higher cognitive restraint broke their restraint in the scent-present condition. Additionally, there were no baseline differences between conditions for BMI or hunger prior to or subsequent to the food-scheduling task.

As well as replicating the main findings of Experiment 1 in terms of food-scheduling selections and their choice latencies, Experiment 2 included an additional measure of the latencies to collect food rewards from the food-hopper where the chocolate rewards were delivered. I found that collection times were faster when participants received their reward immediately on the previous trial. This suggests that the impact of quick food extends beyond food-seeking behaviours in scheduling selections to consummatory behaviours, as participants actually eat the food rewards. However, collection times were not influenced by either anthropometric variation or attitudes to food, as measured by the TFEQ-R; neither were they sensitive to the presence or absence of chocolate aromas. This suggests that it is the deliberative aspects of food-scheduling behaviours that are influenced by the risk factors for weight gain, rather than the behaviours involved in the retrieval and consumption of food.

Participants' choice of the variable delay schedule was markedly associated with their self-reported preferences for variable delays. These results show greater associations than the findings reported in Experiment 1, where I reported no association between participants' proportion of variable delay selections and their estimated proportion of variable delay selections. Neither results in Experiments 1 or 2 showed a relationship between participants' estimated duration of variable delays and choice of the variable delay schedule. In Experiment 1, participants' choice of the variable delay schedule as their favourite was not affected by cognitive restraint. However, participants in the

scent-absent condition in Experiment 2, were less likely to report the variable delay as their favourite if they had high levels of cognitive restraint. In contrast, individuals with high cognitive restraint in the scent-present condition in Experiment 2 were more likely to report the variable delay schedule as their favourite. This finding could link to the supposition that exposure to the chocolate scent sustains choice of the variable delay schedule, following delivery of a treat after a long delay. Overall, evidence presented in these two chapters suggests that participants' self-reported food-scheduling preferences explain little about their food-scheduling behaviours.

In summary, the results of Experiment 2 show that a relatively subtle environmental food cue, as a scent, can influence participants' food-scheduling behaviour. These findings replicate those of Experiment 1 by demonstrating that choice of the variable delay schedule is increased by the delivery of quick food. These results extend those findings by showing that subtle food cues can sustain choice of variable delay schedules following long delays. Most notably, following exposure to the chocolate scent, individuals with high cognitive restraint showed an increased preference for the variable delay schedule, suggesting the olfactory cue had the effect of breaking restraint.

Increasing understanding of how exposure to food cues can disrupt food-scheduling behaviours, could lead to greater help for individuals managing their food intake, and for weight gain and obesity. However, food cues are not the only factor that may influence food-scheduling behaviours. Personality traits such as impulsivity, in the form of heightened delay discounting, may have a substantial impact on individuals' decisions about how they schedule their food intake (Elfhag & Morey, 2008; Jansen

et al., 2009). It is possible that preferences for variable delay schedules reflect the combined discounted value of rewards received after 0s and 30s, compared to rewards delivered after fixed delays of 15s. It follows that individuals who are more impulsive, show greater preference for rewards delivered immediately. With this in mind, the next experiment examined the value of rewards discounted over short time periods, and their relationship to rewards delivered after short delays in the food-scheduling task.

Chapter 4: Delay discounting with directly consumable rewards

Experiment 1 indicated that individuals show a modest but consistent preference for variable delay schedules over fixed delay schedules for high-value palatable food rewards. These preferences are enhanced following the delivery of immediate or quick foods in females with higher BMIs but diminished value in females with high cognitive restraint. Experiment 2 extended these findings by demonstrating that exposure to subtle olfactory (chocolate) cues can enhance preference for variable delay schedules following delayed food rewards (30s), suggesting that such cues act to maintain the value of predicted rewards over longer delays. In addition, there was evidence that food cues can also reduce cognitive restraint to enhance preferences for variable delay schedules following the delivery of immediate food rewards.

In the next phase of my research, I explored whether these preferences for quick/variable delay food rewards are reflected in individual differences in discounting rates for high value food rewards, over the same delays of between 0s and 30s. There are links between obesity and increased discounting of delayed rewards, demonstrating an association between heightened impulsivity in vulnerable individuals (Rasmussen et al., 2010; Weller et al., 2008). For example, obese individuals who show decreased activation in brain areas associated with executive function during a monetary discounting task, gain more weight after a one to three year follow up, suggesting that deficits in areas associated with executive function in obese individuals may impact on lifestyle choices regarding food consumption (Kishinevsky et al., 2012). In the context of Experiments 1 and 2, preference for variable delay schedules could be due to the greater summed subjective value of immediate and (discounted) delayed rewards (0s and 30s) compared to the fixed delay

rewards (15s). Although differences in discounting rates between lean and overweight/obese individuals have been frequently observed (i.e., Rasmussen et al., 2010), to my knowledge, none of these studies have been carried out using short delays (rather than minutes/hours) and involved the delivery of real edible food rewards.

The most relevant published protocol involved liquid rewards as implemented by Jimura, Myerson, Hilgard, Braver, and Green (2009). This procedure allowed the researchers to use an adjusting amount task, delivering small rewards following a short delay and larger rewards following a long delay, to measure indifference points that were used to identify discounting rates. The findings show that individuals discount real liquid rewards more steeply than hypothetical monetary rewards, even after delays of seconds, and their discount rates are influenced by the reward magnitude, showing steeper discounting for smaller rewards than large rewards (Jimura et al., 2009; Odum, Baumann, & Rimington, 2006). Further studies reported differences in discount rates between different types of rewards between hypothetical monetary and real liquid rewards, and among different ages. The authors suggest these differences may be indicative of individual traits separate for different types of rewards, instead of an overall trait reflecting impulsiveness (Jimura et al., 2011).

Here, to test my hypothesis that preference for variable delay schedules compared to fixed delay schedules reflected individual discounting rates, I needed a discounting task that allowed for accurate and reliable measurement of discounting rates of food rewards eaten following the same delays as used in the food-scheduling assessment used in Experiments 1 and 2: 0s, 15s and 30s. Therefore, I attempted to adapt an

adjusting delay task to measure the indifference points necessary to derive a discounting function of subjective value as a function of these three (comparatively) short delays. These indifference points should capture the equivalences between an individual's subjective evaluation of delayed rewards that are equal to the evaluation of a smaller reward received immediately (Mazur, 1987). In this chapter I describe two ultimately unsuccessful attempts to measure individual discounting functions for the food rewards and delays used in Experiments 1 and 2.

Adjusting amount tasks require continuous changes to be made to the amount of reward delivered, contingent on the participants' choices. This presented me with challenges when using immediately consumable rewards: balancing adjustments in the quantity of the food eaten during a discounting assessment while, in the main, preventing participants' sating during the testing sessions. In order to utilise an adjusting amount procedure, the amount of reward would have to start at quantities that would result in satiety, to allow the quantity to decrease over the course of the assessment. Additionally, initial piloting of data from Experiment 1 (data not presented) indicated that the researcher should not be present during consumption tasks to prevent audience effects, leading to practical difficulties in my remaining present to adjust the amounts of reward during testing sessions. These two opposing factors ruled out the possibility of using adjusting amount task. Therefore, I decided to start by using an adjusting delay task, based upon Mazur (1987).

Protocol 1: Adjusting delay procedure for high value edible food rewards

In Mazur's original adjusting delay task, experimental subjects (e.g. pigeons) made selections between small immediate rewards (e.g. 2s of access to grain) following a

fixed delay, or larger rewards (6s of access to grain) following a delay which varied in duration dependent upon previous choices (Mazur, 1987). The delay of the larger reward increased if more choices were made for the larger reward but decreased if more choices were made for the smaller reward. The magnitude or amount of reward (2s of access to grain or 6s of access to grain) was held constant throughout the procedure.

The goal of the adjusting delay procedure is to identify an indifference point- whereby the subjective value of a larger later reward is equal to the subjective value of a smaller sooner reward. This process is then repeated with several reward delays, to give a range of indifference points, allowing an indifference curve to be plotted. Indifference curves can take the form of an exponential or hyperbolic function, with a hyperbolic curve being most common in human experiments (Madden & Johnson, 2010; Mazur, 1987), calculated as:

$$V = \frac{A}{1 + kD}$$

Eq. 4.1

My first attempt followed an adjusting delay design (Mazur, 1987) but with short delays between 1s and 18s, and the same confectionary and savoury edibles of Experiments 1. The task consisted of four blocks of trials, with each block comprising four forced-choice trials and then two free-choice trials. On the four forced-choice trials, a single red or black box measuring 40mm x 40mm was presented in the centre of the computer screen. Pressing the box resulted in a reward being delivered. If the box offered a long delay (e.g., if the box was black), three rewards were dispensed after a delay of initially 30s. If the box offered a short delay (e.g., if the box was red) one reward was delivered after a delay of 1, 3, 9 or 18s. On the free-choice trials, one

red and one black box were presented on the screen, with the same dimensions as the boxes presented in the forced-choice trials, and separated 40mm apart. Selecting the red box resulted in a short delay (one of 1, 3, 9 or 18s) before a reward was delivered, as in the forced-choice trials. Selecting the black box resulted in three rewards after the longer delay, again as in the forced-choice trials.

Following completion of each block (four forced-choice trials and two free-choice trials), the duration of the longer delay was adjusted as follows: if participants had made two choices of the larger delayed reward in the free choice trials, the duration of the long delay was increased by 5s in the following block. If participants made two choices of the smaller short delayed rewards, the duration of the long delay was decreased by 5s on the following block. If participants made one selection each of the smaller, short delay reward and the larger, long delay rewards, an indifference point was deemed to have been reached. The next block commenced with a new short delay and the duration of the long delay was reset to 30s.

The colours assigned the long and short delays were counterbalanced across participants, as was the order of presentation of the short delays.

Ethical approval was granted by Bangor University School of Psychology research ethics committee; all participants provided written informed consent.

Procedure

As in Experiments 1 and 2, participants were asked to rate five sweet and five savoury rewards (cheese savouries, Wotsits, Hula Hoops, pretzels and Twiglets; Revels,

Maltesters, Minstrels, Skittles and Jelly Beans). Participants selected the reward to be used in the assessment between their top ranked sweet reward and savoury reward. During the task, participants sat in front of a touch screen monitor, mounted on a custom built motorised treat dispenser. Prior to the task, I read aloud the following instructions displayed on screen:

'*During this task you will see some red and black boxes on the screen. Touching either of the boxes will produce your favourite treat in the tray in front of you. Please eat each treat as soon as it is delivered. On each go, there will be some practice trials, followed by two choice trials. During the practice trials, a single black or red box will be presented in the centre of the screen. During the choice trials, the red and black boxes will appear side by side in the middle of the screen. All you have to do on each choice trial is choose between the red and black boxes by making a touch response to receive the treat.*'

One male and four female participants were piloted, they were aged between 23-28. Pilot participants 1 – 4 attempted all four blocks of the adjusting delay session in a single session at various times of day (see Table 4.1). For the first four pilot participants, each of the four short delays were presented once within the session. However, pilot participant 5 completed each of the four delays in four separate sessions, one for each short delay duration, with each short delay repeated up to three times within each session. The aim of this adjustment was to decrease the length of each session and reduce the risk of satiety. For this participant, indifference points were determined as the average of (up to three) measurements with the same delay. For the short delay of 1s, pilot participant 5 completed two blocks; for the short delay

of 3s, the participant completed three blocks; for the delay of 9s, the participant completed two blocks; and for the delay of 18s, the participant completed one block.

Results

Completion times for the protocol were protracted, ranging between 1hr and 1.5hr. Only pilot participant 2 successfully completed the whole adjusting delay assessment. Participants 3 and 4 rapidly became sated with their chosen rewards. Participant 5 did not complete all iterations of the task in any session due to satiety.

	Participant 1	**Participant 2**	**Participant 3**	**Participant 4**	**Participant 5**
Gender	Female	Male	Female	Female	Female
Time of day	11.45am	11am	3pm	11.50am	9am
Duration	1.5hrs	1hr	35mins	1hr 10mins	Approx 1hr per session
Food chosen	Cheese savouries	Wotsits	Maltesers	Minstrels	Wotsits
No. of treats consumed	33	20	14	28	24 33 24 18
Notes	Not all treats dispensed	Completed	Did not finish-sated	Did not finish-sated	Divided short delays into 4 sessions

Table 4.1. Information on the gender and testing session characteristics of each pilot participant.

As a first approximation, indifference points should show at least a monotonic decrease with delay. Only one of the pilot participants showed such a pattern (pilot participant 3) and this participant was missing indifference points for the two shortest delays (see Table 4.2). Pilot participants 1 and 5 showed indifference points that first

reduced and then increased across delays, suggesting non-systematic patterns of responding (Johnson & Bickel, 2008). Pilot participants 2 and 4 showed indifference points that actually increased across the delays, implying increasing valuation of delayed rewards; Participants 3 and 4 did not complete the task due to satiety (Table 4.1), and there were no indifference points at three of the short delays.

	Short delays (secs)			
	1	**3**	**9**	**18**
Participant 1	50	30	50	45
Participant 2	5	25	30	30
Participant 3	40	30	-	-
Participant 4	5	5	-	35
Participant 5	50	45	45	60

Table 4.2. The indifference points for each participant when the subjective value of receiving one high value edible reward after a short delay was equivalent to receiving three rewards after the long delay.

Discussion

This adjusting delay procedure showed a number of shortcomings. These included the duration of the measurement and increasing satiety following consumption of a large number of sweet or savoury edibles delivered over a relatively long period of time (between 18-33 treats consumed during the free-choice trials, in addition to the 24 treats already consumed by each participant during the forced-choice trials). In addition, it is possible that, despite the forced-choice trials, participants struggled to estimate the longer delays accurately (Kacelnik & Brito-E-Abreu, 1998; McClure, Podos, & Richardson, 2014) and/or struggled to distinguish temporal differences between blocks that had different short delay durations. Presenting explicit text instructions on screen (i.e., 1 treat in 0s or 2 treats in 85s) might help rectify noise in the data as participants would have a clearer understanding of the task and not have to

rely on learning the delays associated with each reward. This solution, which was implemented in Protocol 2, also diminishes the need for forced-choice trials, reducing the number of rewards delivered and lessening satiety.

It is highly likely that, in contrast to assessment with hypothetical food rewards, participants' choices were influenced by rapid fluctuations in motivational state (i.e., levels of satiety throughout the task) as opposed to their preference or tolerance for longer delays. To reduce satiety, I needed to find a way to test an alternative shorter procedure with fewer rewards. The five trial ED50 procedure (see below; Koffarnus & Bickel, 2014), administered with food rewards, offered a possible solution. Participants were also provided with explicit information about the two delays on offer and their associated number of rewards to minimise learning about the choice contingencies. I also included repeated choices with the same delays so that participants gained adequate experience of the choice outcomes and arrive at accurate estimates of the ED50.

Protocol 2: ED50

The ED50 is the "Effective Delay at 50%", or the delay at which the delayed reward is discounted in value by 50% (Yoon & Higgins, 2008). The ED50 value is derived from Mazur's hyperbolic discounting model (Mazur, 1987) (Eq. 4.1). So, we substitute A/2 for V and ED50 for D in Mazur's equation (Eq. 4.1, above) to give:

$$\frac{A}{2} = \frac{A}{(1 + kED50)}$$

Eq. 4.2

A then cancels out and cross multiplying gives:

$$1 + kED50 = 2$$

Eq. 4.3

Finally, if we subtract 1 from each side and divide by k we get:

$$ED50 = \frac{1}{k}$$

Eq. 4.4

This states that the delay at which A is half its original value is equivalent to 1/k (Yoon & Higgins, 2008). The ED50 is a measure of delay discounting whereby the amount remains the same (i.e. a larger amount after a delay or half the amount available immediately), similar to adjusting delay procedures.

The ED50 (Yoon & Higgins, 2008) assumes a hyperbolic discounting function and, accordingly, Koffarnus and Bickel (2014) developed a 5 trial procedure using the ED50 to measure discounting rates in a shorter time period compared to other discounting assessments. Adapting this measure might allow me to estimate k with the consumption of a smaller number of edible rewards, reducing the likelihood of satiety. K values from an ED50 task correlate with those from an adjusting amount task and factors associated discounting rates (e.g. amount, historical reinforcers, type of reinforcer and monetary values include zero values) and also affect ED50 values (Koffarnus & Bickel, 2014).

For each of 5 delays, participants chose between receiving one reward immediately (short delay option) or two rewards following a delay (long delay option). Participants made their choice by pressing one of the options on the screen (Fig 4.1).

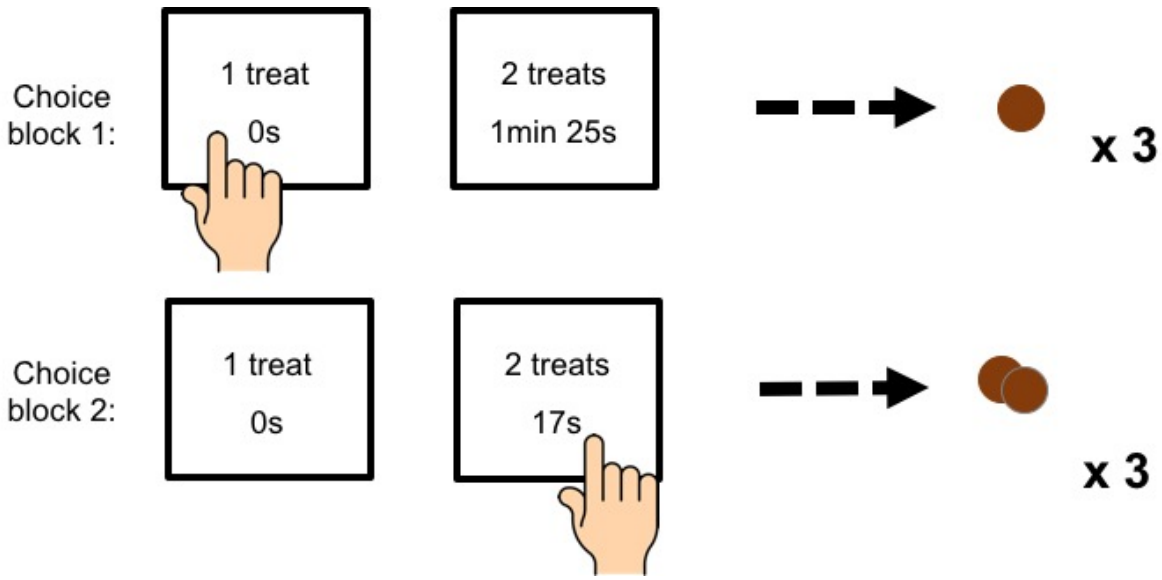


Figure 4.1. Schematic of first two choice blocks of ED50 procedure. As the short delay was selected in the first choice block, the long delay decreased on the second choice block.

Each choice block was comprised of three choices between receiving 1 treat after 0s or 2 treats after a long delay, before progressing to the next choice in the protocol. If participants made two or more selections for the long delay, the long delay duration was increased. If participants made two selections for the short delay, the long delay duration was decreased as in Table 4.3. An ED50 time and k value were calculated from the final selections as Choice 4 in Table 4.3.

Choice 1	1min 25s							
Choice 2	17s				7mins 12s			
Choice 3	7.5s		38s		3mins 12s		16mins 13s	
Choice 4	5s	11.25s	25s	57s	2mins 8s	4mins 48s	10mins 49s	24mins 20s

Table 4.3. Decision tree of long delay contingencies on the ED50 task. The duration of the long delay increased or decreased contingent on the previous choice. Each choice delivered 1 treat immediately, or 2 treats after a long delay.

Procedure. The instructions for the ED50 task were: *"In this task, you will have the choice of receiving one of your chosen treats now, or two treats after a set amount of time. Two delays will appear side by side on the screen and you can choose if you want to receive one treat immediately or two treats after a set amount of time (the longer of the two numbers on the screen). If you would like to receive two treats after the set amount of time, please press the box corresponding with the longer of the two delays. If you would rather receive one treat now, please press the number that corresponds to receiving the treat immediately (i.e. 0 sec). The time you have to wait for a treat after a long delay will change depending on your previous choices."*
All other aspects of the procedure, including informed consent and selecting sweet/savoury edibles were repeated as in the adjusting delay protocol.

Results

The results are shown in Table 4.4, only pilot participant 4 completed this assessment, resulting in an ED50 time of 1.379 and a k value of 0.725. Pilot participant 1 completed only one of the three choices in the 3rd choice block, and pilot participants 2 and 3 failed to make any choices at all in choice blocks 3 or 4. In these cases,

selections of the larger delayed rewards quickly drove up the associated delays, lengthening the time needed to complete the assessment. For example, had either of pilot participants 2 and 3 started choice block three, the long delay option would have been set at 16 mins 13s before the delivery of a reward. On the previous choice block (choice block 2), both participants selected the long delay option, and waited 7 mins 12s, on three out of three choices.

Participant	Choice 1	Choice 2	Choice 3	Choice 4
1	1 min 25s	0s	0s	-
	0s	7 min 12s	-	-
	1 min 25s	7 min 12s	-	-
2	1 min 25s	7 min 12s	-	-
	1 min 25s	7 min 12s	-	-
	1 min 25s	7 min 12s	-	-
3	1 min 25s	7 min 12s	-	-
	1 min 25s	7 min 12s	-	-
	1 min 25s	7 min 12s	-	-
4	0s	17s	38s	0s
	0s	17s	38s	0s
	1 min 25s	17s	38s	57s

Table 4.4. Duration of delay selected on each trial, for each block of choices. Two of three choices for the long delay caused the long delay to increase in the next choice block. Two of three choices for the short delay caused the long delay to decrease in the next choice block.

Discussion

My implementation of the ED50 assessment with experienced delays and real edible rewards involved a sequence of choice blocks with three choices to derive an ED50 value, as the reciprocal of k. However, this increased the overall task duration, as well

as the number of rewards consumed by a factor of three. Both the lengthened completion times and satiety made the assessment even less tolerable and effective for experimental participants. Here, 3 out of 4 participants did not successfully complete the assessment due to time constraints and satiety. In fact, the duration of the longer delays dramatically increased (or decreased), dependent on the choices made in the first block with the first delay of 1.25min. Three participants chose the long delay option on both choice block one and two. Given that these participants repeated these particular decisions in each choice block, it is clear these decisions were intentional and the long delays reflected durable preferences.

These results raise a number of questions about why participants repeatedly made choices for the long delay for real edibles. Possibly, these participants had very low rates of discounting (and were not very impulsive) or that the edible rewards had very high value, again reducing their discounting rates. Alternatively, these participants may have behaved in accordance with perceived demand characteristics. However, the key practical point here is that participants displayed a great deal of tolerance for delays in order to obtain two edible rewards. This choice of the long delay for two rewards then set participants on a path for longer delays where tolerance and compliance may be poor. Although these pilot experiments involved only a small number of participants, their data suggest that delay discounting paradigms using real edibles are very difficult to operationalise due to participants' satiety, and unwillingness to give up sufficient time to complete the experimental procedure. This led me to consider traditional discounting paradigms, using hypothetical monetary rewards.

Notwithstanding the above disappointments, traditional discounting paradigms with hypothetical rewards over much longer delays afford the opportunity to measure individuals' discount rates (k value), as persisting traits across a range of rewards (Odum, 2011b; Odum & Rainaud, 2003; Weller et al., 2008), and test their association with individuals' inter-temporal preferences over variable versus fixed delay schedules. Delay discounting is a personality trait, whereby an individual's rate of discounting is correlated across a range of rewards (Odum, 2011a, 2011b). I hypothesised that individuals with a higher k value will discount the value of longer rewards (following a 15s fixed delay, or a 30s variable delay) more greatly than those with a lower k value, resulting in a higher proportion of choices for the variable delay schedule.

Chapter 5: Does delayed discounting predict food-scheduling behaviours? The relationship between k and food-scheduling behaviours

Experiment 1 suggested that individuals prefer variable over fixed delays to edible food rewards and that there may be links to BMI and eating attitudes. Experiment 2 then examined the effects of environmental food cues on food-scheduling behaviours and demonstrated that preferences for variable over fixed delays can be supported by appetitive olfactory cues that sustain selections following prolonged delays to food rewards. In addition, Experiment 2 demonstrated that links between preferences for variable delay schedules, BMI and eating attitudes are subtle, and unreliable across experiments. One mechanism underlying the preference for variable over fixed delay schedules may be the rate of discounting of delayed rewards.

As reviewed in Chapter 1, delay discounting refers to the decreasing subjective value of a reward as a function of increasing time until receiving it (Odum, 2011a). Rates of discounting will vary across individuals, populations and species but humans are most frequently characterised by the parameter k that specifies the hyperbolic discounting model:

$$V = \frac{A}{1 + kD}$$

Eq. 5.1(Mazur, 1987)

Where V equals the value of reward at each delay, A is the amount of reward, k is the individual's discount rate, and D is the delay until reward is received. Adjusting-amount or delay assessments (see Chapter 4) can be used to specify indifference points as the equivalence between the subjective values of smaller sooner rewards and larger later rewards (Mazur, 1987; Odum, 2011a). Each of these indifference points can then be plotted to form a discounting curve. Usually, though not always, the shape

of this curve is described by a hyperbolic function and its parameter, k (Odum, 2011a). However, exponential discounting has also been reported in individuals who made a series of selections between hypothetical monetary rewards obtained following different delay durations (Schweighofer et al., 2006). The authors argue that the shape of the discount curve (hyperbolic or exponential) varies based on the task used to calculate indifference points (Schweighofer et al., 2006).

Applying this to the food-scheduling task, the summed subjective value of immediate rewards and (discounted) delayed rewards (0s and 30s), may be greater than the subjective value of fixed delay rewards (15s), prompting individuals' preferences for variable over fixed delays. Chapter 4 described my several attempts to measure discounting rates for real rewards that cover the very short intervals used in my experiments: 0s to a few minutes. Sadly, these attempts were unsuccessful. However, under the supposition that discounting can be measured as a trait that operates across a range of rewards and across a wide range of delays (Odum, 2011b), preferences for variable over fixed delay schedules may still reflect a discounting trait, as captured by k for hypothetical monetary rewards. Therefore, I hypothesised that individuals' preferences for variable over fixed delays on the food-scheduling task will be linked to k values.

A good example of individuals' discounting functions can be found in Myerson, Green, Hanson, Holt, and Estle (2003) who examined participants' discounting using hypothetical rewards of $200 and $40,000, received after 1 month, 6 months, 1 year, 2 years, 5 years, 8 years and 12 years. On each trial, participants were given the choice between receiving a larger reward ($200 or $40,000) after a delay, or half the amount,

available immediately. On subsequent trials, the value of the smaller reward increased or decreased dependent on the participant's choice in the previous trial. Participants made six choices at each delay. This procedure allowed for calculation of reliable curves with a relatively small number of trials.

Other evidence suggests that individuals discount monetary rewards at a different rate compared to other forms of rewards such as consumables. Odum and Rainaud (2003) and Odum et al. (2006) compared discounting of hypothetical food rewards with hypothetical monetary rewards. For the food discounting tasks, participants were asked to imagine $100 (Odum & Rainaud, 2003), or $10 worth (Odum et al., 2006) of their favourite food. Both report higher k values and steeper discounting for food compared to monetary rewards.

My findings from Experiment 1 that individuals with a high BMI show increased preference for variable over fixed delays, are in line with research which demonstrates that individuals with a high percent body fat (PBF) show steeper discounting than individuals with low PBF (Rasmussen et al., 2010). In this experiment, they measured discounting of monetary rewards and bites (defined as ½ inch cubes) of participants' favourite food, across high and low quartile percentage body fat (PBF). High PBF individuals discounted food more steeply than low PBF individuals. Additionally, overweight and obese individuals who demonstrated faster discounting of delayed rewards and higher reward sensitivity consumed a larger quantity of palatable food following a preload compared to individuals who were slower to discount delayed rewards (Appelhans et al., 2011). This suggests that overweight/obese individuals place a greater value on obtaining quick food rewards. Furthermore, obese individuals

discounted delayed rewards more quickly compared to healthy weight individuals, in both an adolescent sample (Fields, Sabet, & Reynolds, 2013) and in an adult female sample (Weller et al., 2008). However, in Weller's task, discounting was measured from a hypothetical monetary discounting task, and did not measure discounting relating to food rewards. Nonetheless, these findings add support to the argument that obese individuals discount delayed rewards but, equivalently, value quick rewards.

On the other hand, healthy weight individuals also demonstrate a link between discounting and consumption. Individuals who discounted rewards more quickly, and who had a higher relative reinforcing value of food, consumed a greater amount compared to individuals who were slower to discount delayed rewards (Rollins et al., 2010). This suggests that consumption is mediated by individuals' discount rates, in healthy weight and overweight/obese samples.

If trait impulsivity, through the mechanism of increased delay discounting, mediates or influences, at least in part, food-scheduling behaviour, I should expect individuals who show greater discounting of delayed rewards (as reflected in higher k values) to show stronger preferences for variable over fixed delay reinforcement schedules. To investigate this, I tested the association between delay discounting, measured with a well-established 'adjusting-amount' measure of delay discounting (Myerson et al., 2003) and preferences for variable delay on our food-scheduling task, with high-value edible rewards.

Method

Ethical approval was granted by Bangor University School of Psychology Ethics Committee (Approval number: 2015-15249).

Participants

One hundred and seventy-three adult volunteers were recruited from the Bangor University School of Psychology online participant panel and were compensated with course credits. Following application of exclusion criteria (details below), there were 100 participants remaining in the sample (M = 28; F = 72). Their mean age was 21 years (SE = 0.43; range = 18 to 41).

Psychometric questionnaires

Participants completed questionnaires to assess mood, eating behaviour, impulsivity, cognitive ability, alcohol use, tobacco use, and childhood socio-economic status (SES). As in Experiments 1 and 2, these included the short-form Ravens Matrices form (Arthur & Day, 1994), FCQ-S (Cepeda-Benito et al., 2000), PANAS state (Watson et al., 1988), BDI (Beck et al., 1996), EDE-Q (Fairburn & Beglin, 1994), BIS (Patton et al., 1995), TFEQ-R18 (Karlsson et al., 2000). The published psychometric properties of these scales have been detailed previously: see Chapter 2 for some published norms. Table 5.1 shows the Cronbach's αs for Experiment 3's sample.

Scale	α for sample
FCQ savoury	.884
FCQ sweet	.924
PANAS PA	.866
PANAS NA	.850
BDI	.917
EDEQ restraint	.769
EDEQ shape concern	.900
EDEQ eating concern	.771
EDEQ weight concern	.848
BIS total	.834
TFEQ cognitive restraint	.712
TFEQ emotional eating	.888
TFEQ uncontrolled eating	.863
AUDIT	.800
FTND	.775

Table 5.1. Cronbach's α for the sample for each scale

Literature suggests that individuals with alcohol or nicotine dependence show different patterns of delay discounting compared to individuals without alcohol or nicotine dependence (Odum & Baumann, 2007; Odum & Rainaud, 2003). Therefore I included the Alcohol Use Disorders Identification Test (AUDIT; Saunders, Aasland, Babor, De La Fuente, & Grant, 1993; Appendix M) to assess harmful alcohol consumption patterns. This scale comprises ten items scored on a 5-point likert scale. A Cronbach's α of .82 has previously been reported for this scale (Bergman & Kallmen, 2002); here, my Cronbach's α was .80.

Participants also completed the Fagerstrom Test for Nicotine Dependence (FTND; Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991; Appendix N) to assess nicotine

dependence (only scores for participants who smoked or vaped were included). This scale consists of 6 items scored on 2- (yes/no), 3 or 4-point scales, with higher scores indicating greater nicotine dependence. The Cronbach's α for my sample was .78, which is higher than the previously reported Cronbach's α of .61 (Heatherton et al., 1991). Individuals with greater nicotine dependence and higher alcohol consumption tend to show greater discounting of delayed rewards (Bickel, Odum, & Madden, 1999; Petry, 2001).

Childhood SES was measured using three items that asked participants to think about their childhood before they were 12 years of age (Hill, Prokosch, DelPriore, Griskevicius, & Kramer, 2016; Appendix O). Participants scored, on a 7-point Likert scale from "strongly disagree" to "strongly agree", the degree to which their family had enough money for things while there were growing up; if they grew up in a relatively wealthy neighbourhood and if they felt relatively wealthy compared to others their age. These items had high reliability (α = .87; Hill et al., 2016), with an α of .85 in my sample.

Delay discounting task

The delay discounting task was adapted from the ′adjusting-amount′ procedure described in Myerson et al. (2003). On each trial, participants were asked to choose between an amount of money available immediately and a larger amount available following delays of 1 month, 6 months, 1 year, 2 years, 5 years, 8 years and 12 years, administered in ascending order[1]. Initially, participants were presented with the initial

[1] 20 participants (included in the sample of 100 participants) additionally made six choices at the delay of 1 week, however these extra indifference points were not included in the calculation of k values for these 20 participants.

choice of £1000 after the assigned delay, or half the value (£500) available immediately. Following each choice, the value of the immediate choice increased or decreased by half. For example, if the participant chose £1000 after 1 week instead of £500 now, the following choice would be between £1000 after 1 week or £750 now. Participants were presented with 12 practice trials with different amounts and delays prior to completing the main discounting task.

Food-scheduling task

Details of the food-scheduling task have been reported in Experiment 1 (please refer to p.49, Chapter 2). Participants made a series of choices between a variable delay schedule with equally probable delays of 0s and 30s, and a fixed delay schedule with a delay of 15s to obtain high value food rewards.

Procedure

Participants first completed the adjusting-amount delay discounting task. They then selected their preferred treat from a selection of five savoury snacks (Hula Hoops, Wotsits, Cheddars, Twiglets and Pretzels) and five confectionary snacks (Maltesers, Minstrels, Skittles, Revels, and Jelly Beans). Next, participants completed the short-form Raven's Matrices (Arthur & Day, 1994); state affect with the PANAS (Watson et al., 1988); food craving (Cepeda-Benito et al., 2000); hunger and wanting of their selected treat on 10cm visual analogue scale (VAS), with the anchor points from "Not at all" to "Extremely".

Once they had completed these questionnaires, participants were then seated in front of the food dispenser which was attached to a touch screen monitor. Instructions were displayed on the screen and read aloud:

"On each go, a green box and a blue box will appear side-by-side on the screen.
Touching either of them will produce your favourite treat in the plastic tray here.
You may need to wait a while for the treat to be delivered.
Sometimes the green box will appear on the left and the blue box on the right;
sometimes the boxes will appear the other way around. But this will be random.
Once you've eaten (and enjoyed) the treat, the green and blue boxes will reappear
and you can then obtain another treat.
That's all you have to do.
At the end we'll ask you some questions. But for now, enjoy."

Following the task instructions, I informed participants they could start the task when they were ready and then exited the room. On completion of the food-scheduling task, the participant then completed further wanting and hunger scales using 10cm VAS, as well as the BDI, EDE-Q, BIS-11, AUDIT, FTND, TFEQ-R, their childhood SES and awareness of box contingencies from the task.

Data analysis

Participants' data was excluded if they were not exposed to each delay (variable 0 second, variable 30 second, fixed 15 second) (n = 11), or if BMI was classified as underweight (< 18.5) (n = 3) according to published criteria (WHO, 2016).

Delay discounting. A number of participants showed patterns of non-systematic indifference points. Following Johnson and Bickel (2008), I used two criteria to identify non-systematic datasets: (i) where any indifference point was greater than 20% of the largest delayed reward (i.e., if any indifference point was more than £1200); and (ii) where the last indifference point was not less than the first

indifference point (by £100 or more). Participants′ data were classed as unsystematic (i.e., does not show delay discounting) if they satisfied one or both of these criteria and were not included in the analysis. Application of these criteria were used to identify the final sample, resulting in 59 participants being removed prior to further analysis.

Calculation of k. Discounting rates (k) were calculated from individuals' indifference points, fitted using equation 5.1 (Mazur, 1987). K values were log transformed to account for the positively skewed distribution. A constant of 10^{-34} was added to each k value to allow inclusion of k values equal to 0 (n = 2).

Area under the curve (AUC) analysis. Participants′ AUCs were calculated from the equation proposed by Myerson, Green, and Warusawitharana (2001) to provide an a-theoretical measure of discounting:

$$(x^2 - x^1)*[(y^1 + y^2)/2]$$

Where x^1 and x^2 are successive delays, and y^1 and y^2 are their indifference points. This calculation is repeated for each section of delays, then the products summed to give an AUC value for each participant. Smaller values indicate greater delay discounting, showing steeper curves. AUC values give a more accurate picture of individual discounting rates, as they are derived directly from the indifference points rather than being fit using model parameters (Madden et al., 2003). Although they more accurately portray individual discount rates, AUC values are not able to express an individual's discount rate that might operate over a range of rewards and delays (Odum, 2011a).

Correlations between discount rates and health relevant behaviours. The literature suggests relationships between delay discounting, alcohol, and nicotine use (Odum & Baumann, 2007; Odum & Rainaud, 2003). Therefore, I carried out correlations between discount rates, AUDIT scores and FTND scores. Separate correlations were carried out using each measure of discounting (k values and AUC values).

Proportionate choice of the variable delay option. As in Experiments 1 and 2, participants' selections of the variable and fixed delays were analysed using binomial logistic models (please refer to p. 52, Chapter 2).

As before Model 1 tested the relationships between proportionate choice of the variable delay schedule and (i) side of the monitor on which the variable box appeared (right as the referent), (ii) colour of the variable-delay schedule box (blue as the referent); (iii) time of day (morning as the referent); (iv) treat type (sweet as the referent); (v) hunger, and the interaction between treat type and time of day (vi) (Model 1).

In Model 2, retaining only those predictors of Model 1 whose β-coefficients were significant, I then added (vii) k, (viii) the delay to the food reward of the preceding choice (last delay; with fixed 15s delay as the referent); (ix) BMI and (x-xii) the cognitive restraint, emotional eating and uncontrolled eating subscales of the TFEQ-R. In Model 3, I then tested the two-way interactions between (xiii) last delay and BMI, (xiv-xvi) and last delay and the subscales of the TFEQ-R. Next, I tested the interaction between (xvii) last delay and k (Model 4). In Model 5, I added the

interactions between (xviii) k and BMI; and (xix) the three-way interaction between k, BMI and last delay. In a final model, I tested (xx-xxiii) the three-way interaction between k, last delay and the subscales of the TFEQ-R (Model 6).

Similar models using normal distribution regressions with the same structure were run for choice and collection time latencies. Finally, as a check, I constructed the equivalent models replacing log k with AUC. These models are not reported as the results were not significantly different

Results

Demographic and psychometric sample characteristics

Table 5.2 displays the demographic, recent mood scores and eating characteristics of the 100 participants retained for analysis. Sixty-five participants had a BMI within the healthy range (18.5-24.9), 24 participants' BMI fell within the overweight category (25 – 29.9), and 11 participants were classed as obese (BMI between 30 – 35). All participants were recruited from a student sample, and show an age range of 18 to 41 years.

	N	Mean (SE)
Gender	100	M = 28; F = 72
Age	100	21.03 (0.43)
BMI	100	24.26 (0.39)
TFEQ Cognitive restraint subscale	99	27.10 (1.62)
TFEQ Uncontrolled eating subscale	100	28.06 (1.59)
TFEQ Emotional eating subscale	100	28.67 (2.31)
Raven's scaled score	97	11.41 (0.25)
BIS-11 Total score	86	63.09 (1.26)
EDE-Q Restraint subscale	99	1.20 (0.14)

EDE-Q Eating concern subscale	99	0.76 (0.10)
EDE-Q Shape concern subscale	100	2.38 (0.16)
EDE-Q Weight concern subscale	100	1.88 (0.16)
BDI-II	98	10.79 (0.95)
FCQ sweet subscale	99	3.54 (0.13)
FCQ savoury subscale	94	3.57 (0.13)
AUDIT	80	7.10 (0.63)
FTND	75	0.41 (0.15)

Table 5.2. Means ± standard errors for gender, age, BMI and subscales of each psychometric questionnaire. Missing scores are due to participants choosing to omit responses to some items.

The mean scores for eating, weight, shape and restraint concern (as measured by the EDE-Q) fall below the threshold for disordered eating (Fairburn & Beglin, 1994), however, 28 participants reached criteria for 'caseness' in one or more of the subscales, with eight participants reaching the criteria for cognitive restraint, two for eating concern, 22 for shape concern and 19 for weight concern. Participants' mean BDI scores indicated only mild depressive symptoms (Beck et al., 1996), with 14 participants experiencing moderate low mood. Thirty-eight participants reported AUDIT scores, suggesting levels of harmful or hazardous alcohol consumption as advised by Saunders et al. (1993). Only three participants reported moderate or greater dependence on nicotine (Heatherton et al., 1991).

Delay discounting task

Indifference points from the delay discounting task were used to plot discounting curves and fit with a hyperbolic model (Figure 5.1).

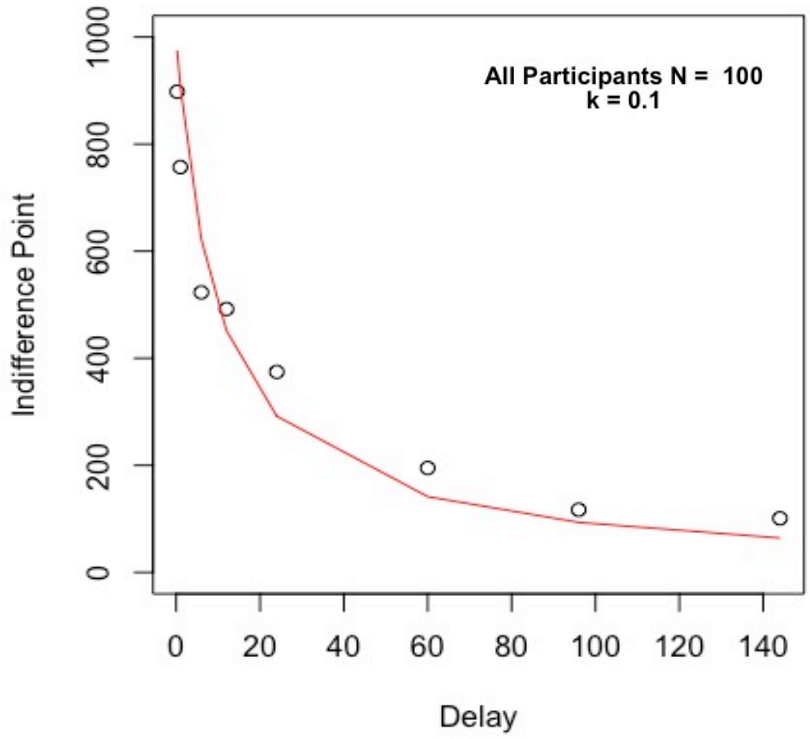


Figure 5.1. Median discounting curve based on indifference points for each delay (displayed in months). Model fit is based on the hyperbolic model (Eq. 5.1).

AUC was calculated for individual participants (M = 0.29 ± 0.02). Participants who chose lower proportion of variable delay schedules and those with high BMIs tended to report low AUC scores (r = .19, n = 100, p = .07; r = -.22, n = 100, p = .03, respectively).

Correlations between discount rates and health relevant behaviours

Individuals who reported greater nicotine dependence (measured by the FTND) were more likely to have higher k values (r = .35, n = 95, p = .001). However, there was no relationship between k and alcohol use (measured by the AUDIT; r = .01, n = 100, p =

.92). Additionally, there was no relationship between AUC and FTND scores (r = -.06, n = 95, p = .59) or AUDIT scores (r = -.03, n = 100, p = .78).

Variable and fixed delay selections: preliminary analyses

Selection of the variable delay option was not influenced significantly by the side of the screen on which it was presented (β= -0.06±0.08; Z = -0.75; Model 1, Table 5.3) or its colour (β= -0.06±0.19; Z = -0.32). Individuals who chose a savoury treat during the midday session were significantly less likely to select the variable schedule compared to the fixed schedule (β= -1.72 ± 0.52, Z = -3.31). However, variable delay vs fixed delay preference was not significantly influenced by state hunger (β= -0.01±0.04, Z = -0.25).

Variable and fixed delay schedule selections: BMI and discounting rates

As I expected, participants were more likely to select the variable option when they received a reward immediately on the previous trial than following a 15s delay (0.65±0.03; β= 0.58±0.10, Z = 5.80; Model 2, Table 5.3). By contrast, participants were significantly less likely to select the variable option following a 30 second delay on the previous trial, (0.49 ± 0.03, β= -0.26± 0.10, Z = -2.60). Additionally, there were no changes in preferences for variable delays following 0s or 30s delays for individuals with high or low k values (0s: β= 0.03±0.07, Z = 0.43; 30s: β= -0.06±0.07, Z = 0.86; Model 4, Table 5.3, Fig 5.2a).

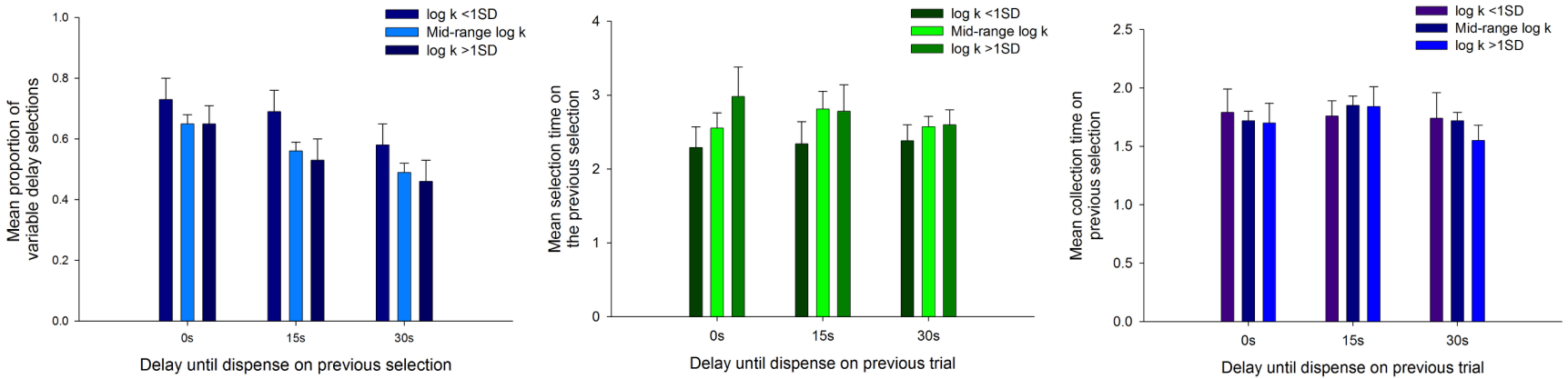


Figure 5.2. a) Mean proportion of variable delay selections; b) mean selection time between variable and fixed delay schedules; and c) mean collection time following 0s, 15s, and 30s delays, for individuals with high, mid-range and low log k values. Participants' k values have been log transformed and classified as less than 1SD (log k < -4.15); mid-range log k (log k between -4.15 to -1.87); and greater than 1SD (log k > -1.87).

Overall, preference for the variable delay schedule over the fixed delay schedule was not significantly associated with variation in BMI (β= -0.01±0.03, Z = -0.33; Model 2; Table 5.3). However, individuals with high BMIs and high k scores were more likely to continue to select the variable delay schedule following delays of 0s compared to 15s (0s: β= 0.06±0.02, Z = 3.00; Model 5; Figure 5.3).

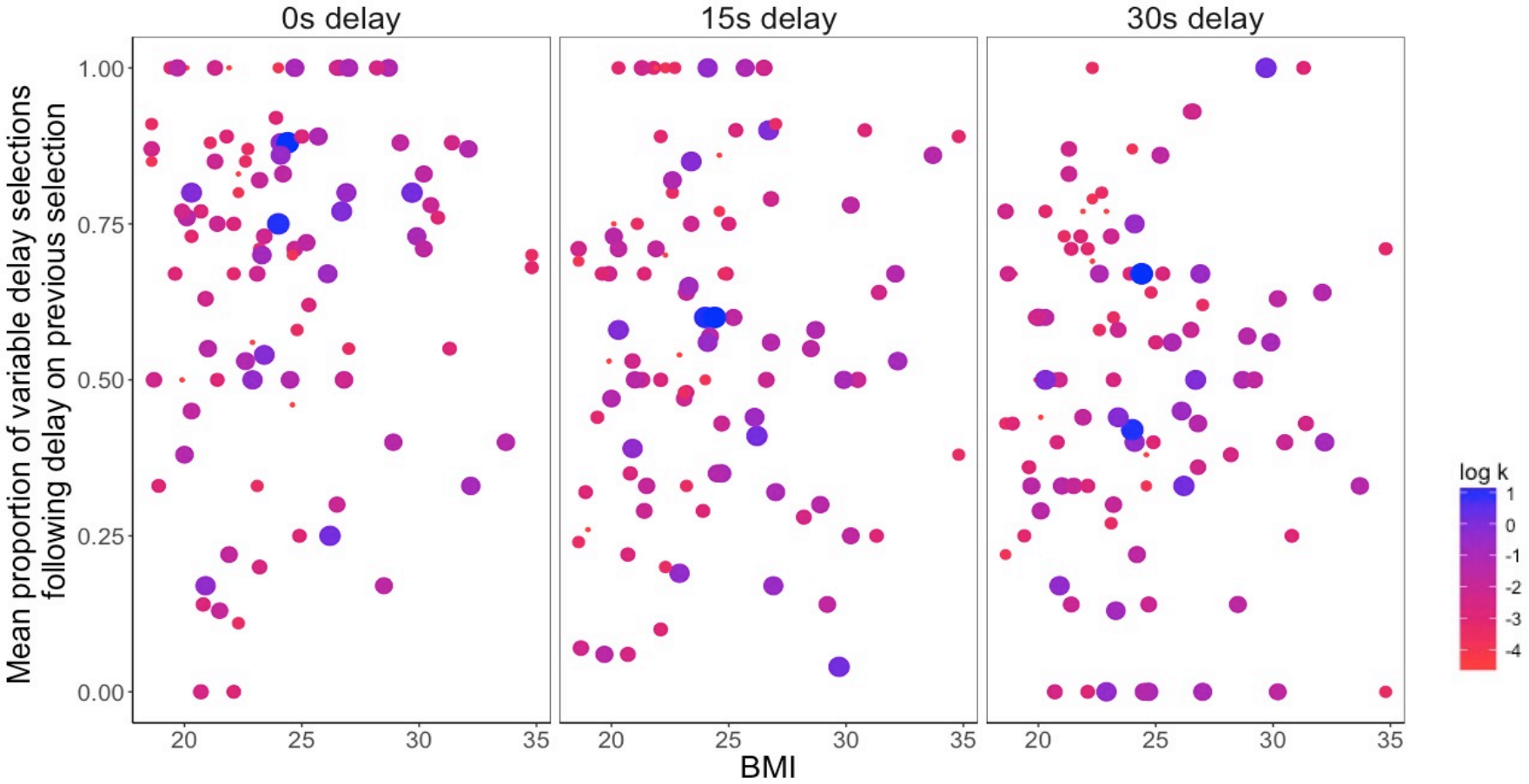


Figure 5.3. Mean proportion of variable delay choices following a) 0s, b) 15s, and c) 30s delays for participants as a function of their discount rate (k value) and BMI. Individuals with a higher k value are portrayed by a larger dot. Participants' k values have been log transformed.

Variable and fixed delay schedules: eating behaviours

Participants' variable delay selections were not affected by their levels of cognitive restraint (β= -0.01±0.01, Z = -1.00; Model 2; Table 5.3). Preference for the variable delay was not affected by cognitive restraint following 0s or 30s delays compared to delays of 15s (0s: β= 0.01±0.01, Z = 1.00; 30s β= -0.00 ± 0.01, Z = -0.00; Model 3, Table 5.3). Similarly, selections of the variable delay schedule were not affected by the discount rates of individuals with high cognitive restraint scores following 0s or 30s delays (0s: β= 0.01±0.01, Z = 1.00; 30s β= 0.00±0.01, Z = 0.00; Model 6, Table 5.3).

Participants were more likely to select the variable delay schedule if they had high emotional eating scores following delays of 0s compared to 15s delays on the previous selection (β= 0.02±0.01, Z = 2.00; Model 3, Table 5.3), but not 30s delays (β= 0.01 ± 0.01, Z = 1.00; Model 3, Table 5.3). Additionally, participants were more likely to select the variable delay schedule following 0s delays if they had high emotional eating scores and high discount rates (k value) in comparison to 15s delays (0s: β= 0.02±0.01, Z = 2.00; Model 6, Table 5.3).

Overall, participants' selections of the variable delay schedule did not differ markedly as a function of their uncontrolled eating overall (β= 0.01±0.01, Z = 1.00; Model 2; Table 5.3). However, individuals were less likely to select the variable delay following delays of 0s on previous selections if they had high uncontrolled eating (0s: β= -0.02±0.01, Z = 2.00; 30s β= -0.00±0.01, Z = -0.00; Model 3, Table 5.3). Further effects between uncontrolled eating, discount rates and delays on previous selections are difficult to interpret, but suggest that individuals were less likely to select the

variable delay schedule following rewards delivered immediately if they had a low discount rate (k value) and either high or low uncontrolled eating scores, compared to mid-range uncontrolled eaters (β= -0.03±0.01, Z = -3.00; Model 6, Table 5.3).

Predictor	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Intercept	-0.05 (0.41)	-0.85 (0.66)	-1.22 (0.71)	-0.83 (0.66)	0.57 (1.48)	-0.34 (0.79)
Side of variable delay option	-0.06 (0.08)	-	-	-	-	-
Colour of variable delay option	-0.06 (0.19)	-	-	-	-	-
Time of day - midday	1.07 (0.32)**	0.95 (0.30)**	0.95 (0.30)**	0.95 (0.30)**	0.96 (0.30)**	0.97 (0.29)**
Time of day – afternoon	0.49 (0.24)*	0.38 (0.23)	0.38 (0.23)	0.38 (0.23)	0.39 (0.23)	0.34 (0.23)
Treat type	0.91 (0.30)**	0.81 (0.28)**	0.81 (0.28)**	0.81 (0.28)**	0.81 (0.28)**	0.76 (0.27)**
Hunger	-0.01 (0.04)	-	-	-	-	-
Treat type * Time of day - midday	-1.72 (0.52)**	-1.59 (0.49)**	-1.57 (0.48)**	-1.58 (0.49)**	-1.59 (0.49)**	-1.46 (0.48)**
Treat type * Time of day – afternoon	-0.52 (0.45)	-0.48 (0.42)	-0.47 (0.41)	-0.48 (0.42)	0.48 (0.42)	-0.33 (0.41)
k	-	-0.14 (0.07)*	-0.14 (0.07)*	-0.14 (0.08)	0.58 (0.55)	0.07 (0.19)
Last delay 0s	-	0.58 (0.10)**	1.47 (0.63)*	0.66 (0.19)**	-2.46 (1.47)**	0.75 (0.58)*
Last delay 30s	-	-0.26 (0.10)**	0.77 (0.67)	-0.40 (0.19)*	-1.25 (1.57)	-0.91 (0.56)
BMI	-	-0.01 (0.03)	0.03 (0.03)	0.01 (0.03)	-0.05 (0.06)	-0.01 (0.03)
TFEQ Cognitive restraint	-	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)	-0.00 (0.01)	0.00 (0.01)
TFEQ Emotional eating		0.00 (0.01)	-0.01 (0.01)	0.00 (0.01)	0.00 (0.01)	-0.01 (0.01)
TFEQ Uncontrolled eating		0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.00 (0.02)
Last delay 0s * BMI	-	-	-0.05 (0.03)	-	0.13 (0.06)*	-
Last delay 30s * BMI	-	-	-0.05 (0.03)	-	0.04 (0.06)	-
Last delay 0s * Restraint	-	-	0.01 (0.01)	-	-	0.02 (0.01)†
Last delay 30s * Restraint	-	-	-0.00 (0.01)	-	-	0.00 (0.01)
Last delay 0s * Emotional Eating	-	-	0.02 (0.01)*	-	-	0.05 (0.01)**
Last delay 30s * Emotional Eating	-	-	0.01 (0.01)	-	-	0.04 (0.01)**

Last delay 0s * Uncontrolled Eating	-	-	-0.02 (0.01)	-	-	-0.08 (0.02)
Last delay 30s * Uncontrolled Eating	-	-	-0.00 (0.01)	-	-	-0.02 (0.02)
Last delay 0s * k	-	-	-	0.03 (0.07)	-1.39 (0.53)**	0.10 (0.20)
Last delay 30s * k	-	-	-	-0.06 (0.07)	-0.76 (0.61)	-0.23 (0.20)
k * BMI	-	-	-	-	-0.03 (0.02)	-
k * Restraint	-	-	-	-	-	-0.00 (0.01)
k * Emo eating	-	-	-	-	-	-0.00 (0.00)
k * Unc eating	-	-	-	-	-	-0.00 (0.01)
k*Last delay 0s*BMI	-	-	-	-	0.06 (0.02)**	-
k*Last delay 30s*BMI	-	-	-	-	0.03 (0.03)	-
k*Last delay 0s*Rest	-	-	-	-	-	0.01 (0.01)
k*Last delay 30s*Rest	-	-	-	-	-	0.00 (0.01)
k*Last delay 0s*Emo	-	-	-	-	-	0.02 (0.01)*
k*Last delay 30s*Emo	-	-	-	-	-	0.01 (0.01)
k*Last delay 0s*Unc	-	-	-	-	-	-0.03 (0.01)**
k*Last delay 30s*Unc	-	-	-	-	-	-0.01 (0.01)
AIC	4314.50	4213.70	4211.30	4216.30	4216.90	4209.50
BIC	4381.90	4305.50	4352.00	4320.30	4351.60	4405.40

Table 5.3. β-coefficients (and standard errors) for 5 multi-level binomial regression models of proportionate choice of variable delays (0s vs 30s) over fixed delays (15s) to delivery of preferred edible treats. Dividing the β-coefficient by the standard error (SE) yields a Z-score. *p< .05; **p <0.01. Akaike information criterion (AIC) and Bayesian information criterion (BIC) provide estimates of model fit.

Choice times between variable and fixed delay schedules: BMI and discounting rates

In contrast to results from Experiments 1 and 2, participants' choice times were not affected by receiving a reward following a delay of 0s or 30s (0s: 2.57±0.16 vs 2.73±0.18, β= -0.12±0.10, t(3344)= -1.20; 30s: 2.55±0.10 vs 2.73±0.18, β= -0.10±0.11, t(3329)= -0.10, Model 2). Similarly, choice times were not influenced by participants′ discount rate (k value) (β= 0.01±0.13, t(91)= 0.08; Model 2); or their discount rate (k value) following 0s or 30s delays (0s: β= 0.03±0.08, t(3329)= 0.38; 30s: β= -0.06±0.08, t(3317)= -0.75; Model 4; see Fig 5.2b); by participants' BMI (β= -0.02±0.05, t(92)= -0.40; Model 2); or by BMI following 0s or 30s delays (0s: β= -0.01±0.03, t(3321)= -0.33; 30s: β= -0.02±0.03, t(3310)= -0.67, Model 3).

Finally, choice times were not affected by receiving immediate or delayed rewards as a function of BMI and discounting rate (k value) (0s: β= -0.02±0.02, t(3324)= -1.00; 30s: β= -0.00±0.03, t(3311)= -0.00; Model 5).

Choice times between variable and fixed delay schedules: eating behaviours

There were no significant relationships between choice time, cognitive restraint, emotional eating, uncontrolled eating, and their associations with delays on previous trials, or discounting rate (k value) (all 0.00±0.00 < βs < 0.01±0.01).

Collection times between variable and fixed delay schedules

As in Experiment 2, participants were faster to collect their treat if they received a reward following a variable delay of 0s or 30s on the previous trial (0s: β= -0.12±0.04, t(3051)= -3.00; 30s: β=- 0.13±0.04, t(3041)= -3.25). Collection times were not affected by overall discounting rate (β= 0.01±0.05, t(88.70)= 0.23; Model 2), or following 0s or 30s delays (0s:

β= 0.03±0.03, t(3040)= 1.00; 30s: β= -0.01±0.03, t(3029)= -0.33, Model 4, Fig 5.2c). Similarly, collection times were not modulated by BMI overall (β= -0.02±0.02, t(89.30)= -1.00; Model 2). However, participants were slower to collect their reward if they had a high BMI following an immediate delay (β= 0.02±0.01, t(3036)= 2.00; Model 3), and after a 30s delay (β= 0.02±0.01, t(3024)= 2.00; Model 3). Finally, collection times were not markedly influenced by BMI and k together following either 0s or 30s delays on the previous trial (0s: β= 0.01±0.01, t(3039)= 1.00; 30s: β= -0.00±0.01, t(3025)= 0.00).

Discussion

To the best of my knowledge, this is the first study that sought to examine whether preferences for variable delay versus fixed delay schedules, with real edible high-value rewards, are linked to individuals′ (trait) temporal discounting rates. I found that individuals' preferences for variable delay schedules over fixed delay schedules, or the speed of selecting between these options, are not strongly associated with high discounting rates. Instead there was only an association with discounting rates specifically in individuals with an increased BMI, and following immediate food rewards (0s) on previous selections. However, these effects were modest and should be interpreted cautiously.

My design used a previously validated adjusting-amount procedure (Myerson et al., 2003) to calculate individuals' k values from a set of indifference points. This measurement took place in the same experimental session, but prior to the completion of the food-scheduling assessment. Therefore, the estimates of participants' k values would have been unaffected by changes in motivational state, such as satiety following consumption of confectionary or savoury snacks. As before, participants provided preference rankings and had selected their preferred treats, confirming that each participant made choices over personally high-value

rewards. The larger sample size of 100 participants, and the less stringent exclusion criteria, compared to Experiment 1, was intended to provide a somewhat wider and more representative estimate of weight compared to the participants in Experiment 1. In fact, participants in Experiment 3 reported BMIs between 18.6-34.8 (M = 24.39±4.00), only marginally higher than in Experiment 1, BMI between 18.5-32 (M = 23.42±3.15). Finally, I cleansed the discounting data of non-systematic responding to ensure I retained only k estimates with more easily interpretable discount functions (Johnson & Bickel, 2008).

Overall, my results show that preferences for variable delay schedules over food rewards do not markedly vary with delay discounting rates (as measured by k or AUCs) per se. However, participants who discounted monetary rewards more rapidly and whose BMIs were high did show marginally increased preference for variable delays following the delivery of immediate rewards on previous selections. This suggests that individuals' discount rates can sustain preferences for variable over fixed delay schedules among individuals with high BMI, perhaps reflecting enhanced sensitivity to quick or rapidly delivered food rewards. Factors associated with vulnerability to weight gain, such as BMI and high k values, may interact to increase the value of short delays (Nederkoorn et al., 2006), strengthening the reinforcing effects of quick food.

These findings are comparable to observations in restrained eaters who show counter-regulation, where individuals consume a greater quantity of food following a preload, than if they had not previously eaten a preload (Herman & Mack, 1975; Polivy, 1996). However, these counter regulation effects appear dependent upon disinhibited eating (Kirschenbaum & Dykman, 1991; van Strien et al., 2000; Westenhoefer et al., 1994), such that only individuals with high restrained eating and high disinhibition showed counter regulation and increased

their consumption of ice cream following a preload compared to individuals with low restrained eating and high disinhibition; high restrained eating and low disinhibition; or low restrained eating and low disinhibition (Westenhoefer et al., 1994).

Here, Experiment 1 showed that choice of the variable delay schedule was increased following immediate rewards but more so in individuals with high BMI. Experiment 3 indicates that these effects may be supported by higher discounting rates; specifically, in heavy compared to lean individuals (with higher compared to lower k values) who discount delayed rewards quickly. The modulation of preference for variable delay schedules by BMI and discounting rates was marginal, and requires replication. In fact, counter-regulation effects following preloads tend to be inconsistent and do not always replicate as a function of self-control and disinhibited eating (Kirschenbaum & Dykman, 1991; Ouwens et al., 2003; van Strien et al., 2000; Westenhoefer et al., 1994; Zhou, Gao, Chen, & Kong, 2017). Ouwens et al. (2003) replicated the findings of van Strien et al. (2000).

Given the only modest associations between preferences for variable over fixed delay schedules and discounting rates as reflected in k, it is worth noting the differences in delay durations in the monetary delay discounting task (Myerson et al., 2003) and those in the food-scheduling task. The delays used in Myerson's discounting assessment range over a period of months and years (Myerson et al., 2003), whereas delays in the food-scheduling task were a matter of seconds. This means that there may be differences in discount rates between delays of durations up to 30s, and delays over periods of months and years. It is possible that delay discounting over these different delays reflect different psychological functions. This is also reflected in a change in preference for variable delays following either a 0s or a 30s delay on the previous selection, whereby, as my results show, individuals select the variable delay

schedule again following rewards that were delivered immediately on the previous selection, but are less likely to select the variable delay schedule again following a 30s delay on the previous selection. However, as seen in these results, selection of the variable delay schedule was not associated with discount rate.

Moreover, Experiment 3 used a monetary discounting task to examine the relationship between discounting rates and food-scheduling preferences; possibly, if I had used a discounting task with hypothetical food rewards, instead of hypothetical monetary rewards, my results may have shown steeper discounting of food rewards compared to monetary rewards, as reported by Rasmussen et al. (2010) and Odum et al. (2006) and a closer association with preferences for the variable delay over the fixed delay schedule. As described in Chapter 4, it was not possible to deliver a food discounting task with real rewards, due to reasons of participant satiety and the adjustment of reward amount during the procedure, making it hard to establish and independent measure of discounting over these short delays.

Notwithstanding its limitations, this study has value by demonstrating a preference for variable rewards and that these preferences are associated with changes in BMI and discounting rates. These findings call for future research to further investigate this relationship, with the aim to design interventions targeting discounting to better manage individuals' food-scheduling decisions that might lead to weight gain and obesity.

Chapter 6: General Discussion

Evolutionary perspectives posit that animals will tolerate risk and uncertainty to access quick food, sometimes under circumstances of great risk (Kacelnik & Bateson, 1996). Possibly these inherited foraging strategies and consumption patterns promote weight gain in today's obesogenic environment (Lieberman, 2006). My research explored whether it might be possible to use individuals' preferences for variable and fixed intervals to investigate people's food-scheduling behaviours and preference for quick food.

Summary of findings

This thesis examined individuals' food-scheduling preferences using selections for variable vs fixed delay schedules to obtain a series of food rewards. My main findings are as follows. First, the delay on the previous selection influenced subsequent choices. All three experiments show that participants were more likely to select the variable delay schedule if they received a reward immediately (0s delay) on the previous selection. This suggests participants highly value quick food rewards and this strengthens preferences for the variable delay schedule. Additionally, participants in Experiments 1 and 3 were less likely to select the variable delay following a long delay of 30s, suggesting long delays to food rewards are less valuable than intermediate delays of 15s. In contrast, exposing participants to an olfactory cue sustained participants' choice of the variable delay following 30s delays. Further, these preferences were not related in a straightforward way to individuals' delay discounting rates. Participants also made faster selections following 0s delays (Experiment 1 and 2), and 30s delays (Experiment 2), and were faster to collect their reward following 0s delays (Experiment 2 and 3) and 30s delays (Experiment 3) compared to 15s delays. Overall, individuals with high BMIs did not show consistent patterns of preferences for the variable delay schedule. In Experiments 1 and 2, participants with high BMIs were more likely to

choose the variable delay schedule when they received an immediate reward on the previous selection. However, in Experiment 3, this effect was observed only in participants who reported high delay discounting rates.

Moving on to the exploratory psychological factors that influence individuals' food-scheduling decisions, cognitive restraint showed, somewhat unreliably, an association with decreased preference for the variable delay schedule. In Experiment 1, individuals with high cognitive restraint were less likely to select the variable delay schedule following 0s delays, however, this result was not replicated in Experiments 2 and 3. In Experiment 1, and in the scent-absent condition of Experiment 2, individuals with higher cognitive restraint were again less likely to select the variable delay schedule following 0s delays, and 30s delays (in Experiment 2 only). Finally, participants' overall preferences for variable delays over fixed delays were not consistently affected by their levels of emotional eating or uncontrolled eating.

Collectively, my findings suggest that individuals have modest but consistent preferences for variable delay schedules over fixed delay schedules and that these preferences are strengthened by the delivery of quick food. However, the associations between food/eating attitudes, that in other contexts are linked to obesity and weight gain, are inconsistent. In one sense, this is not surprising. My samples were tested to select preferences for variable versus fixed delays, their dependence upon previous delays to selection and consumption, their sensitivity to external cues and their relationship to delay discounting. Food attitudes and behaviours will have varied (and been uncontrolled) between experiments. Nonetheless, all three experiments showed that preferences for variable delays versus fixed delays were moderated by the psychological aspects of food and eating. Further work can explore these

associations in samples selected to have high BMI scores or, for example, individuals with histories of unsuccessful dieting, or increased sensitivity to external cues.

Where my research fits into the literature

In this next section, I summarise how my findings relate to previous literature involving foraging theory (Bateson & Kacelnik, 1997; Kacelnik & Bateson, 1996; Marsh & Kacelnik, 2002), eating attitudes (Fedoroff et al., 1997; Herman & Mack, 1975; Jansen & van den Hout, 1991; van Strien et al., 2000) and individual factors such as BMI (Rasmussen et al., 2010) and delay discounting (Odum & Rainaud, 2003).

Foraging theory suggests that animals overvalue receiving quick food to compensate for the risk of starvation or predation (Bateson & Kacelnik, 1997; Kacelnik & Bateson, 1996; Marsh & Kacelnik, 2002). Evolutionary perspectives of obesity posit that these food foraging strategies – involving the consumption of high-energy food at the soonest possible opportunity in circumstances in which food would have been scarce - are incompatible with our current obesogenic environment where food is constantly readily available and easily accessible (Lieberman, 2006; Pinel et al., 2000). It is likely that receiving rewards immediately on the previous selection raises the reward value of variable delay schedules, making it more likely that individuals will select the variable delay schedules subsequently.

Consuming quick food may result in an enhanced increase of its reward value in specific groups of individuals, such as those vulnerable to weight gain, who already have a high BMI. This may increase the tolerance of risk or uncertainty in food-seeking behaviours order to obtain food quickly (since that is of greater value). There is evidence that individuals with higher BMIs have quicker discount rates and especially for food rewards (Rasmussen et al.,

2010). Individuals with quicker discount rates might show a preference for variable over fixed delays due to the combined value of immediate rewards (received after 0s delays) and discounted delayed rewards (received after 30s), compared to the value fixed rewards received after an intermediary delay of 15s (see Chapter 5). Although my results did not show a strong relationship between participants' BMI scores and their discounting rates (as k values), I did find (subtle) evidence that individuals with higher BMIs and higher discounting rates showed preference for the variable delay schedule following 0s delays, in line with my predictions. This possibility needs systematic investigation, perhaps testing associations between discounting rates for food rewards in individuals selected specifically to include individuals with high BMIs, in the obese range.

Furthermore, exposing individuals with a high BMI to an olfactory cue resulted in a reduced preference for the variable delay schedule following immediate and delayed rewards (Experiment 2). This is the opposite to patterns of findings where individuals with high BMIs previously showed increased preference for the variable delay following 0s and 30s delays (Experiment 1). Exposure to the chocolate aroma seemingly reversed preferences for the variable delay schedule in individuals with high BMIs. Possibly, the aroma acted as a conditioned cue to support the ability to tolerate the fixed and intermediate delays of 15s, and that the potential of aromas to do this is enhanced in high BMI individuals.

Individuals with high cognitive restraint often attempt to deliberately control the urge to eat (Fedoroff et al., 1997). Restrained eaters with high disinhibition show a pattern of counter-regulation where they increase their consumption following a preload (Herman & Mack, 1975; Jansen & van den Hout, 1991). My findings suggest that individuals attempt to exert rigorous control over when they choose to eat, seeing more regularity in their food intake.

Results from Experiment 2 showed that individuals with high cognitive restraint showed an increase in preference for the variable delay schedule after receiving immediate rewards. This supports previous research showing that individuals who are restrained in their eating habits can exhibit counter-regulation following exposure to a preload, in this case an olfactory cue. Counter-regulation following exposure to the olfactory cue may act to increase the value of immediate food rewards. This could enhance the likelihood of individuals breaking their restraint over scheduling their food rewards, resulting in increased choice of the variable delay schedule and, in everyday environments, seeking quick foods.

Emotional eating is associated with a lack of patience (van Strien et al., 1985), negative affect and facets of neuroticism (Elfhag & Morey, 2008). Emotional eaters tend to eat to reduce feelings of anxiety and negative affect (Kaplan & Kaplan, 1957) and is linked with weight gain (Ganley, 1989; Patel & Schlundt, 2001). My results overall suggest that individuals who are high in emotional eating tend to show marginal preferences for variable delay schedules (especially in Experiments 1 and 3), possibly reflecting feeling an increased sense of urgency for quick foods that might be heightened by feelings of negative affect. As shown in individuals with high BMIs, this could lead to vulnerability to weight gain, through being unable to regulate food intake through their choices of when to consume food.

Previous research has shown a relationship between exposure to environmental cues and consumption behaviour (Schachter, 1971; Wansink, 2004; Wansink et al., 2006; Wansink et al., 2005). External eaters are more heavily influenced by food cues in the environment and will consume food in the absence of hunger, particularly following exposure to environmental cues, which make food more salient (Burton et al., 2007; Schachter, 1971). In Experiment 2, participants showed an increase in preference for the variable delay schedule if

they received a reward following a 30s delay on the previous trial, if they had been exposed to the chocolate aroma. This shows that exposure to an olfactory cue can sustain preferences for variable delays to food rewards, perhaps in the same way as conditioned stimuli can reduce delay discounting by providing information about when a delayed reward will be delivered (e.g., Winstanley et al., 2003). My results extend findings by showing that an olfactory cue can also influence food-scheduling behaviour in addition to consumption behaviour. These findings, to the best of my knowledge, are the first to demonstrate a relationship between an olfactory environmental cue and food-scheduling behaviours.

Limitations

A number of issues should be taken into account when considering these findings. These relate to the methodology and results of individual experiments, as well as some general issues across this thesis as a whole.

First, I cover the methodological issues relating to Chapter 3. Possibly, the olfactory cue was too subtle. I carried out extensive pilot testing to ascertain the optimum intensity, with the aim that participants could smell something but only identify the aroma as chocolate when given a forced choice. The manipulation check revealed that significantly more individuals reported being able to smell something than not being able to smell anything specifically. Participants' selection of the chocolate scent from the forced choice of chocolate and other aromas suggested that the intensity was strong enough to be distinguishable.

I took great care in scheduling testing sessions that a scent-absent condition would not immediately follow a scent-present condition without necessary time for the aroma to dissipate from the lab. Instead of using a food based aroma, I could have attempted to use a

cue targeting participants' decision-making behaviour relating to variability and intertemporal choice. However, due to the more abstract nature of this concept, this would be more challenging to carry out in a valid manner. Nonetheless, Experiment 2 still demonstrated increased choice of the variable delays following longer delays of 30s, suggesting that exposure to an olfactory cue sustains preferences for variable and longer delays to food rewards.

In Chapter 5 I used a hypothetical monetary discounting task to measure discount rates for the food-scheduling task. Instead of a hypothetical monetary discounting task, I could have used a hypothetical food discounting task, especially since previous studies have reported higher discounting rates for food rewards in high BMI or high percent fat individuals (e.g., Rasmussen et al., 2010). Because I was interested in testing the relationship between food-scheduling behaviours and impulsivity as a general trait (as indicated by discounting rates), I chose to use this specific hypothetical monetary discounting task as it had been previously established as a valid measure of k (Myerson et al., 2003). However, one limitation of this task was the high number of non-systematic responses identified using the method proposed by Johnson and Bickel (2008).

Proceeding from methodological issues to issues relating to the findings, the results in Chapter 3 showed an effect of box position on the screen, where participants were more likely to select the variable delay schedule if it was presented on the right-hand side of the screen compared to the left. This could have been due to the fact the food hopper where the rewards were delivered was situated on participants' right-hand side, so this might indicate a bias towards the right as it would be a shorter distance to the hopper. It is not quite clear why this effect was apparent in Experiment 2 but not in Experiments 1 or 3. In any case though, I

controlled for this side bias in all of the regression models of Experiment 2 so that it is unlikely to account for the substantive findings. The instructions remained the same as in the previous experiment and were delivered in the same manner. This experiment had a similar size sample, overall, to the sample size in previous and successive chapters (70 participants compared to 60 and 100). So, side-biases represent only an occasional and inconsistent confound in my experiments.

In addition, the lack of replication of some of the reported findings involving BMI and eating attitudes and behaviours across experiments is notable. My samples sizes were, in the main, adequate, being a single group of 60 in Experiment 1 and a single group of 100 in Experiment 3. The sample sizes in Experiment 2 were modest (35 participants in each condition). However, the sample in Experiment 2 included males and females, compared to the female only sample in Experiment 1. This increases my confidence in the findings of Experiment 2 by extending the findings of Experiment 1 to show the effect of an environmental olfactory cue on males' and females' food-scheduling preferences.

There is also the possibility that participants' consumption and food-scheduling behaviours were influenced by audience or experimenter effects. Male and female participants may have been adapting their schedule selections in line with impression management tactics, to be regarded in a positive light by the experimenter (Herman, Roth, & Polivy, 2003). Impression management studies demonstrate that individuals will eat less when in the presence of another individual who is not consuming food (Herman et al., 2003), and that males and females will adapt their consumption differently when in the company of others (Kniffin et al., 2015). We do not know whether individuals' food-scheduling behaviours may be influenced when in the presence of others. Early piloting revealed that participants'

consumption during the food-scheduling task was dramatically reduced when I, as the experimenter, was present in the room while they completed the task. The number of rewards consumed during the task increased when participants completed the task while I was not present.

In addition to the number of rewards consumed during the task, it might be reasonable to consider if consuming snacks is a realistic behaviour at specific times of the day. During Experiment 1 (Chapter 2), I carried out testing sessions at 11am and 4pm. Eating patterns vary as a function of circadian rhythms throughout the day, although the previous work has focused upon meals instead of snacks (Asher & Sassone-Corsi, 2015; de Castro, 2004). However, there is plenty of evidence to suggest that snacking is a common behaviour throughout the day (Halkjaer et al., 2009; Howarth et al., 2007; Ma et al., 2003; Wardle, 2007). Therefore, it is plausible that the consumption of sweet and savoury snacks in my experiments aligned with times between meals when individuals consume snacks.

Finally, it is worth considering if the delays of the food-scheduling task can be generalised to a real world, non-laboratory environment. Establishing this procedure in the laboratory allowed me a high degree of control over a number of extraneous factors, such as the effect of irrelevant environmental cues, varying hunger levels, amount of rewards consumed and the amount of time between reward consumption. However, such short delays would not frequently occur in a real world environment. If individuals' food-scheduling decisions can be generalised from the short durations in the lab to the durations between food-scheduling decisions in real life, this research could lead to a number of potential implications for future research into interventions targeting food-scheduling decisions that lead to weight gain and obesity.

Strengths

This research has a number of strengths. Participants, initially, were highly screened to ensure food-scheduling behaviours would not be affected by eating pathologies or mood disturbances. In each experiment, participants chose their most preferred reward from a selection of treats, ensuring each individual's reward was of highest motivational value. Each of my three experiments had a relatively large overall sample size, and a moderate size sample for each group in Experiment 2 (Chapter 3). Extensive work was put into piloting and development of each of the experiments, with a large number of pilot testing sessions carried out to establish the optimum scent intensity (Chapter 3), and attempts at developing a delay discounting task (Chapter 4). These experiments are one of only a few that use real, directly consumable food rewards to measure food-scheduling. This has not been investigated previously in relation to variable versus fixed delay schedules with human subjects. I provide additional perspectives on food-scheduling, showing how environmental cues and impulsivity affect food-scheduling decisions.

Implications

Overall, my thesis suggests individuals value quick food rewards and variable delays that offer the chance of receiving food rewards quickly over fixed duration intermediary delays. These findings contribute to the academic literature on food seeking behaviours. Food-scheduling behaviours have not been previously investigated as a factor underlying obesity in humans using real food rewards. The findings in this thesis are a first with real edibles, and contribute a base for future research to work from. Previous literature has focused on consumption and obesity, however, this thesis explores a new way to understand people's

preferences and tolerance of risks to obtain quick foods, laying the foundation for translational experiments in populations vulnerable to weight gain.

Chapter 3 shows links between exposure to environmental cues and food-scheduling behaviours and could potentially inform practices such as food advertising, using olfactory cues to influence individuals' purchasing behaviours (Moore, 2014; Moore & Konrath, 2015; Spangenberg, Crowley, & Henderson, 1996). Findings from Chapters 4 and 5 might inform future research into delay discounting and food choice, especially a delay discounting task could be designed using directly consumable food rewards to measure individuals' discounting rates for food. Validating the food-scheduling assessment used there in this way may provide a steady-state operant measure of discounting in food choices over (micro)delays. Although research states there is little difference in discounting rates between types of rewards used in discounting tasks (Estle, Green, Myerson, & Holt, 2007), no research has measured discounting rates using real food rewards.

As well as developing understanding of weight gain and obesity, human food-scheduling assessments could be used to help explain various eating pathologies such as BED and other disordered eating behaviours. Decision-making deficits are seen across a range of disordered eating behaviours such as BED (Svaldi, Brand, & Tuschen-Caffier, 2010), anorexia and bulimia (Brogan et al., 2010; Garrido & Subira, 2013), and in overweight and obesity (Brogan, Hevey, O'Callaghan, Yoder, & O'Shea, 2011; Davis, Strachan, & Berkson, 2004). A feature of these psychopathologies is the inability to forgo small rewards in the short term to obtain larger rewards in the long term. Individuals show riskier decision making compared to healthy individuals (Brogan et al., 2011; Brogan et al., 2010). Learning about individuals'

food-scheduling and preferences for variable delays (and immediately available rewards) may relate to various eating pathologies that show a similar pattern, as mentioned above.

This thesis holds value in being the first to explore preferences between variable versus fixed delay schedules with real edible rewards and their tentative association with factors associated with weight gain and obesity. These findings act as a building block for research on human food-scheduling behaviours. If these findings can be generalised outside of the laboratory, in the real world, they could inform pharmacological or behavioural interventions targeting food-scheduling to reduce the value of quick food, which has potential links to overeating, weight gain and obesity; a virtual public health concern involving 35,820 preventable deaths a year in the UK, and saving £2.47 billion to the NHS (Tovey, 2017).

Conclusion

This thesis is the first to investigate food-scheduling behaviours in humans using directly consumable rewards. These experiments are the first to show the role of environmental cues and individuals' discounting rates in food-scheduling behaviours. In an environment where food is constantly readily available, we have inherited maladaptive food foraging strategies that lead to weight gain and obesity (Lieberman, 2006). Investigating individuals' food-scheduling behaviours tells us more about how intertemporal choices for food rewards leads to weight gain and obesity. These findings could inform interventions targeting food-scheduling behaviours as a mechanism for preventing weight gain and obesity, in an effort to help lessen the effect of the global obesity crisis.

Appendix A1 – Informed Consent Form

School of psychology, Bangor University

Informed Consent Form

Developing an experimental model of snacking behaviour

Name and positions of principal investigators:

L-J Stokes, PhD student

Robert D Rogers, Professor of Cognitive Neuroscience

This is to certify that I, ……..……..…., hereby agree to participate as a volunteer in the above research investigation within the School of Psychology at Bangor University.

The investigation and my part in the investigation have been fully explained to me by one of the investigators listed above and I understand what I am expected to do. The procedures of this investigation and their risks have been answered to my satisfaction.

I understand that all data will be stored, analysed and published in a completely confidential manner with regard to my identity, and that I am free to withdraw my consent and terminate my participation at any time without penalty.

I understand that I will receive information about the aims of the research project at the end of the experiment, that my questions will be answered and that I may request a summary of the results of this study. I know of no medical condition which may cause adverse effects to me if I participate in this experiment.

Signed _____

Date _____

I, the undersigned, have fully explained the investigation to the above individual.

Signature of Investigator _____
Date _____

Any complaints concerning the conduct of this research should be addressed to Mr. Hefin Francis, School Manager, School of Psychology, Adeilad Brigantia, Penrallt Road, Gwynedd, LL57 2AS.

School of psychology, Bangor University

Informed Consent Form

An experimental investigation of food choices at different times of the day

Name and positions of principal investigators:

L-J Stokes, PhD student

Robert D Rogers, Professor of Cognitive Neuroscience

This is to certify that I, ……..……..…., hereby agree to participate as a volunteer in the above research investigation within the School of Psychology at Bangor University.

The investigation and my part in the investigation have been fully explained to me by one of the investigators listed above and I understand what I am expected to do. The procedures of this investigation and their risks have been answered to my satisfaction.

I understand that all data will be stored, analysed and published in a completely confidential manner with regard to my identity, and that I am free to withdraw my consent and terminate my participation at any time without penalty.

I understand that I will receive information about the aims of the research project at the end of the experiment, that my questions will be answered and that I may request a summary of the results of this study. I know of no medical condition which may cause adverse effects to me if I participate in this experiment.

Signed _____

Date _____

I, the undersigned, have fully explained the investigation to the above individual.

Signature of Investigator _____
Date _____

Any complaints concerning the conduct of this research should be addressed to Mr. Hefin Francis, School Manager, School of Psychology, Adeilad Brigantia, Penrallt Road, Gwynedd, LL57 2AS.

School of psychology, Bangor University

Informed Consent Form

Validating an experimental model of snacking behaviour

Name and positions of principal investigators:

L-J Stokes, PhD student

Robert D Rogers, Professor of Cognitive Neuroscience

This is to certify that I, ……..……..…., hereby agree to participate as a volunteer in the above research investigation within the School of Psychology at Bangor University.

The investigation and my part in the investigation have been fully explained to me by one of the investigators listed above and I understand what I am expected to do. The procedures of this investigation and their risks have been answered to my satisfaction.

I understand that all data will be stored, analysed and published in a completely confidential manner with regard to my identity, and that I am free to withdraw my consent and terminate my participation at any time without penalty.

I understand that I will receive information about the aims of the research project at the end of the experiment, that my questions will be answered and that I may request a summary of the results of this study. I know of no medical condition which may cause adverse effects to me if I participate in this experiment.

Signed _____

Date _____

I, the undersigned, have fully explained the investigation to the above individual.

Signature of Investigator _____
Date _____

Any complaints concerning the conduct of this research should be addressed to Mr. Hefin Francis, School Manager, School of Psychology, Adeilad Brigantia, Penrallt Road, Gwynedd, LL57 2AS.

Appendix A2 – Participant Information Sheet

7th January, 2014

INFORMATION FOR STUDENT VOLUNTEERS

Developing an experimental model of snacking behaviour

You are invited to take part in a research study. Before you decide about whether to participate, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and, if you wish, discuss it with friends and relatives. Ask us if there is anything that is unclear or if you would like more information.

What is the purpose of the study?

In this study, we wish to investigate peoples' decisions to consume snacks. This research can help us understand how and why some people develop problems with their eating, possibly offering new ways to help about affected individuals.

What is involved in the study?

The study will take place at the School of Psychology in the Brigantia Building on College Road. Taking part involves 1 study visit of about 60 minutes. On the morning of the study, we will ask you to breakfast normally and then to avoid any further food or caffeinated drinks before coming to the School for 11am. First, we will ask you to complete some questionnaires about your eating, your personality and your recent mood. We will also take some measurements of your height and weight. Then, we will ask you to complete a simple task in which you can make simple responses to visual displays to obtain tasty snacks. At the end of the study visit, you will receive 2 course credits and £4 printer credits.

Why have I been asked to take part?

We are looking to recruit a general sample of both students and people from the local community to help us with us with our research on eating behaviours.

Are there any benefits or risks?

There are no direct benefits or risks for you in taking part. However, you will not be allowed to take part if you have certain food allergies or intolerances, or if we think you may have concerns about eating, weight or mood. In the longer-term, information

gathered from studies like this may improve our understanding of dieting, obesity and eating problems and behaviours.

What will happen to my data?

The researcher will be using the results of this research to write her post-graduate PhD thesis. This and any other publications will not identify you individually. All data collected will be confidential. The data will be stored securely for 5 years. If you choose to withdraw from the study and your data is identifiable to the research team, you have the right to request that your data is not used.

What if I don't want to take part?

It is up to you to decide whether or not you would like to participate in this study. Deciding not to take part will not impact any other aspect of your studies or your relationship with the university.

Who do I contact with any concerns about this study?

The study has been approved by Bangor University Research Ethics Committee (Study No: 11124). If you have any concerns or complaints about this study or the conduct of individuals conducting this study, then please contact Mr Hefin Francis, School Manager, School of Psychology, Bangor University, Bangor Gwynedd LL57 2AS or e-mail h.francis@bangor.ac.uk

Who do I contact about the study?

The team members are listed below and are based at the School of Psychology, Bangor University.

L-J Stokes

School of Psychology

Brigantia Building

Bangor University

LL57 2AS, UK

Tel: (01248) 382625

E-mail: psub6b@bangor.ac.uk

Professor Robert D Rogers

School of Psychology

Brigantia Building

Bangor University

LL57 2AS, UK

Tel: (01248) 382095

E-mail: r.rogers@bangor.ac.uk

13th October, 2015

INFORMATION FOR PSYCHOLOGY STUDENT VOLUNTEERS

An experimental investigation of food choices at different times of the day

You are invited to take part in a research study. Before you decide about whether to participate, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and, if you wish, discuss it with friends and relatives. Ask us if there is anything that is unclear or if you would like more information.

What is the purpose of the study?

In this study, we wish to investigate how the time of day affects peoples' decisions to consume snacks. This research can help us understand peoples' eating patterns and why some people develop problems with their eating, possibly offering new ways to help about affected individuals.

What is involved in the study?

The study will take place at the School of Psychology in the Brigantia Building on College Road. Taking part involves 1 study visit, which will last no longer than 90 minutes. You can choose a time that is most convenient for you.

Unfortunately you will not be able to take part if your BMI is below 19 or above 40, or if you have any food allergies that make it not possible for you to eat the foods in our experiment.

We will ask you to complete some questionnaires about your eating, personality and mood, and take some measurements of your height, weight and waist. Then, we will ask you to complete a simple task in which you can make 'touch' responses to visual displays to obtain tasty chocolate treats.

You will receive 2 course credits and £4 printer credits.

Why have I been asked to take part?

We are looking to recruit a general sample of both students and members of university staff to help us with us with our research on eating behaviours.

Are there any benefits or risks?

There are no direct benefits or risks in taking part. However, you will not be allowed to take part if you have food allergies or intolerances. Information from studies like this may improve our understanding of obesity and eating problems.

What will happen to my data?

The researcher will be using the results of this research to write her post-graduate PhD thesis. This and any other publications will not identify you individually. All data collected will be confidential. The data will be stored securely for 5 years. If you choose to withdraw from the study and your data is identifiable to the research team, you have the right to request that your data is not used.

What if I don't want to take part?

It is up to you to decide whether or not you would like to participate in this study. Deciding not to take part will not impact any other aspect of your studies or your relationship with the university.

Who do I contact with any concerns about this study?

The study has been approved by Bangor University Research Ethics Committee (Study No: 2015-15482). If you have any concerns or complaints about this study or the conduct of individuals conducting this study, then please contact Mr Hefin Francis, School Manager, School of Psychology, Bangor University, Bangor Gwynedd LL57 2AS or e-mail h.francis@bangor.ac.uk

Who do I contact about the study?

The team members are listed below and are based at the School of Psychology, Bangor University.

L-J Stokes
School of Psychology
Brigantia Building
Bangor University
LL57 2AS, UK

Tel: (01248) 383657
E-mail: psub6b@bangor.ac.uk

Professor Robert D Rogers
School of Psychology
Brigantia Building
Bangor University
LL57 2AS, UK

Tel: (01248) 382095
E-mail: r.rogers@bangor.ac.uk

20th September, 2016

INFORMATION FOR STUDENT VOLUNTEERS

Validating an experimental model of snacking behaviour

You are invited to take part in a research study. Before you decide about whether to participate, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and, if you wish, discuss it with friends and relatives. Ask us if there is anything that is unclear or if you would like more information.

What is the purpose of the study?

In this study, we wish to investigate peoples' decisions to consume snacks. This research can help us understand how and why some people develop problems with their eating, possibly offering new ways to help about affected individuals.

What is involved in the study?

The study will take place at the School of Psychology in the Brigantia Building on College Road. Taking part involves completing an online questionnaire in your own time, followed by a visit to the lab for the experimental session, which will last around 90 minutes.

On the visit to the lab, we will ask you to complete some simple questionnaires about your eating, personality and mood, and take some measurements of your height, weight and waist. Then we will ask you to complete a simple task in which you can make 'touch' responses to visual displays to obtain tasty snacks.

You will receive 3 course credits.

Why have I been asked to take part?

We are looking to recruit a general sample of students to help us with us with our research on eating behaviours.

Are there any benefits or risks?

There are no direct benefits or risks for you in taking part. However, information gathered from studies like this may improve our understanding of obesity and eating problems.

What will happen to my data?

The researcher will be using the results of this research to write her post-graduate PhD thesis. This and any other publications will not identify you individually. All data collected will be confidential. The data will be stored securely for 5 years. If you choose to withdraw from the study and your data is identifiable to the research team, you have the right to request that your data is not used.

What if I don't want to take part?

It is up to you to decide whether or not you would like to participate in this study. Deciding not to take part will not impact any other aspect of your studies or your relationship with the university.

Who do I contact with any concerns about this study?

The study has been approved by Bangor University Research Ethics Committee (Study No: 2015-15249). If you have any concerns or complaints about this study or the conduct of individuals conducting this study, then please contact Mr Hefin Francis, School Manager, School of Psychology, Bangor University, Bangor Gwynedd LL57 2AS or e-mail h.francis@bangor.ac.uk

Who do I contact about the study?

The team members are listed below and are based at the School of Psychology, Bangor University.

L-J Stokes
School of Psychology
Brigantia Building
Bangor University
LL57 2AS, UK

Tel: (01248) 383657
E-mail: psub6b@bangor.ac.uk

Professor Robert D Rogers
School of Psychology
Brigantia Building
Bangor University
LL57 2AS, UK

Tel: (01248) 382095
E-mail: r.rogers@bangor.ac.uk

Appendix B – Beck Depression Inventory

BDI – II

Instructions: This questionnaire consists of 21 groups of statements. Please read each group of statements carefully, and then pick out the **one statement** in each group that best describes the way you have been feeling during the **past two weeks, including today**. Circle the number beside the statement you have picked. If several statements in the group seem to apply equally well, circle the highest number for that group. Be sure that you do not choose more than one statement for any group, including Item 16 (Changes in Sleeping Pattern) or Item 18 (Changes in Appetite).

1. Sadness
   - 0 I do not feel sad.
   - 1 I feel sad much of the time.
   - 2 I am sad all the time.
   - 3 I am so sad or unhappy that I can't stand it.

2. Pessimism
   - 0 I am not discouraged about my future.
   - 1 I feel more discouraged about my future than I used to be.
   - 2 I do not expect things to work out for me.
   - 3 I feel my future is hopeless and will only get worse.

3. Past Failure
   - 0 I do not feel like a failure.
   - 1 I have failed more than I should have.
   - 2 As I look back, I see a lot of failures.
   - 3 I feel I am a total failure as a person.

4. Loss of Pleasure
   - 0 I get as much pleasure as I ever did from the things I enjoy.
   - 1 I don't enjoy things as much as I used to.
   - 2 I get very little pleasure from the things I used to enjoy.
   - 3 I can't get any pleasure from the things I used to enjoy.

5. Guilty Feelings
   - 0 I don't feel particularly guilty.
   - 1 I feel guilty over many things I have done or should have done.
   - 2 I feel quite guilty most of the time.
   - 3 I feel guilty all of the time.

6. Punishment Feelings
    - 0 I don't feel I am being punished.
    - 1 I feel I may be punished.
    - 2 I expect to be punished.
    - 3 I feel I am being punished.

7. Self-Dislike
    - 0 I feel the same about myself as ever.
    - 1 I have lost confidence in myself.
    - 2 I am disappointed in myself.
    - 3 I dislike myself.

8. Self-Criticalness
    - 0 I don't criticise or blame myself more than usual.
    - 1 I am more critical of myself than I used to be.
    - 2 I criticise myself for all of my faults.
    - 3 I blame myself for everything bad that happens.

9. Suicidal Thoughts or Wishes
    - 0 I don't have any thoughts of killing myself.
    - 1 I have thoughts of killing myself, but I would not carry them out.
    - 2 I would like to kill myself.
    - 3 I would kill myself if I had the chance.

10. Crying
    - 0 I don't cry any more than I used to.
    - 1 I cry more than I used to.
    - 2 I cry over every little thing.
    - 3 I feel like crying, but I can't.

11. Agitation
    - 0 I am no more restless or wound up than usual.
    - 1 I feel more restless or wound up than usual.
    - 2 I am so restless or agitated that it's hard to stay still.
    - 3 I am so restless or agitated that I have to keep moving or doing something.

12. Loss of Interest
    - 0 I have not lost interest in other people or activities.
    - 1 I am less interested in other people or things than before.
    - 2 I have lost most of my interest in other people or things.
    - 3 It's hard to get interested in anything.

13. Indecisiveness
    - 0 I make decisions about as well as ever.
    - 1 I find it more difficult to make decisions than usual.
    - 2 I have much greater difficulty in making decisions than I used to.
    - 3 I have trouble making any decisions.

14. Worthlessness
    - 0 I do not feel I am worthless.
    - 1 I don't consider myself as worthwhile and useful as I used to.
    - 2 I feel more worthless as compared to other people.
    - 3 I feel utterly worthless.

15. Loss of Energy
    - 0 I have as much energy as ever.
    - 1 I have less energy than I used to have.
    - 2 I don't have enough energy to do very much.
    - 3 I don't have enough energy to do anything.

16. Changes in Sleeping Pattern
    - 0 I have not experienced any change in my sleeping pattern.
    - 1a I sleep somewhat more than usual.
    - 1b I sleep somewhat less than usual.
    - 2a I sleep a lot more than usual.
    - 2b I sleep a lot less than usual.
    - 3a I sleep most of the day.
    - 3b I wake up 1-2 hours early and can't get back to sleep.

17. Irritability
    - 0 I am no more irritable than usual.
    - 1 I am more irritable than usual.
    - 2 I am much more irritable than usual.
    - 3 I am irritable all the time.

18. Changes in Appetite
    - 0 I have not experienced any change in my appetite.
    - 1a My appetite is somewhat less than usual.
    - 1b My appetite is somewhat greater than usual.
    - 2a My appetite is much less than before.
    - 2b My appetite is much greater than usual.
    - 3a I have no appetite at all.
    - 3b I crave food all the time.

19. Concentration Difficulty
    0 I can concentrate as well as ever.
    1 I can't concentrate as well as usual.
    2 It's hard to keep my mind on anything for very long.
    3 I find I can't concentrate on anything.

20. Tiredness or Fatigue
    0 I am no more tired or fatigued than usual.
    1 I get more tired or fatigued more easily than usual.
    2 I am too tired or fatigued to do a lot of the things I used to do.
    3 I am too tired or fatigued to do most of the things I used to do.

21. Loss of Interest in Sex
    0 I have not noticed any recent change in my interest in sex.
    1 I am less interested in sex than I used to be.
    2 I am much less interested in sex now.
    3 I have lost interest in sex completely.

Appendix C – Eating Disorder Examination Questionnaire

EATING QUESTIONNAIRE

Instructions: The following questions are concerned with the past four weeks (28 days) only. Please read each question carefully. Please answer all the questions. Thank you. Questions 1 to 12: Please circle the appropriate number on the right. Remember that the questions only refer to the past four weeks (28 days) only.

On how many of the past 28 days…	No days	1-5 days	6-12 days	13-15 days	16-22 days	23-27 days	Every day
1. Have you been deliberately trying to limit the amount of food you eat to influence your shape or weight (whether or not you have succeeded)?	0	1	2	3	4	5	6
2. Have you gone for long periods of time (8 waking hours or more) without eating anything at all in order to influence your shape or weight?	0	1	2	3	4	5	6
3. Have you tried to exclude from your diet any foods that you like in order to influence your shape or weight (whether or not you have succeeded)?	0	1	2	3	4	5	6
4. Have you tried to follow definite rules regarding your eating (for example, a calorie limit) in order to influence your shape or weight (whether or not you have succeeded)?	0	1	2	3	4	5	6
5. Have you had a definite desire to have an empty stomach with the aim of influencing your shape or weight?	0	1	2	3	4	5	6
6. Have you had a definite desire to have a totally flat stomach?	0	1	2	3	4	5	6
7. Has thinking about food, eating or calories made it very difficult to concentrate on things you are interested in (for example, working, following a conversation, or reading)?	0	1	2	3	4	5	6
8. Has thinking about shape or weight made it very difficult to concentrate on things you are interested in (for example, working, following a conversation, or reading)?	0	1	2	3	4	5	6
9. Have you had a definite fear of losing control over eating?	0	1	2	3	4	5	6
10. Have you had a definite fear that you might gain weight?	0	1	2	3	4	5	6
11. Have you felt fat?	0	1	2	3	4	5	6

12. Have you had a strong desire to lose weight?	0	1	2	3	4	5	6

Questions 13-18: please fill in the appropriate number in the boxes on the right. Remember that the questions only refer to the past four weeks (28 days).

Over the past four weeks (28 days) ……

13. Over the past 28 days, how many <u>times</u> have you eaten what other people would regard as an <u>unusually large amount of food</u> (given the circumstances)?	.....
14. … On how many of these times did you have a sense of having lost control over your eating (at the time that you were eating)?	.....
15. Over the past 28 days, on how many **<u>DAYS</u>** have such episodes of overeating occurred (i.e., you have eating an unusually large amount of food <u>and</u> have had a sense of loss of control at the time)?	.....
16. Over the past 28 days, how many <u>times</u> have you made yourself sick (vomit) as a means of controlling your shape or weight?	.....
17. Over the past 28 days, how many <u>times</u> have you taken laxatives as a means of controlling your shape or weight?	.....
18. Over the past 28 days, how many <u>times</u> have you exercised in a "driven" or "compulsive" way as a means of controlling your weight, shape or amount of fat, or to burn off calories?	.....

Questions 19 to 21: please circle the appropriate number. <u>Please note that for these questions the term "binge eating" means</u> eating what others would regard as an usually large amount of food for the circumstances, accompanied by a sense of having lost control over eating.

19. Over the past 28 days, on how many days have you eaten in secret (ie, furtively)?	No days	1-5 days	6-12 days	13-15 days	16-22 days	23-27 days	Every day
….. Do not count episodes of binge eating	0	1	2	3	4	5	6
20. On what proportion of the times that you have eaten have you felt guilty (felt that you've done wrong) because of its effect on your shape or weight?	None of the times	A few of the times	Less than half	Half of the times	More than half	Most of the time	Every time
….. Do not count episodes of binge eating	0	1	2	3	4	5	6
21. Over the past 28 days, how concerned have you been about other people seeing you eat?	Not at all		Slightly		Moderately		Markedly
….. Do not count episodes of binge eating	0	1	2	3	4	5	6

Questions 22 to 28: Please circle the appropriate number on the right. Please remember that the questions only refer to the past four weeks (28 days).

Over the past 28 days …..	**Not at all**		**Slightly**	**Moderate-ly**		**Markedly**	
22. Has your weight influenced how you think about (judge) yourself as a person?	0	1	2	3	4	5	6
23. Has your shape influenced how you think about (judge) yourself as a person?	0	1	2	3	4	5	6
24. How much would it have upset you if you had been asked to weigh yourself once a week (no more, or less, often) for the next four weeks?	0	1	2	3	4	5	6
25. How dissatisfied have you been with your weight?	0	1	2	3	4	5	6
26. How dissatisfied have you been with your shape?	0	1	2	3	4	5	6
27. How uncomfortable have you felt seeing your body (for example, seeing your shape in the mirror, in a shop window reflection, while undressing or taking a bath or shower)?	0	1	2	3	4	5	6
28. How uncomfortable have you felt about others seeing your shape or figure (for example, in communal changing rooms, when swimming or wearing tight clothes)?	0	1	2	3	4	5	6

What is your weight at present? (Please give your best estimate.) …….

What is your height? (Please give your best estimate.) …….

If female: Over the past three-to-four months have you missed any menstrual periods?

…….

If so, how many? …….

Have you been taking the "pill"? …….

THANK YOU

Appendix D – PANAS

PANAS

This scale consists of a number of words that describe different feelings and emotions. Read each item and then list the number from the scale below next to each word. Indicate to what extent you feel this way right now, that is, *at the present moment*

Please answer on a scale of 1 – 5 where:

1	2	3	4	5
Very Slightly or Not at All	A Little	Moderately	Quite a Bit	Extremely

1. Interested	1	2	3	4	5
2. Distressed	1	2	3	4	5
3. Excited	1	2	3	4	5
4. Upset	1	2	3	4	5
5. Strong	1	2	3	4	5
6. Guilty	1	2	3	4	5
7. Scared	1	2	3	4	5
8. Hostile	1	2	3	4	5
9. Enthusiastic	1	2	3	4	5
10. Proud	1	2	3	4	5
11. Irritable	1	2	3	4	5
12. Alert	1	2	3	4	5
13. Ashamed	1	2	3	4	5
14. Inspired	1	2	3	4	5
15. Nervous	1	2	3	4	5
16. Determined	1	2	3	4	5
17. Attentive	1	2	3	4	5
18. Jittery	1	2	3	4	5
19. Active	1	2	3	4	5
20. Afraid	1	2	3	4	5

Appendix E – Three Factor Eating Questionnaire – Revised

1. When I smell a sizzling steak or juicy piece of meat, I find it very difficult to keep from eating, even if I have just finished a meal.

Definitely true / mostly true / mostly false / definitely false

2. I deliberately take small helpings as a means of controlling my weight.

Definitely true / mostly true / mostly false / definitely false

3. When I feel anxious, I find myself eating.

Definitely true / mostly true / mostly false / definitely false

4. Sometimes when I start eating, I just can't seem to stop.

Definitely true / mostly true / mostly false / definitely false

5. Being with someone who is eating often makes me hungry enough to eat also.

Definitely true / mostly true / mostly false / definitely false

6. When I feel blue, I often overeat.

Definitely true / mostly true / mostly false / definitely false

7. When I see a real delicacy, I often get so hungry that I have to eat right away.

Definitely true / mostly true / mostly false / definitely false

8. I get so hungry that my stomach often seems like a bottomless pit.

Definitely true / mostly true / mostly false / definitely false

9. I am always hungry so it is hard for me to stop eating before I finish the food on my plate.

Definitely true / mostly true / mostly false / definitely false

10. When I feel lonely, I console myself by eating.

Definitely true / mostly true / mostly false / definitely false

11. I consciously hold back at meals in order not to weight gain.

Definitely true / mostly true / mostly false / definitely false

12. I do not eat some foods because they make me fat.

Definitely true / mostly true / mostly false / definitely false

13. I am always hungry enough to eat at any time.

Definitely true / mostly true / mostly false / definitely false

14. How often do you feel hungry?

Only at meal times / sometimes between meals / often between meals / almost always

15. How frequently do you avoid "stocking up" on tempting foods?

Almost never / seldom / usually / almost always

16. How likely are you to consciously eat less than you want?

Unlikely / slightly likely / moderately likely / very likely

17. Do you go on eating binges though you are not hungry?

Never / rarely / sometimes / at least once a week

18. On a scale of 1 to 8, where 1 means no restraint in eating (eating whatever you want, whenever you want it) and 8 means total restraint (constantly limiting food intake and never "giving in"), what number would you give yourself?

Appendix F – Barratt Impulsiveness Scale

BIS - 11

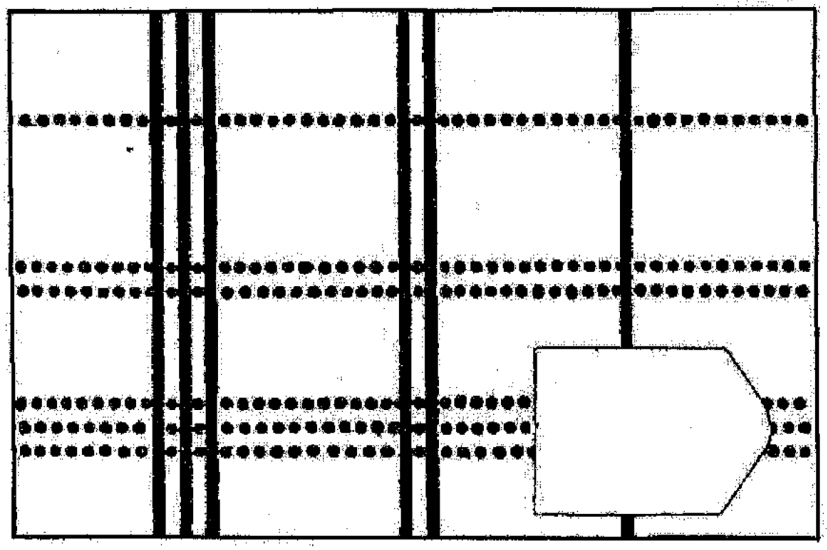
Please answer on a scale of 1 – 4 where:

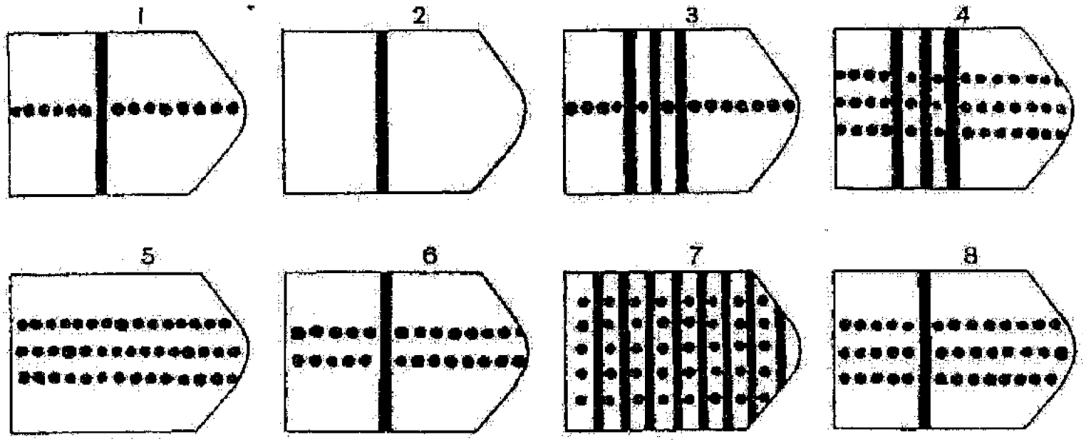
1	2	3	4
Rarely / Never	Occasionally	Often	Almost always / Always

1.	I plan tasks carefully	1	2	3	4
2.	I do things without thinking	1	2	3	4
3.	I make-up my mind quickly	1	2	3	4
4.	I am happy-go-lucky	1	2	3	4
5.	I don't pay attention	1	2	3	4
6.	I have "racing" thoughts	1	2	3	4
7.	I plan trips well ahead of time	1	2	3	4
8.	I am self-controlled	1	2	3	4
9.	I concentrate easily	1	2	3	4
10.	I save regularly	1	2	3	4
11.	I "squirm" at plays or lectures	1	2	3	4
12.	I am a careful thinker	1	2	3	4
13.	I plan for job security	1	2	3	4
14.	I say things without thinking	1	2	3	4
15.	I like to think about complex problems	1	2	3	4
16.	I change jobs	1	2	3	4
17.	I act "on impulse"	1	2	3	4
18.	I get bored when solving thoughts problems	1	2	3	4
19.	I act on the spur of the moment	1	2	3	4
20.	I am a steady thinker	1	2	3	4
21.	I change residences	1	2	3	4
22.	I buy things on impulse	1	2	3	4
23.	I can only think about one problem at a time	1	2	3	4
24.	I change hobbies	1	2	3	4
25.	I spend or charge more than I earn	1	2	3	4
26.	I often have extraneous thoughts when thinking	1	2	3	4
27.	I am more interested in the present than the future	1	2	3	4
28.	I am restless at the theatre or lectures	1	2	3	4
29.	I like puzzles	1	2	3	4
30.	I am future oriented	1	2	3	4

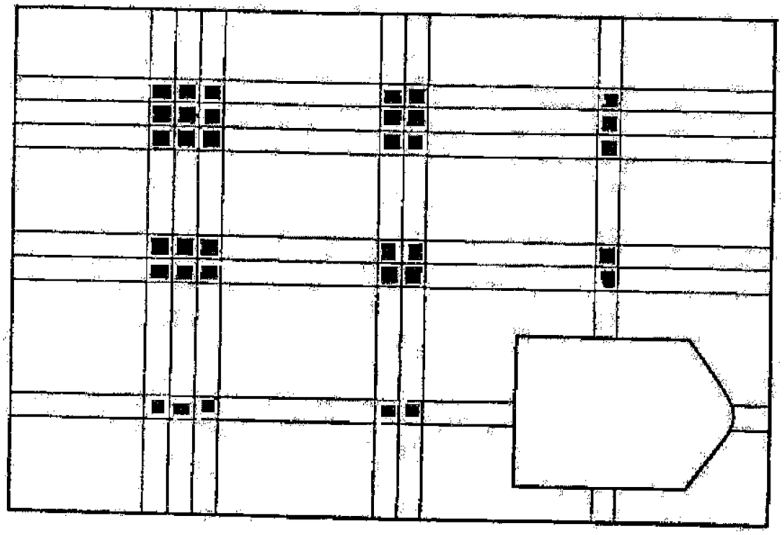
Appendix G – Ravens Matrices Short Form

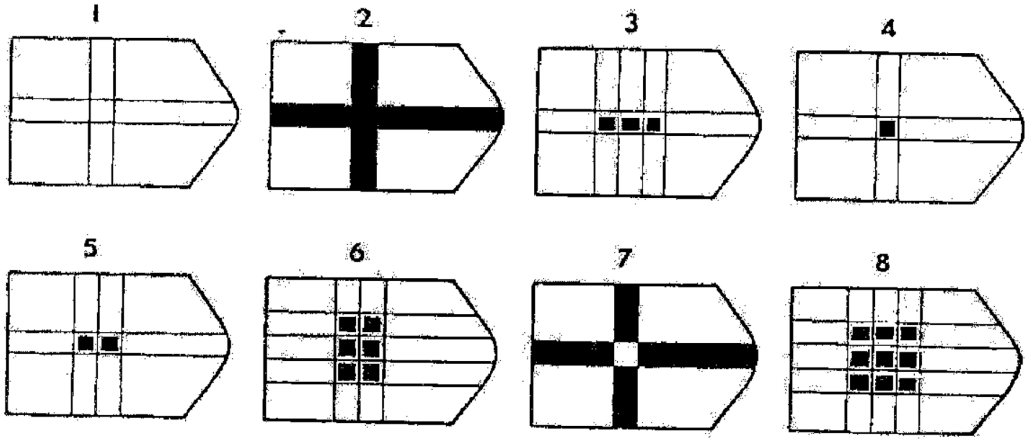
1



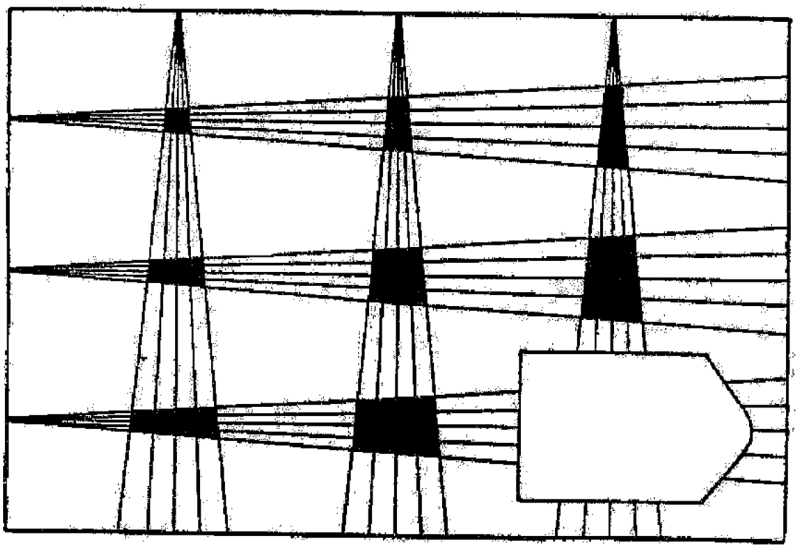


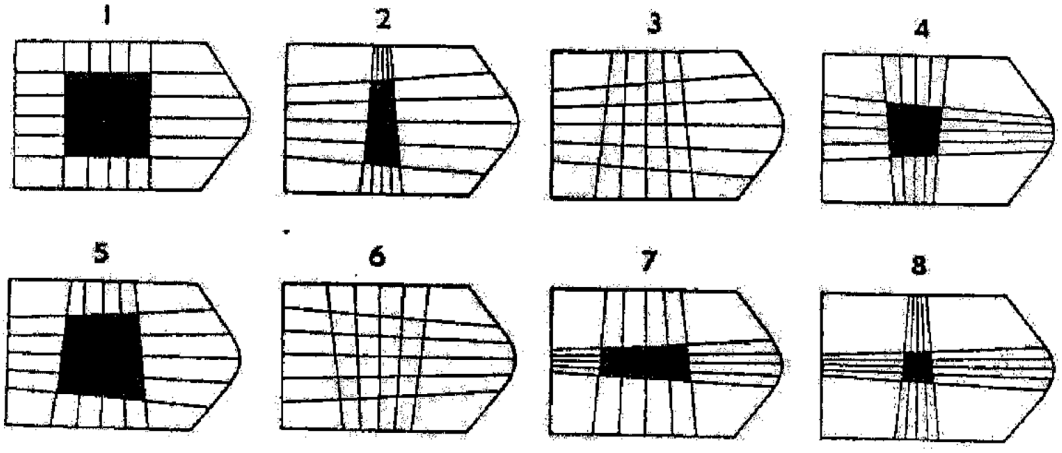
2



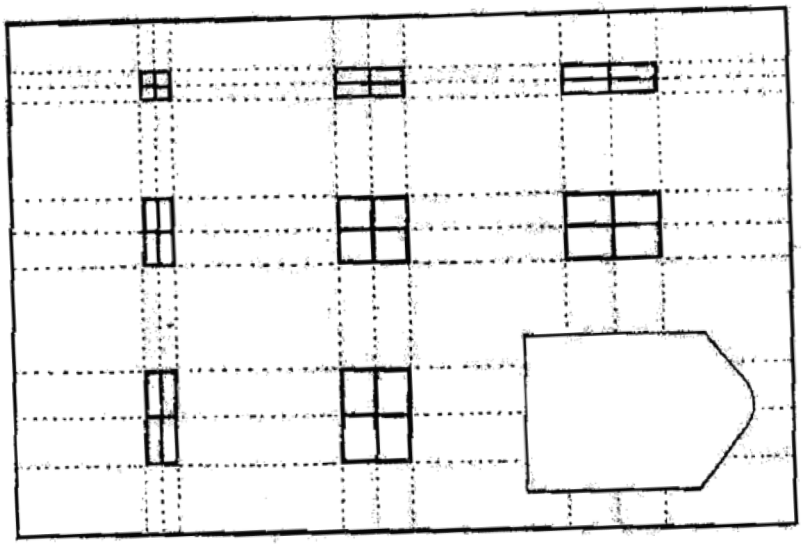


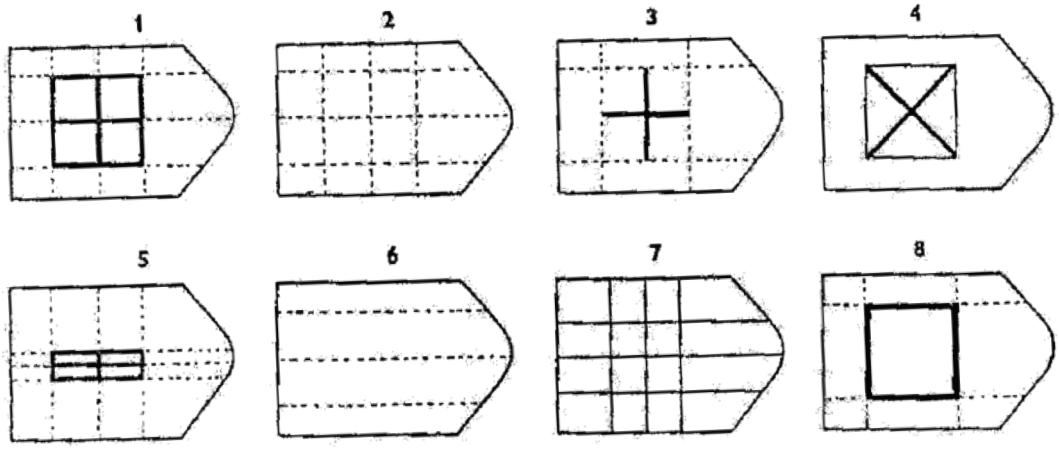
3



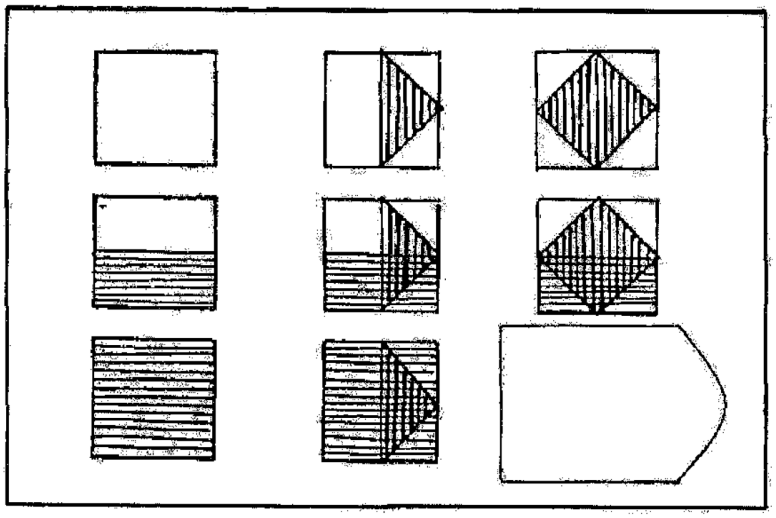


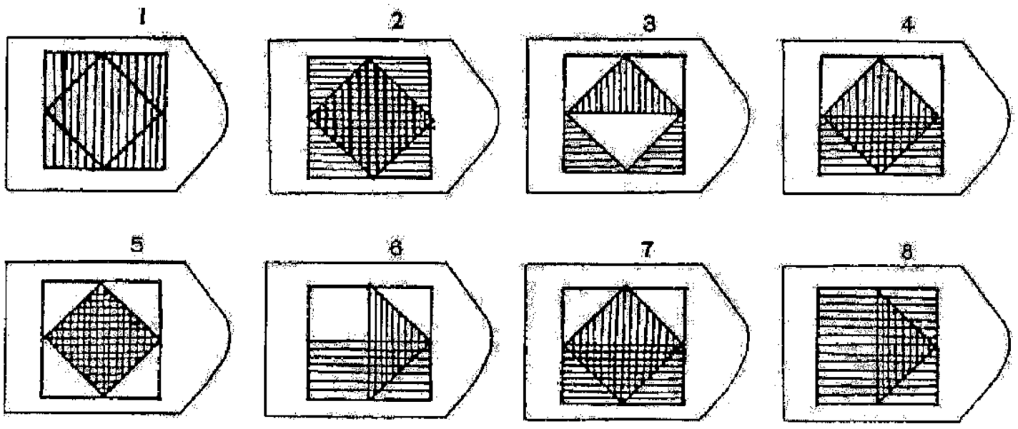
4



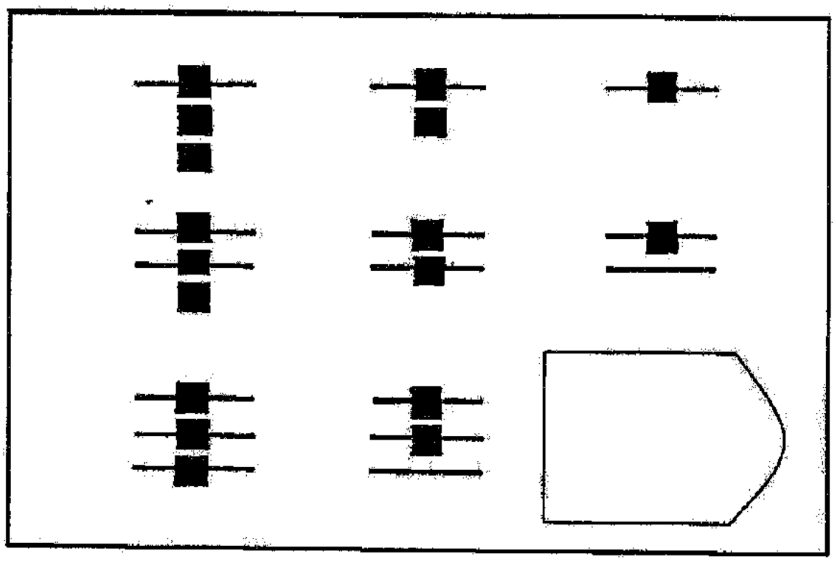


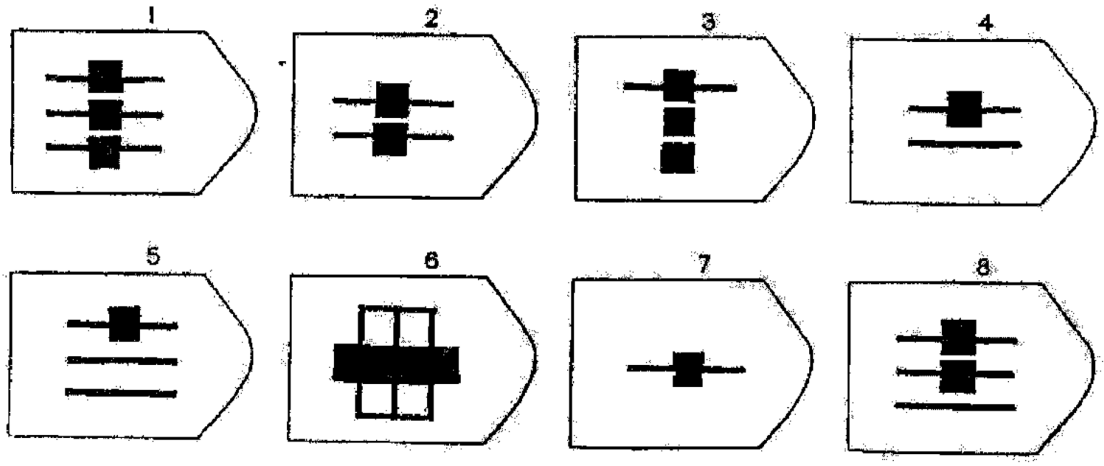
5



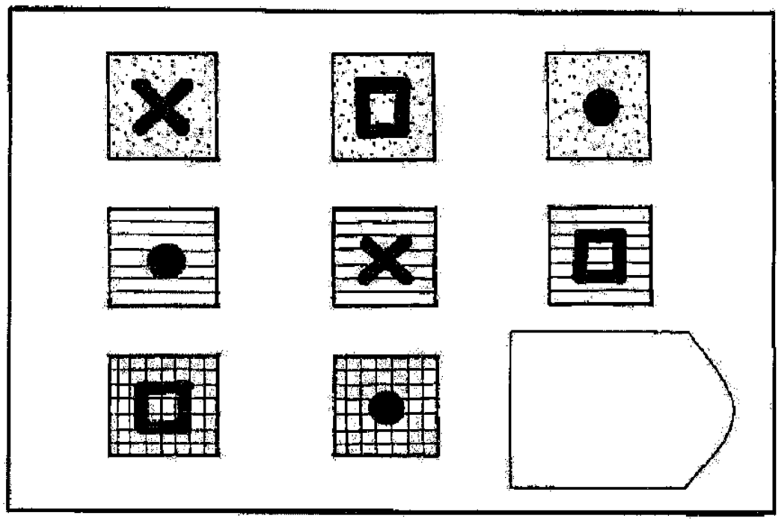


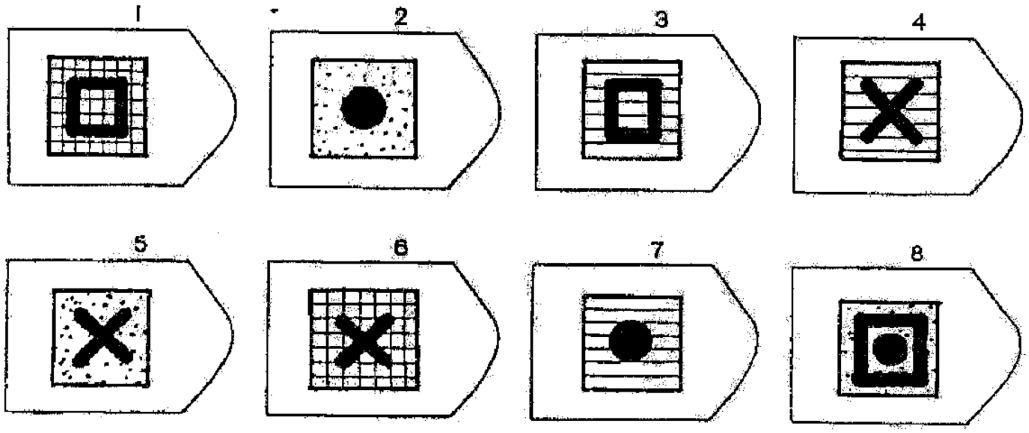
6



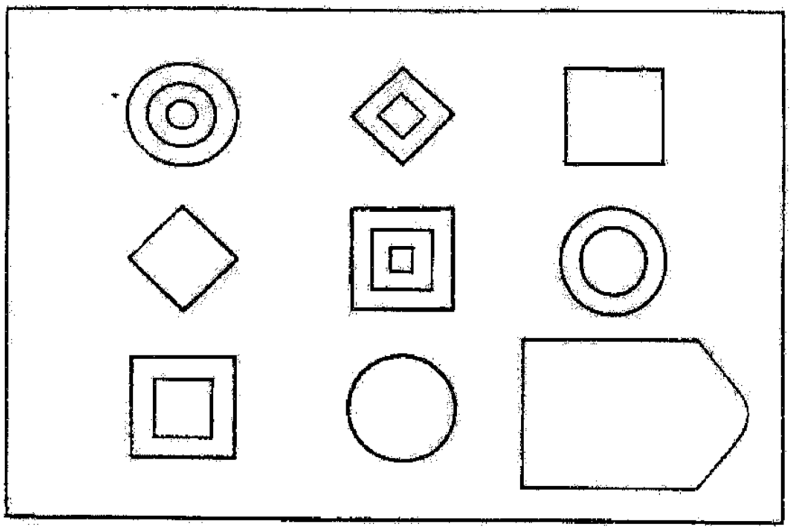


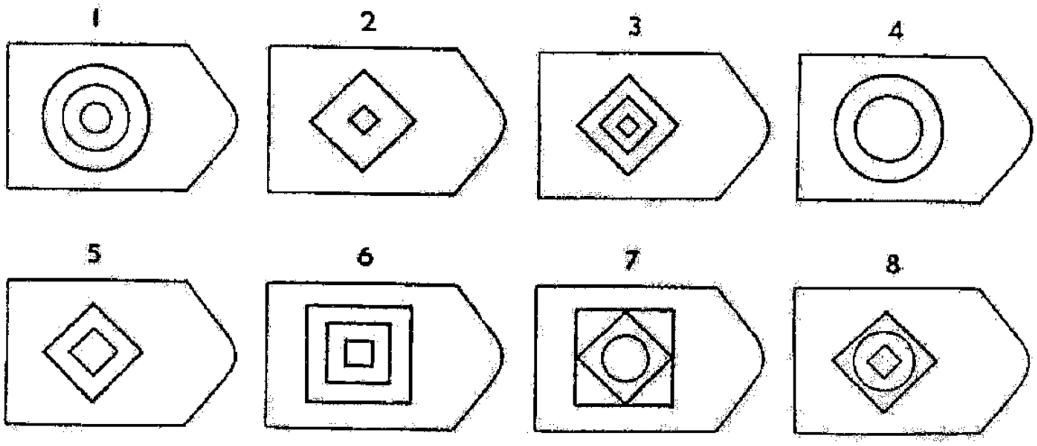
7



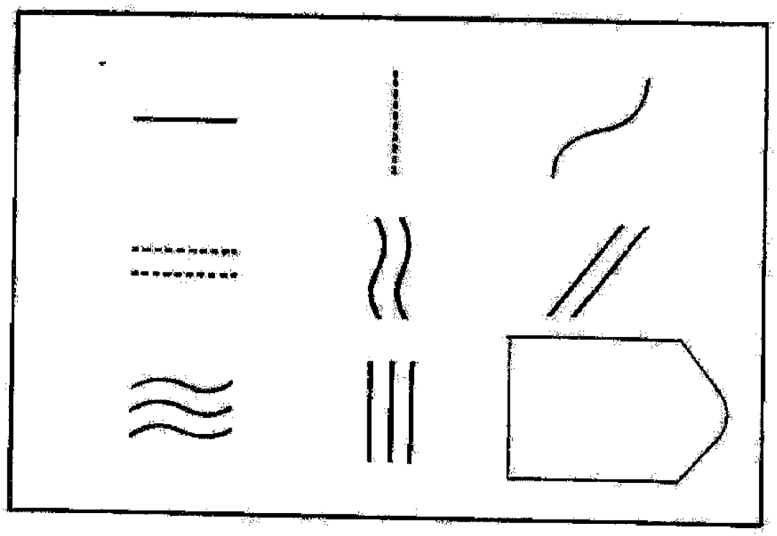


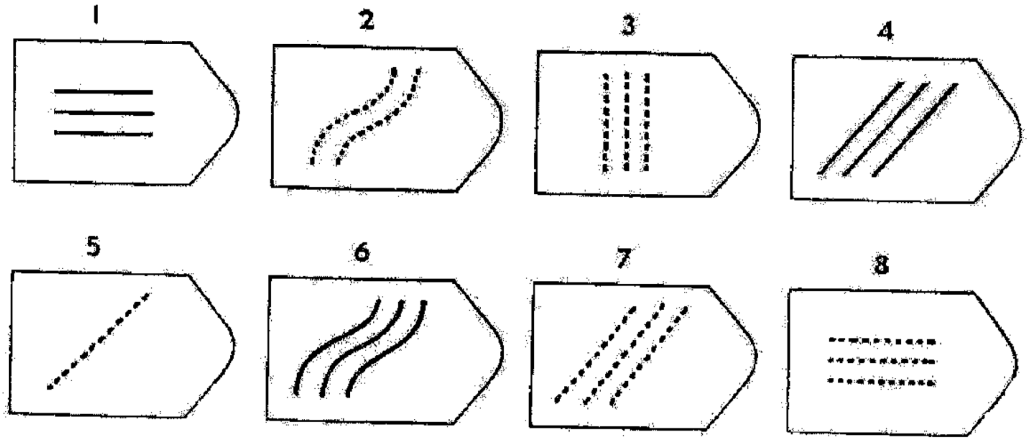
8



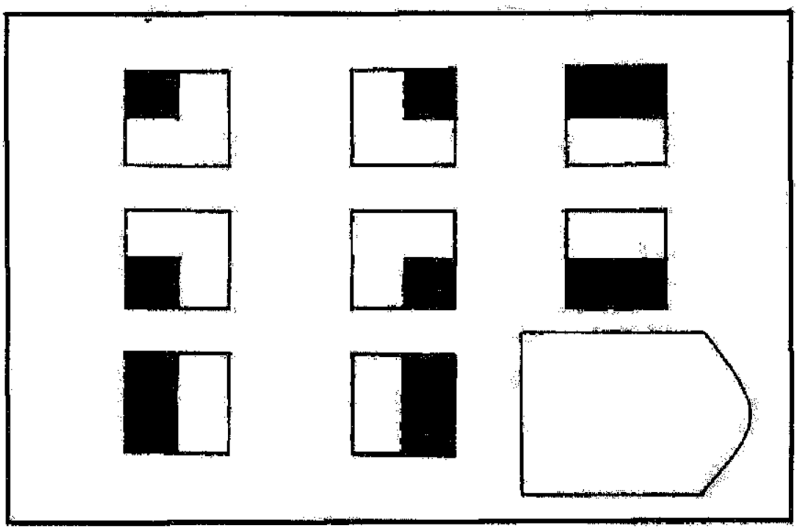


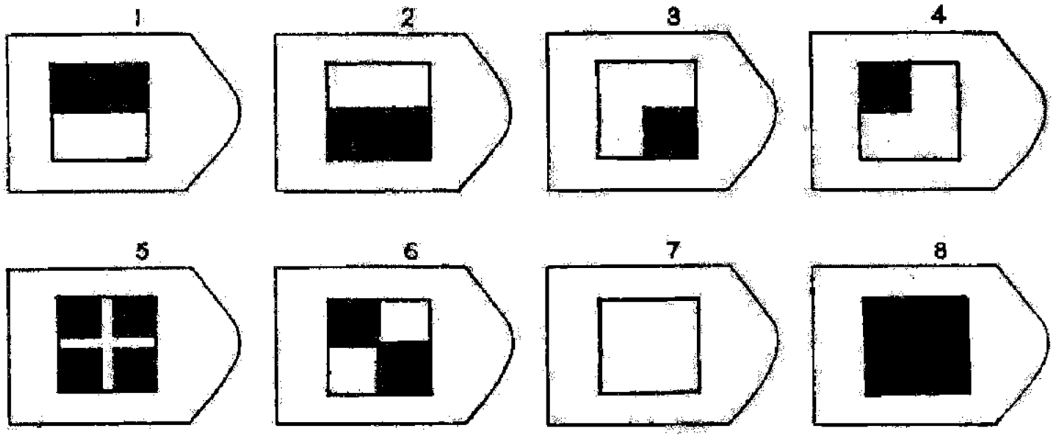
9



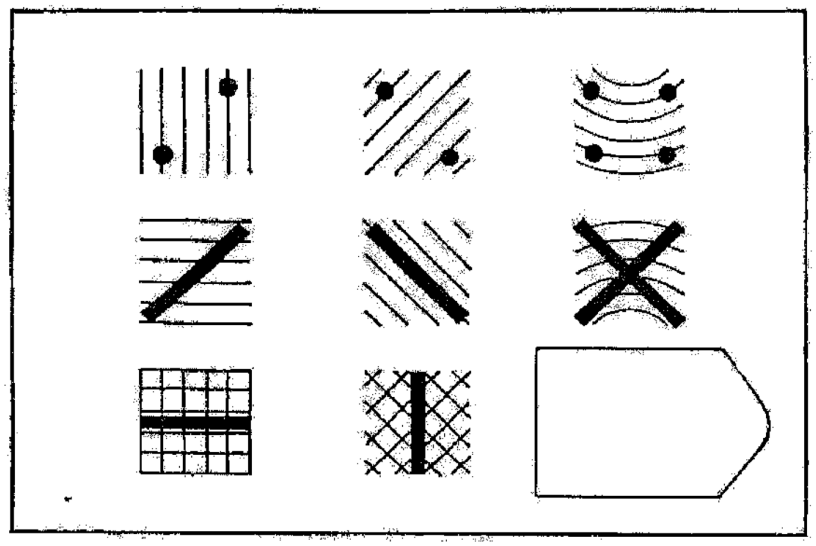


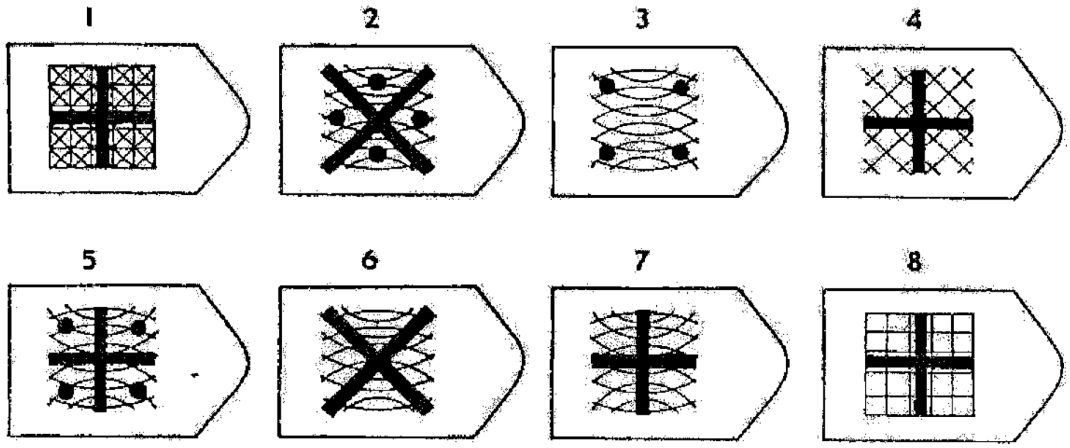
10



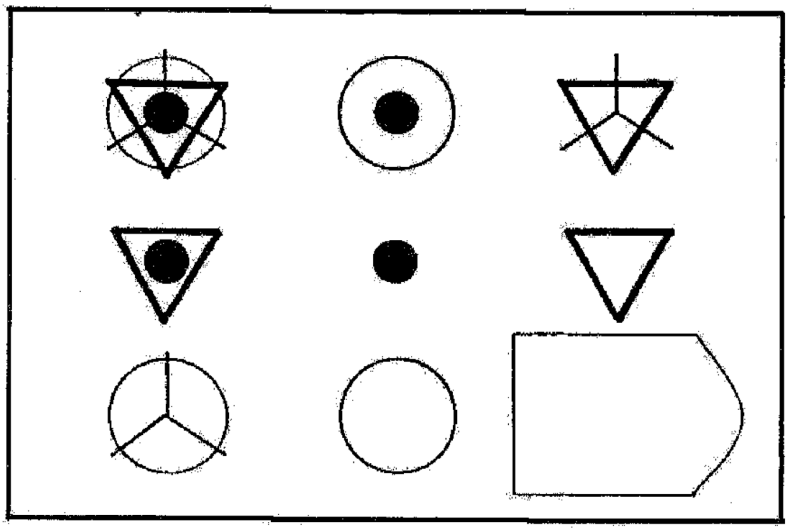


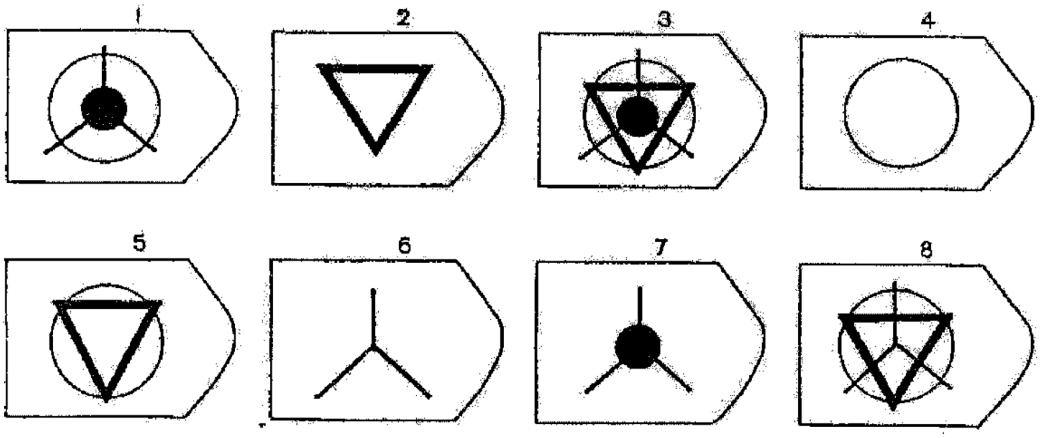
II





12





Appendix H – Post Task Questionnaire

Please circle the most appropriate answer:

1. Which box was your favourite?

   Green *or* *Blue*

2. On average, how many seconds do you think you had to wait before receiving a treat after pressing the green box? (Please use an integer value)

   _____seconds

3. On average how many seconds do you think you had to wait before receiving a treat after pressing the blue box? (Please use an integer value)

   _____seconds

4. How many treats you do think you received?

   _____

5. What percentage of your presses were on the green box?

   0 *5* *10* *15* *20* *25* *30* *35* *40* *45* *50*

   55 *60* *65* *70* *75* *80* *85* *90* *95* *100*

Appendix I – Hunger Likert Scale

Please circle the most appropriate answer:

How hungry do you feel right now?

Not at all hungry	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*Extremely hungry*

Appendix J – Food Craving Questionnaire

Appetite towards specific food choices

Indicate the extent to which you agreed with each statement "right now, at this very moment" using a 7-point scale that ranged from 1 (strong disagree) to 7 (strongly agree)

Please answer on a scale of 1 – 7 where:

1	2	3	4	5	6	7
Strongly Disagree	Disagree		Neither Agree nor Disagree		Agree	Strongly Agree

1. I have an intense desire to east something tasty	1	2	3	4	5	6	7
2. I'm craving sweet food (e.g. a chocolate bar)	1	2	3	4	5	6	7
3. I have an urge for sweet food	1	2	3	4	5	6	7
4. Eating sweet food would make things just perfect	1	2	3	4	5	6	7
5. If I were to eat what I'm craving, I am sure my mood would improve.	1	2	3	4	5	6	7
6. Eating sweet food would feel wonderful.	1	2	3	4	5	6	7
7. If I ate something, I wouldn't feel so sluggish and lethargic.	1	2	3	4	5	6	7
8. Satisfying my cravings would make me feel less grouchy and irritable.	1	2	3	4	5	6	7
9. I would feel more alert if I could satisfy my cravings.	1	2	3	4	5	6	7
10. If I had sweet food, I could not stop eating it.	1	2	3	4	5	6	7
11. My desire to eat sweet food seems overpowering.	1	2	3	4	5	6	7
12. I know I'm going to keep on thinking about sweet food until I actually have it.	1	2	3	4	5	6	7
13. I am hungry	1	2	3	4	5	6	7
14. If I ate right now, my stomach wouldn't feel as empty.	1	2	3	4	5	6	7
15. I feel weak because of not eating.	1	2	3	4	5	6	7

Appetite towards specific food choices

Indicate the extent to which you agreed with each statement "right now, at this very moment" using a 7-point scale that ranged from 1 (strong disagree) to 7 (strongly agree)

Please answer on a scale of 1 – 7 where:

1	2	3	4	5	6	7
Strongly Disagree	Disagree		Neither Agree nor Disagree		Agree	Strongly Agree

1.	I have an intense desire to east something tasty	1	2	3	4	5	6	7
2.	I'm craving savoury food (e.g. pizza)	1	2	3	4	5	6	7
3.	I have an urge for savour food	1	2	3	4	5	6	7
4.	Eating savoury food would make things just perfect	1	2	3	4	5	6	7
5.	If I were to eat what I'm craving, I am sure my mood would improve.	1	2	3	4	5	6	7
6.	Eating savoury food would feel wonderful.	1	2	3	4	5	6	7
7.	If I ate something, I wouldn't feel so sluggish and lethargic.	1	2	3	4	5	6	7
8.	Satisfying my cravings would make me feel less grouchy and irritable.	1	2	3	4	5	6	7
9.	I would feel more alert if I could satisfy my cravings.	1	2	3	4	5	6	7
10.	If I had savoury food, I could not stop eating it.	1	2	3	4	5	6	7
11.	My desire to eat savoury food seems overpowering.	1	2	3	4	5	6	7
12.	I know I'm going to keep on thinking about savoury food until I actually have it.	1	2	3	4	5	6	7
13.	I am hungry	1	2	3	4	5	6	7
14.	If I ate right now, my stomach wouldn't feel as empty.	1	2	3	4	5	6	7
15.	I feel weak because of not eating.	1	2	3	4	5	6	7

Appendix K – PAD Scale

Dimensions of Emotions (PAD)

Mehrabian and Russell 1974

Each pair of words below describes a feeling dimension. Some of the pairs might seem unusual, but you may generally feel more one way than the other. Please take your time so as to arrive at a real characteristic description of your feelings. Circle the number that is most appropriate to you.

1 Happy	2	3	4	5 Unhappy
1 Pleased	2	3	4	5 Annoyed
1 Satisfied	2	3	4	5 Unsatisfied
1 Contented	2	3	4	5 Melancholic
1 Hopeful	2	3	4	5 Despairing
1 Relaxed	2	3	4	5 Bored
1 Stimulated	2	3	4	5 Relaxed
1 Excited	2	3	4	5 Calm

1 Frenzied	2	3	4	5 Sluggish
1 Jittery	2	3	4	5 Dull
1 Wide awake	2	3	4	5 Sleepy
1 Aroused	2	3	4	5 Unaroused
1 Controlling	2	3	4	5 Controlled
1 Influential	2	3	4	5 Influenced
1 In control	2	3	4	5 Cared for
1 Important	2	3	4	5 Awed
1 Dominant	2	3	4	5 Submissive
1 Autonomous	2	3	4	5 Guided

Appendix L – Chocolate Habits Questionnaire

Please indicate how much you agree with the following statements by ticking the box that best applies to you:

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. I tend to eat chocolate when I am feeling emotionally upset.					
2. When I have a strong desire to eat chocolate, I go out of my way to get some.					
3. I tend to eat chocolate when I have nothing to do.					
4. I would find it difficult to go without chocolate for a week.					
5. I like the taste of chocolate.					
6. When I am hungry, I often think about eating chocolate.					
7. When passing newsagents, vending machines etc., I cannot resist buying chocolate.					
8. I eat chocolate most often when I have not eaten anything for at least two hours.					
9. When I am with someone who is eating chocolate, I want to eat some too.					
10. When I have a strong desire to eat chocolate, I give in and eat some.					
11. Eating chocolate helps me to think.					
12. Eating chocolate puts me in a good mood.					
13. I regard myself as someone who craves chocolate.					

Appendix M – Alcohol Use Disorders Identification Test

AUDIT

Please circle the answer that is correct for you

1. How often do you have a drink containing alcohol?

Never	Monthly or less	Two to four times a month	Two to three times a week	Four or more times a week

2. How many drinks containing alcohol do you have on a typical day when you are drinking?

1 or 2	3 or 4	5 or 6	7 to 9	10 or more

3. How often do you have six or more drinks on one occasion?

Never	Less than monthly	Monthly	Weekly	Daily or almost daily

4. How often during the last year have you found that you were not able to stop drinking once you had started?

Never	Less than monthly	Monthly	Weekly	Daily or almost daily

5. How often during the last year have you failed to do what was normally expected from you because of drinking?

Never	Less than monthly	Monthly	Weekly	Daily or almost daily

6. How often during the last year have you needed a first drink in the morning to get yourself going after a heavy drinking session?

Never	Less than monthly	Monthly	Weekly	Daily or almost daily

7. How often during the last year have you had a feeling of guilt or remorse after drinking?

Never	Less than monthly	Monthly	Weekly	Daily or almost daily

8. How often during the last year have you been unable to remember what happened the night before because you had been drinking?

Never	Less than monthly	Monthly	Weekly	Daily or almost daily

9. Have you or someone else been injured as a result of your drinking?

No	Yes, but not in	Yes,
during	the last year	the last year

10. Has a relative or friend, or a doctor or other health worker been concerned about your drinking or suggested you cut down?

No	Yes, but not in	Yes,
during	the last year	the last year

Appendix N – Fagerstrom Test for Nicotine Dependence

	0	**1**	**2**	**3**
1. How soon after you wake up do you smoke your first cigarette?	After 60 minutes	31 – 60 minutes	6 – 30 minutes	Within 5 minutes
2. Do you find it difficult to refrain from smoking in places where it is forbidden, e.g., in church, at the library, cinema, etc?	No	Yes		
3. Which cigarette would you hate most to give up?	All others	The first one in the morning		
4. How many cigarettes/day do you smoke?	10 or less	11 – 20	21 - 30	31 or more
5. Do you smoke more frequently during the first hours of waking than during the rest of the day?	No	Yes		
6. Do you smoke if you are so ill that you are in bed most of the day?	No	Yes		

Appendix O – Childhood Socio-Economic Status

Please think about your childhood before age 12 and indicate, using the rating scale below, your agreement or disagreement with the following statements:

My family had enough money for things growing up

1 2 3 4 5 6 7

Strongly disagree Strongly agree

I grew up in a relatively wealthy neighbourhood

1 2 3 4 5 6 7

Strongly disagree Strongly agree

I felt relatively wealthy compared to others my age

1 2 3 4 5 6 7

Strongly disagree Strongly agree

References

Albuquerque, D., Stice, E., Rodriguez-Lopez, R., Manco, L., & Nobrega, C. (2015). Current review of genetics of human obesity: from molecular mechanisms to an evolutionary perspective. *Mol Genet Genomics, 290*(4), 1191-1221. doi:10.1007/s00438-015-1015-9

Amlung, M., Petker, T., Jackson, J., Balodis, I., & MacKillop, J. (2016). Steep discounting of delayed monetary and food rewards in obesity: a meta-analysis. *Psychol Med, 46*(11), 2423-2434. doi:10.1017/S0033291716000866

Anbarci, N., Arin, K. P., Okten, C., & Zenker, C. (2016). Is Roger Federer more loss averse than Serena Williams? *Journal of Applied Economics, 49*(35), 3546-3559. doi:10.1080/00036846.2016.1262527

Anglé, S., Engblom, J., Erickson, T., Kautiainen, S., Saha, M.-T., Lindfors, P., . . . Rimpelä, A. (2009). Three factor eating questionnaire - R18 as a measure of cogntive restraint, uncontrolled eating and emotional eating in a sample of young Finnish females. *International Journal of Behavioural Nutrition and Physical Activity, 6*(41). doi:10.1186/1479-5868-6-41

Appelhans, B. M., Waring, M. E., Schneider, K. L., Pagoto, S. L., DeBiasse, M. A., Whited, M. C., & Lynch, E. B. (2012). Delay discounting and intake of ready-to-eat and away-from-home foods in overweight and obese women. *Appetite, 59*(2), 576-584. doi:10.1016/j.appet.2012.07.009 S0195-6663(12)00233-4 [pii]

Appelhans, B. M., Woolf, K., Pagoto, S. L., Schneider, K. L., Whited, M. C., & Liebman, R. (2011). Inhibiting food reward: delay discounting, food reward sensitivity, and palatable food intake in overweight and obese women. *Obesity (Silver Spring), 19*(11), 2175-2182. doi:10.1038/oby.2011.57

Arthur, W., & Day, D. (1994). Development of a short form for the Raven Progressive Matrices test. *Educational and Psychological Measurement, 54*(2), 394-403.

Asher, G., & Sassone-Corsi, P. (2015). Time for food: the intimate interplay between nutrition, metabolism, and the circadian clock. *Cell, 161*(1), 84-92. doi:10.1016/j.cell.2015.03.015

Avena, N. M., Gearhardt, A. N., Gold, M. S., Wang, G. J., & Potenza, M. N. (2012). Tossing the baby out with the bathwater after a brief rinse? The potential downside of dismissing food addiction based on limited data. *Nat Rev Neurosci, 13*(7), 514; author reply 514. doi:10.1038/nrn3212-c1

Bateson, M., & Kacelnik, A. (1995). Preferences for fixed and variable food sources: variability in amount and delay. *Journal of the Experimental Analysis of Behaviour, 63*(3), 313-329.

Bateson, M., & Kacelnik, A. (1997). Starlings' preferences for predictable and unpredictable delays to food. *Animal Behaviour, 53*(6), 1129-1142. doi:S0003-3472(96)90388-7 [pii]10.1006/anbe.1996.0388

Beck, A. T., Steer, R. A., & Brown, G. K. (1996). *Manual for the Beck Depression Inventory-II*. San Antonio, TX:: Psychological Corporation.

Berg, C., Lappas, G., Wolk, A., Strandhagen, E., Toren, K., Rosengren, A., . . . Lissner, L. (2009). Eating patterns and portion size associated with obesity in a Swedish population. *Appetite, 52*(1), 21-26. doi:10.1016/j.appet.2008.07.008

Berghofer, A., Pischon, T., Reinhold, T., Apovian, C. M., Sharma, A. M., & Willich, S. N. (2008). Obesity prevalence from a European perspective: a systematic review. *BMC Public Health, 8*, 200. doi:10.1186/1471-2458-8-200

Bergman, H., & Kallmen, H. (2002). Alcohol use among Swedes and a psychometril evaluation of the Alcohol Use Disorders Identification Test. *Alcohol & Alcoholism, 37*(3), 245-251.

Berridge, K. C. (1996). Food reward: brain substrates of wanting and liking. *Neuroscience and Biobehavioural Reviews, 20*(1), 1-25.

Berridge, K. C. (2009). 'Liking' and 'wanting' food rewards: brain substrates and roles in eating disorders. *Physiology & Behaviour, 97*(5), 537-550. doi:10.1016/j.physbeh.2009.02.044

Bes-Rastrollo, M., Sanchez-Villegas, A., Basterra-Gortari, F. J., Nunez-Cordoba, J. M., Toledo, E., & Serrano-Martinez, M. (2010). Prospective study of self-reported usual snacking and weight gain in a Mediterranean cohort: the SUN project. *Clin Nutr, 29*(3), 323-330. doi:10.1016/j.clnu.2009.08.017

Bezerra, I. N., & Sichieri, R. (2009). Eating out of home and obesity: a Brazilian nationwide survey. *Public Health Nutr, 12*(11), 2037-2043. doi:10.1017/S1368980009005710

Bickel, W. K., Jarmolowicz, D. P., Mueller, E. T., Koffarnus, M. N., & Gatchalian, K. M. (2012). Excessive discounting of delayed reinforcers as a trans-disease process contributing to addiction and other disease-related vulnerabilities: emerging evidence. *Pharmacology & Therapeautics, 134*, 287-297.

Bickel, W. K., Odum, A. L., & Madden, G. J. (1999). Impulsivity and cigarette smoking: delay discounting in current, never, and ex-smokers. *Psychopharmacology (Berl), 146*, 447-454.

Bickel, W. K., Wilson, A. G., Franck, C. T., Mueller, E. T., Jarmolowicz, D. P., Koffarnus, M. N., & Fede, S. J. (2014). Using crowdsourcing to compare temporal, social temporal, and probability discounting among obese and non-obese individuals. *Appetite, 75*, 82-89.

Bixter, M. T., & Luhmann, C. C. (2013). Adaptive intertemporal preferences in foraging-style environments. *Frontiers in Neuroscience, 7*, 93. doi:10.3389/fnins.2013.00093

Blaine, B. (2008). Does depression cause obesity?: A meta-analysis of longitudinal studies of depression and weight control. *J Health Psychol, 13*(8), 1190-1197. doi:10.1177/1359105308095977;13/8/1190 [pii]

Boswell, R. G., & Kober, H. (2016). Food cue reactivity and craving predict eating and weight gain: a meta-analytic review. *Obesity Reviews, 17*, 159-177.

Brogan, A., Hevey, D., O'Callaghan, G., Yoder, R., & O'Shea, D. (2011). Impaired decision making among morbidly obese adults. *J Psychosom Res, 70*(2), 189-196. doi:10.1016/j.jpsychores.2010.07.012

Brogan, A., Hevey, D., & Pignatti, R. (2010). Anorexia, bulimia, and obesity: shared decision making deficits on the Iowa Gambling Task (IGT). *J Int Neuropsychol Soc, 16*(4), 711-715. doi:10.1017/S1355617710000354 S1355617710000354 [pii]

Bruch, H. (1973). *Eating Disorders: Obesity, Anorexia Nervosa and the Person Within*. New York: Basic Books

Burton, P., Smit, H. J., & Lightowler, H. J. (2007). The influence of restrained and external eating patterns on overeating. *Appetite, 49*(1), 191-197. doi:10.1016/j.appet.2007.01.007

Campbell, M. C., Manning, K. C., Leonard, B., & Manning, H. M. (2015). Kids, cartoons, and cookies: Stereotype priming effects on children's food consumption. *Journal of Consumer Psychology, 26*(2), 257-264. doi:10.1016/j.jcps.2015.06.003

Campbell-Meiklejohn, D., Wakeley, J., Herbert, V., Cook, J., Scollo, P., Ray, M. K., . . . Rogers, R. D. (2011). Serotonin and dopamine play complementary roles in gambling to recover losses. *Neuropsychopharmacology, 36*(2), 402-410. doi:10.1038/npp.2010.170

Canetti, L., Bachar, E., & Berry, E. M. (2002). Food and emotion. *Behav Processes, 60*, 157-164.

Caraco, T. (1981). Energy budgets, risk and foraging preferences in dark-eyed juncos. *Behavioural Ecology and Sociobiology, 8*, 213-217.

Caraco, T., Blanckenhorn, W. U., Gregory, G. M., Newman, J. A., Recer, G. M., & Zwicker, S. M. (1990). Risk-sensitivity: ambient temperature affects foraging choice. *Animal Behaviour, 39*, 338-345.

Cardinal, R. N., Robbins, T. W., & Everitt, B. J. (2000). The effects of d -amphetamine, chlordiazepoxide, α-flupenthixol and behavioural manipulations on choice of signalled and unsignalled delayed reinforcement in rats. *Psychopharmacology (Berl), 152*(4), 362-375. doi:10.1007/s002130000536

Carels, R. A., Konrad, K., & Harper, J. (2007). Individual differences in food perceptions and calorie estimation: an examination of dieting status, weight, and gender. *Appetite, 49*(2), 450-458. doi:S0195-6663(07)00027-X [pii] 10.1016/j.appet.2007.02.009

Case, D., Nichols, P., & Fantino, E. (1995). Pigeons' preference for variable-interval water reinforcement under widely varied water budgets. *Journal of the Experimental Analysis of Behaviour, 64*, 299-311.

Cepeda-Benito, A., Gleaves, D. H., Williams, T. L., & Erath, S. A. (2000). The Development and Validation of the State and Trait Food-Cravings Questionnaires. *Behaviour Therapy, 31*, 151-173.

Charness, G., & Gneezy, U. (2012). Strong Evidence for Gender Differences in Risk Taking. *Journal of Economic Behavior & Organization, 83*(1), 50-58. doi:10.1016/j.jebo.2011.06.007

Coelho, J. S., Polivy, J., Herman, C. P., & Pliner, P. (2009). Wake up and smell the cookies. Effects of olfactory food-cue exposure in restrained and unrestrained eaters. *Appetite, 52*(2), 517-520. doi:10.1016/j.appet.2008.10.008

Cohen, D. A. (2008). Obesity and the built environment: changes in environmental cues cause energy imbalances. *Int J Obes (Lond), 32 Suppl 7*, S137-142. doi:10.1038/ijo.2008.250

Cornell, C. E., Roddin, J., & Weingarten, H. (1989). Stimulus-induced eating when satiated. *Phyiology & Behaviour, 45*, 695-704.

Cornier, M. A., Salzberg, A. K., Endly, D. C., Bessesen, D. H., & Tregellas, J. R. (2010). Sex-based differences in the behavioral and neuronal responses to food. *Physiol Behav, 99*(4), 538-543. doi:10.1016/j.physbeh.2010.01.008

Daniel, T. O., Stanton, C. M., & Epstein, L. H. (2013). The future is now: comparing the effect of episodic future thinking on impulsivity in lean and obese individuals. *Appetite, 71*, 120-125.

Davis, C., Patte, K., Curtis, C., & Reid, C. (2010). Immediate pleasures and future consequences. A neuropsychological study of binge eating and obesity. *Appetite, 54*(1), 208-213. doi:10.1016/j.appet.2009.11.002

Davis, C., Strachan, S., & Berkson, M. (2004). Sensitivity to reward: implications for overeating and overweight. *Appetite, 42*(2), 131-138. doi:10.1016/j.appet.2003.07.004

de Castro, J. M. (2004). The time of day of food intake influences overall intake in humans. *Journal of Nutrition, 134*, 104-111.

de Lauzon, B., Romon, M., Deschamps, V., Lafay, L., Borys, J.-M., Karlsson, J., . . . Charles, M. A. (2004). The three-factor eating questionnaire-R18 is able to distinguish among different eating patters in a general population. *Nutrional Epidemiology, 134*, 2372-2380.

de Wit, H. (2008). Impulsivity as a determinant and consequence of drug use: a review of underlying processes. *Addiction Biology, 14*, 22-31.

Donovan, R. J., & Rossiter, J. R. (1982). Store atmosphere: an environmental psychology approach. *Journal of Retailing, 58*(1), 34-57.

Donovan, R. J., Rossiter, J. R., Marcoolyn, G., & Nesdale, A. (1994). Store Atmosphere and Purchasing Behaviour. *Journal of Retailing, 70*(3), 283-294.

Duffey, K. J., Gordon-Larson, P., Jacobs, D. R., Williams, O. D., & Popkin, B. M. (2007). Differential associations of fast food and restaurant food consumption with 3-y change in body mass index: the Coronary Artery Risk Development in Young Adults Study. *American Journal of Clinical Nutrition, 85*, 201-208.

Elfhag, K., & Morey, L. C. (2008). Personality traits and eating behaviour in the obese: Poor self-control in emotional and external eating but personality assets in restrained eating. *Eating Behaviours, 9*, 285-293.

Estle, S. J., Green, L., Myerson, J., & Holt, D. D. (2007). Discounting of monetary and directly consumable rewards. *Psychol Sci, 18*(1), 58-63. doi:10.1111/j.1467-9280.2007.01849.x

Evenden, J. L. (1999). Varieties of impulsivity. *Psychopharmacology (Berl), 146*, 348-361.

Fairburn, C., & Beglin, S. (1994). Assessment of eating disorders: interview or self-report questionnaire? *International Journal of Eating Disorders, 16*(4), 363-370.

Fairburn, C., Cooper, Z., & O'Connor, M. (2008). Eating Disorder Examination. In C. Fairburn (Ed.), *Cognitive Behavior Therapy: Eating Disorders*. New York: Guilford Press.

Fedoroff, I., Polivy, J., & Herman, C. P. (1997). The Effect of Pre-exposure to Food Cues on the Eating Behavior of Restrained and Unrestrained Eaters. *Appetite, 28*, 33-47.

Fedoroff, I., Polivy, J., & Herman, C. P. (2003). The specificity of restrained versus unrestrained eaters' responses to food cues: general desire to eat, or craving for the cued food? *Appetite, 41*, 7-13.

Fields, S. A., Sabet, M., & Reynolds, B. (2013). Dimensions of impulsive behavior in obese, overweight, and healthy-weight adolescents. *Appetite, 70*, 60-66. doi:10.1016/j.appet.2013.06.089

Finlayson, G., & Dalton, M. (2012). Current progress in the assessment of 'liking' vs. 'wanting' food in human appetite. Comment on '"You say it's liking, i say it's wanting..."'. On the difficulty of disentangling food reward in man'. *Appetite, 58*(1), 373-378; discussion 252-375. doi:10.1016/j.appet.2011.10.011

Fishbach, A., Friedman, R. S., & Kruglanski, A. W. (2003). Leading us not into temptation: Momentary allurements elicit overriding goal activation. *Journal of Personality and Social Psychology, 84*(2), 296-309. doi:10.1037/0022-3514.84.2.296

French, S. A., Epstein, L. H., Jeffery, R. W., Blundell, J. E., & Wardle, J. (2012). Eating behaviour dimensions. Associations with energy intake and body weight. A review. *Appetite, 59*, 541-549.

Gaillet, M., Sulmont-Rossé, C., Issanchou, S., Chabanet, C., & Chambaron, S. (2013). Priming effects of an olfactory food cue on subsequent food-related behaviour. *Food Quality and Preference, 30*, 274-281.

Gaillet-Torrent, M., Sulmont-Rossé, C., Issanchou, S., Chabanet, C., & Chambaron, S. (2014). Impact of a non-attentively perceived odour on subsequent food consumption. *Appetite, 76*, 17-22.

Gallus, S., Lugo, A., Murisic, B., Bosetti, C., Boffetta, P., & La Vecchia, C. (2015). Overweight and obesity in 16 European countries. *Eur J Nutr, 54*(5), 679-689. doi:10.1007/s00394-014-0746-4

Ganley, R. M. (1988). Emotional eating and how it relates to dietary restraint, disinhibition, and perceived hunger. *International Journal of Eating Disorders, 7*(5), 635-647.

Ganley, R. M. (1989). Emotion and eating in obesity: a review of the literature. *International Journal of Eating Disorders, 8*(3), 343-361.

Garrido, I., & Subira, S. (2013). Decision-making and impulsivity in eating disorder patients. *Psychiatry Res, 207*(1-2), 107-112. doi:10.1016/j.psychres.2012.10.004

Gibbon, J. (1977). Scalar expectancy theory and Weber's Law in animal timing. *Psychologial Review, 84*(3), 279-325.

Gibson, E. L., & Desmond, E. (1999). Chocolate craving and hunger state: implications for the acquisition and expression of appetite and food choice. *Appetite, 32*, 219-240.

Green, L., & Myerson, J. (2010). Experimental and correlational analyses of delay and probability discounting. In G. J. Madden & W. K. Bickel (Eds.), *Impulsivity: The behavioral and neurological science of discounting*. Washington DC: American Psychological Association.

Halkjaer, J., Tjonneland, A., Overvad, K., & Sorensen, T. I. (2009). Dietary predictors of 5-year changes in waist circumference. *J Am Diet Assoc, 109*(8), 1356-1366. doi:10.1016/j.jada.2009.05.015

Havermans, R. C. (2011). "You Say it's Liking, I Say it's Wanting ...". On the difficulty of disentangling food reward in man. *Appetite, 57*(1), 286-294. doi:10.1016/j.appet.2011.05.310

Havermans, R. C. (2012). How to tell where 'liking' ends and 'wanting' begins. *Appetite, 58*(1), 252-255. doi:10.1016/j.appet.2011.10.013

Havermans, R. C., Janssen, T., Giesen, J. C. A. H., Roefs, A., & Jansen, A. (2009). Food wanting, food liking, and sensory-specific satiety. *Appetite, 52*, 222-225.

Hays, N. P., & Roberts, S. B. (2008). Aspects of eating behaviors "disinhibition" and "restraint" are related to weight gain and BMI in women. *Obesity (Silver Spring), 16*(1), 52-58. doi:10.1038/oby.2007.12

Heatherton, T. F., Kozlowski, L. T., Frecker, R. C., & Fagerstrom, K.-O. (1991). The Fagerstrom Test for Nicotine Dependence: a revision of the Fagerstrom Tolerance Questionnaire. *British Journal of Addiction, 86*, 1119-1127.

Hendrickson, K. L., & Rasmussen, E. B. (2013). Effects of mindful eating training on delay and probability discounting for food and money in obese and healthy-weight individuals. *Behaviour Research and Therapy, 51*, 399-409.

Herman, C. P., & Mack, D. (1975). Restrained and unrestrained eating. *Journal of Personality, 43*(4), 647-660. doi:10.1111/1467-6494.ep8970396

Herman, C. P., & Polivy, J. (2008). External cues in the control of food intake in humans: the sensory-normative distinction. *Physiol Behav, 94*(5), 722-728. doi:10.1016/j.physbeh.2008.04.014

Herman, C. P., Polivy, J., Lank, C. N., & Heatherton, T. F. (1987). Anxiety, hunger, and eating behaviour. *Journal of Abnormal Psychology, 96*(3), 264-269.

Herman, C. P., Roth, D. A., & Polivy, J. (2003). Effects of the presence of others on food intake: a normative interpretation. *Psychol Bull, 129*(6), 873-886. doi:10.1037/0033-2909.129.6.873

Herrnstein, R. J. (1964). Aperiodicity as a factor in choice. *Journal of Experimental Analysis of Behaviour, 7*(2), 179-182.

Hill, J. O., Wyatt, H. R., & Peters, J. C. (2012). Energy balance and obesity. *Circulation, 126*(1), 126-132.

Hill, S. E., Prokosch, M. L., DelPriore, D. J., Griskevicius, V., & Kramer, A. (2016). Low Childhood Socioeconomic Status Promotes Eating in the Absence of Energy Need. *Psychol Sci, 27*(3), 354-364. doi:10.1177/0956797615621901

Hirsch, A. R. (1995). Effects of ambient odors on slot-machine usage in a Las Vegas casino. *Psychology & Marketing, 12*(7), 585-594.

Hofman, W., De Houwer, J., Perugini, M., Baeyens, F., & Crombez, G. (2010). Evaluative conditioning in humans: a meta-analysis. *Psychological Bulletin, 136*(3), 390-421.

Howarth, N. C., Huang, T. T., Roberts, S. B., Lin, B. H., & McCrory, M. A. (2007). Eating patterns and dietary composition in relation to BMI in younger and older adults. *Int J Obes (Lond), 31*(4), 675-684. doi:10.1038/sj.ijo.0803456

HSCIC. (2006). *Statistics on obesty, physical activity and diet: England, 2006*. Retrieved from

Huang, T. T., Howarth, N. C., Lin, B.-H., Roberts, S. B., & McCrory, M. A. (2004). Energy Intake and Meal Portions: Associations with BMI Percentile in U.S. Children. *Obesity Research, 12*(11), 1875-1885.

IBM. (2013). IBM SPSS Statistics for MacIntosh (Version 22). Armonk, NY: IBM Corp.

Janiszewski, C., & Wyer Jr., R. S. (2014). Content and process priming: a review. *Journal of Consumer Psychology, 24*(1), 96-118.

Jansen, A., Nederkoorn, C., van Baak, L., Keirse, C., Guerrieri, R., & Havermans, R. (2009). High-restrained eaters only overeat when they are also impulsive. *Behav Res Ther, 47*(2), 105-110. doi:10.1016/j.brat.2008.10.016

Jansen, A., & van den Hout, M. (1991). On being led into temptation: "Counterregulation" of dieters after smelling a "preload". *Addictive Behaviors, 16*, 247-253.

Jeffery, R. W., & French, S. A. (1998). Epidemic Obesity in the United States: Are Fast Foods and Television Viewing Contributing? *American Journal of Public Health, 88*, 277-280.

Jimura, K., Myerson, J., Hilgard, J., Braver, T. S., & Green, L. (2009). Are people really more patient than other animals? Evidence from human discounting of real liquid rewards. *Psychon Bull Rev, 16*(6), 1071-1075. doi:10.3758/PBR.16.6.1071

Jimura, K., Myerson, J., Hilgard, J., Keighley, J., Braver, T. S., & Green, L. (2011). Domain independence and stability in young and older adults' discounting of delayed rewards. *Behav Processes, 87*(3), 253-259. doi:10.1016/j.beproc.2011.04.006

Johnson, M. W., & Bickel, W. K. (2008). An algorithm for identifying nonsystematic delay-discounting data. *Exp Clin Psychopharmacol, 16*(3), 264-274. doi:10.1037/1064-1297.16.3.264

Kacelnik, A., & Bateson, M. (1996). Risky theories- the effects of variance on foraging decisions. *American Zoology, 36*, 402-434.

Kacelnik, A., & Bateson, M. (1997). Risk-sensitivity: crossroads for theories of decision-making. *Trends Cogn Sci, 1*(8), 304-309.

Kacelnik, A., & Brito-E-Abreu, F. (1998). Risky choice and Weber's Law. *Journal of Theoretical Biology, 194*, 289-298.

Kaplan, H. I., & Kaplan, H. S. (1957). The psychosomatic concept of obesity. *Journal of Nervous and Mental Disease, 125*, 181-201.

Karlsson, J., Persson, L.-O., SjoÈstroÈm, L., & Sullivan, M. (2000). Psychometric properties and factor structure of the Three-Factor Eating Questionnaire (TFEQ) in obese men and women. Results from the Swedish Obese Subjects (SOS) study. *Int J Obes (Lond), 24*, 1715-1725.

Killeen, P. (1968). On the measurement of reinforcement frequency in the study of preference. *J Exp Anal Behav, 11*(3), 263-269. doi:10.1901/jeab.1968.11-263

Kirschenbaum, D. S., & Dykman, B. M. (1991). Disinhibited eating by resourceful restrained eaters. *Journal of Abnormal Psychology, 100*(2), 227-230.

Kishinevsky, F. I., Cox, J. E., Murdaugh, D. L., Stoeckel, L. E., Cook, E. W., 3rd, & Weller, R. E. (2012). fMRI reactivity on a delay discounting task predicts weight gain in obese women. *Appetite, 58*(2), 582-592. doi:10.1016/j.appet.2011.11.029

Klajner, F., Herman, C. P., Polivy, J., & Chhabra, R. (1981). Human obesity, dieting, and anticipatory salivation to food. *Physiology & Behaviour, 27*, 195-198.

Knasko, S. (1995). Pleasant odours and congruency: effects on approach behaviour. *Chem Senses, 20*, 479-487.

Kniffin, K. M., Sigirci, O., & Wansink, B. (2015). Eating Heavily: Men Eat More in the Company of Women. *Evolutionary Psychological Science, 2*(1), 38-46. doi:10.1007/s40806-015-0035-3

Koch, A., & Pollatos, O. (2014). Interoceptive sensitivity, body weight and eating behaviour in children: a prospective study. *Front Psychol, 5*, 1-11.

Koffarnus, M. N., & Bickel, W. K. (2014). A 5-trial adjusting delay discounting task: accurate discount rates in less than one minute. *Exp Clin Psychopharmacol, 22*(3), 222-228. doi:10.1037/a0035973

Konttinen, H., Haukkala, A., Sarlio-Lahteenkorva, S., Silventoinen, K., & Jousilahti, P. (2009). Eating styles, self-control and obesity indicators. The moderating role of obesity and dieting history on restrained eating. *Appetite, 53*, 131-134.

Krishna, A. (2012). An integrative review of sensory marketing: Engaging the senses to affect perception, judgment and behavior. *Journal of Consumer Psychology, 22*(3), 332-351. doi:10.1016/j.jcps.2011.08.003

Kuijer, R., de Ridder, D., Ouwehand, C., Houx, B., & van de Bos, R. (2008). Dieting as a case of behavioural decision making. Does self-control matter? *Appetite, 51*, 506-511.

Lattimore, P., & Mead, B. (2015). See it, grab it, or stop! Relationships between trait impulsivity, attentional bias for pictorial food cues and associated response inhibition following in-vivo food cue exposure. *Appetite, 90*, 248-253.

Lebens, H., Roefs, A., Martijn, C., Houben, K., Nederkoorn, C., & Jansen, A. (2011). Making implicit measures of associations with snack foods more negative through evaluative conditioning. *Eat Behav, 12*(4), 249-253. doi:10.1016/j.eatbeh.2011.07.001

Legoff, D. B., & Spigelman, M. N. (1987). Salivary Response to Olfactory Food Stimuli as a Function of Dietary Restraint and Body Weight. *Appetite, 8*, 29-35.

Leitch, M. A., Morgan, M. J., & Yeomans, M. R. (2013). Different subtypes of impulsivity differentiate uncontrolled eating and dietary restraint. *Appetite, 69*, 54-63. doi:10.1016/j.appet.2013.05.007

Lejuez, C. W., Richards, J. B., P., R. J., Kahler, C. W., Ramsey, S., Stuart, G. L., . . . Brown, R. A. (2002). Evauation of a behavioural measure of risk tasking: the balloon analogue risk task (BART). *Journal of Experimental Psychology: Applied, 8*(2), 75-84.

Leyton, M. (2010). The neurobiology of desire: dopamine and the regulation of mood and motivational states in humans. In M. L. Kringelbach & C. K. Berridge (Eds.), *Pleasures of the Brain*. New York: Oxford University Press.

Lieberman, L. S. (2006). Evolutionary and anthropological perspectives on optimal foraging in obesogenic environments. *Appetite, 47*(1), 3-9. doi:10.1016/j.appet.2006.02.011

Locey, M. L., Pietras, C. J., & Hackenberg, T. D. (2009). Human risky choice: delay sensitivity depends on reinforcer type. *Journal of Experimental Psychology, 35*(1), 15-22.

Luce, K. H., Crowther, J. H., & Pole, M. (2008). Eating Disorder Examination Questionnaire (EDE-Q): norms for undergraduate women. *Int J Eat Disord, 41*(3), 273-276. doi:10.1002/eat.20504

Luppino, F. S., de Wit, L. M., Bouvy, P. F., Stijnen, T., Cuijpers, P., Pennix, B. W. H., & Zitman, F. G. (2010). Overweight, obesity, and depression. *Archives of General Psychiatry, 67*(3), 220-229.

Ma, Y., Bertone, E. R., Stenek, E. J., Reed, G. W., Hebert, J. R., Cohen, N. L., . . . Ockene, I. S. (2003). Association between Eating Patterns and Obesity in a Free-living US Adult Population. *American Journal of Epidemiology, 158*(1), 85-92. doi:10.1093/aje/kwg117

Madden, G. J., Begotka, A. M., Raiff, B. R., & Kastern, L. L. (2003). Delay discounting of real and hypothetical rewards. *Exp Clin Psychopharmacol, 11*(2), 139-145.

Madden, G. J., Francisco, M. T., Brewer, A. T., & Stein, J. S. (2011). Delay discounting and gambling. *Behav Processes, 87*(1), 43-49. doi:10.1016/j.beproc.2011.01.012

Madden, G. J., & Johnson, P. S. (2010). A delay-discounting primer. In G. J. Madden & W. K. Bickel (Eds.), *Impulsivity: The behavioural and neurlogical science of discounting*. Washington, D.C.: American Psychological Association.

Malik, V. S., Willett, W. C., & Hu, F. B. (2013). Global obesity: trends, risk factors and policy implications. *Nat Rev Endocrinol, 9*(1), 13-27. doi:10.1038/nrendo.2012.199

Manasse, S. M., Forman, E. M., Ruocco, A. C., Butryn, M. L., Juarascio, A. S., & Fitzpatrick, K. K. (2015). Do executive functioning deficits underpin binge eating disorder? A comparison of overweight women with and without binge eating pathology. *Int J Eat Disord, 48*(6), 677-683. doi:10.1002/eat.22383

Manwaring, J., Green, L., Myerson, J., Strube, M., & Wilfley, D. (2011). Discounting of various types of rewards by women with and without binge eating disorder: evidence for general rather than specific differences. *Psychological Record, 21*(4), 561–582.

Marin-Guerrero, A. C., Gutierrez-Fisac, J. L., Guallar-Castillon, P., Banegas, J. R., & Rodriguez-Artalejo, F. (2008). Eating behaviours and obesity in the adult population of Spain. *Br J Nutr, 100*(5), 1142-1148. doi:10.1017/S0007114508966137

Marmonier, C., Chapelot, D., & Louis-Sylvestre, J. (1999). Metabolic and behavioural consequences of a snack consumed in a satiety state. *Am J Clin Nutr, 70*, 854-866.

Marsh, B., & Kacelnik, A. (2002). Framing effects and risky decisions in starlings. *Proceedings of the National Academy of Sciences, 99*(5), 3352–3355. doi:10.1073

Maruyama, K., Sato, S., Ohira, T., Maeda, K., Noda, H., Kubota, Y., . . . Iso, H. (2008). The joint impact on being overweight of self reported behaviours of eating quickly and eating until full: cross sectional survey. *BMJ, 337*, a2002. doi:10.1136/bmj.a2002

Mattila, A. S., & Wirtz, J. (2001). Congruency of scent and music as a driver of in-store evaluations. *Journal of Retailing, 77*, 273-289.

Mazur, J. E. (1987). An adjusting procedure for studying delayed reinforcement. In M. Commons, J. E. Mazur, J. A. Nevin, & H. Rachlin (Eds.), *Quantitative analysis of behaviour. The effect of delay and of intervening events on reinforcement value* (Vol. 5, pp. 55-73). Sussex: Psychology Press.

McClure, J., Podos, J., & Richardson, H. N. (2014). Isolating the delay component of impulsive choice in adolescent rats. *Front Integr Neurosci, 8*, 3. doi:10.3389/fnint.2014.00003

McGuire, M. T., Jeffery, R. W., French, S. A., & Hannan, P., J. (2001). The relationship between restraint and weight and weight-related behaviours among individuals in a community weight gain prevention trial. *Int J Obes (Lond), 25*, 574-580.

Mehrabian, A. (1996). Pleasure-arousal-dominance: A general framework for describing and measuring individual differences. *Current Psychology, 14*(4), 261-292.

Mehrabian, A., & Russell, J. A. (1974). *An approach to environmental psychology*. Cambridge, MA: M.I.T Press.

Mesas, A. E., Munoz-Pareja, M., Lopez-Garcia, E., & Rodriguez-Artalejo, F. (2012). Selected eating behaviours and excess body weight: a systematic review. *Obesity Reviews, 13*(2), 106-135. doi:10.1111/j.1467-789X.2011.00936.x

Mitchell, D. J., Kahn, B. E., & Knasko, S. (1995). There's something in the air: effects of congruent or incongruent ambient odor on consumer decision making. *Journal of Consumer Research, 22*(2), 229-238.

Mond, J. M., Hay, P. J., Rodgers, B., Owen, C., & Beumont, P. J. V. (2004). Validity of the Eating Disorder Examination Questionnaire (EDE-Q) in screening for eating disorders in community samples. *Behaviour Research and Therapy, 42*(5), 551-567. doi:10.1016/s0005-7967(03)00161-x

Moody, A. (2013). *Adult anthropometric measures, overweight and obesity*. Retrieved from

Moore, D. J. (2014). Is anticipation delicious? Visceral factors as mediators of the effect of olfactory cues on purchase intentions. *Journal of Business Research, 67*(9), 2045-2051. doi:10.1016/j.jbusres.2013.10.005

Moore, D. J., & Konrath, S. (2015). “I can almost taste it:” Why people with strong positive emotions experience higher levels of food craving, salivation and eating intentions. *Journal of Consumer Psychology, 25*(1), 42-59. doi:10.1016/j.jcps.2014.07.001

Myerson, J., Green, L., Hanson, S., Holt, D. D., & Estle, S. J. (2003). Discounting delayed and probabilistic rewards: processes and traits. *Journal of Economic Psychology, 24*, 619-635.

Myerson, J., Green, L., & Warusawitharana, M. (2001). Area under the curve as a measure of discounting. *Journal of Experimental Analysis of Behaviour, 76*, 235-243.

Nederkoorn, C., Smulders, F. T., Havermans, R. C., Roefs, A., & Jansen, A. (2006). Impulsivity in obese women. *Appetite, 47*(2), 253-256. doi:10.1016/j.appet.2006.05.008

Neel, J. (1999). Diabetes Mellitus: a "thrify" genotype rendered detrimental by "progress"? 1962. *Bulletin of the World Health Organisation, 77*(8), 694-693.

Nestle, M. (2003). Increasing portion sizes in american diets: more calories, more obesity. *J Am Diet Assoc, 103*(1), 39-40.

Nielsen, L. A., Nielsen, T. R., & Holm, J. C. (2015). The Impact of Familial Predisposition to Obesity and Cardiovascular Disease on Childhood Obesity. *Obes Facts, 8*(5), 319-328. doi:10.1159/000441375

Odum, A. L. (2011a). Delay discounting: I'm a K, you're a K. *Experimental Analysis of Behaviour, 96*, 427-439.

Odum, A. L. (2011b). Delay discounting: trait variable? *Behav Processes, 87*(1), 1-9. doi:10.1016/j.beproc.2011.02.007

Odum, A. L., & Baumann, A. A. (2007). Cigarette smokers show steeper discounting of both food and cigarettes than money. *Drug Alcohol Depend, 91*(2-3), 293-296. doi:10.1016/j.drugalcdep.2007.07.004

Odum, A. L., Baumann, A. A., & Rimington, D. D. (2006). Discounting of delayed hypothetical money and food: effects of amount. *Behav Processes, 73*(3), 278-284. doi:10.1016/j.beproc.2006.06.008

Odum, A. L., & Rainaud, C. P. (2003). Discounting of delayed hypothetical money, alcohol, and food. *Behav Processes, 64*(3), 305-313. doi:10.1016/s0376-6357(03)00145-1

Otsuka, R., Tamakoshi, K., Yatsuya, H., Murata, C., Sekiya, A., Wada, K., . . . Toyoshima, H. (2006). Eating Fast Leads to Obesity: Findings Based on Self-administered Questionnaires among Middle-aged Japanese Men and Women. *Journal of Epidemiology, 16*(3), 117-124.

Ouwens, M. A., van Strien, T., & van der Staak, C. P. F. (2003). Tendency toward overeating and restraint as predictors of food consumption. *Appetite, 40*(3), 291-298. doi:10.1016/s0195-6663(03)00006-0

Papies, E. K., & Hamstra, P. (2010). Goal priming and eating behaviour: enhancing self-regulation by environmental cues. *Health Psychology, 29*(4), 384-388.

Papies, E. K., Stroebe, W., & Aarts, H. (2008). The allure of forbidden food: On the role of attention in self-regulation. *Journal of Experimental Social Psychology, 44*(5), 1283-1292. doi:10.1016/j.jesp.2008.04.008

Patel, K. A., & Schlundt, D. G. (2001). Impact of moods and social context on eating behavior. *Appetite, 36*(2), 111-118.

Patton, J., Stanford, M., & Barratt, E. (1995). Factor Structure of the Barratt Impulsiveness Scale. *Journal of Clinical Psychology, 51*(6), 768-774.

Pereira, M. A., Kartashov, A. I., Ebbeling, C. B., Van Horn, L., Slattery, M. L., Jacobs, D. R., & Ludwig, D. S. (2005). Fast-food habits, weight gain, and insulin resistance (the CARDIA study): 15-year prospective analysis. *The Lancet, 365*(9453), 36-42. doi:10.1016/s0140-6736(04)17663-0

Petry, N. M. (2001). Delay discounting of money and alcohol in actively using alcoholics, currently abstinent alcoholics, and controls. *Psychopharmacology (Berl), 154*(3), 243-250. doi:10.1007/s002130000638

Pinel, J. P., Assanand, S., & Lehman, D. R. (2000). Hunger, eating, and ill health. *Am Psychol, 55*(10), 1105-1116.

Polivy, J. (1996). Psychological Consequences of Food Restriction. *J Am Diet Assoc, 96*(6), 589-592. doi:10.1016/s0002-8223(96)00161-7

Polivy, J., Coleman, J., & Herman, C. P. (2005). The effect of deprivation on food cravings and eating behavior in restrained and unrestrained eaters. *International Journal of Eating Disorders, 38*(4), 301-309. doi:10.1002/eat.20195

Pool, E., Sennwald, V., Delplanque, S., Brosch, T., & Sander, D. (2016). Measuring wanting and liking from animals to humans: a systematic review. *Neuroscience and Biobehavioural Reviews, 63*, 124-142.

Rachlin, H., & Green, L. (1972). Commitment, choice and self-control. *Journal of Experimental Analysis of Behaviour, 17*, 15-22.

Rasmussen, E. B., Lawyer, S. R., & Reilly, W. (2010). Percent body fat is related to delay and probability discounting for food in humans. *Behav Processes, 83*(1), 23-30. doi:10.1016/j.beproc.2009.09.001

Raven, J. C., Court, J. H., & Raven, J. (1985). *A manual for Raven's Progressive Matrices and Vocabulary Scales*. London, UK: H. K. Lewis.

Reboreda, J. C., & Kacelnik, A. (1991). Risk sensitivity in starlings: variability in food amount and food delay. *Behavioural Ecology, 2*, 301-308.

Rogers, R. D., Wong, A., McKinnon, C., & Winstanley, C. A. (2013). Systemic administration of 8-OH-DPAT and eticlopride, but not SCH23390, alters loss-chasing behavior in the rat. *Neuropsychopharmacology, 38*(6), 1094-1104. doi:10.1038/npp.2013.8

Rollins, B. Y., Dearing, K. K., & Epstein, L. H. (2010). Delay discounting moderates the effect of food reinforcement on energy intake among non-obese women. *Appetite, 55*(3), 420-425. doi:10.1016/j.appet.2010.07.014

Rolls, E. T. (2007). Understanding the mechanisms of food intake and obesity. *Obesity Reviews, 8*(S1), 67-72. doi:10.1111/j.1467-789X.2007.00321.x

Rouby, C. (2002). *Olfaction, Taste, and Cognition* (C. Rouby, B. Schaal, D. Dubois, R. Gervais, & A. Holley Eds.). Cambridge, UK: Cambridge University Press.

RStudio. (2015). RStudio: Integrated development for R. Boston, MA: RStudio Inc.

Saunders, J. B., Aasland, O. G., Babor, T. F., De La Fuente, J. R., & Grant, M. (1993). Development of the Alcohol Use Disorders Identification Test (AUDIT): WHO collaborative project on early detection of persons with harmful alcohol consumption-II. *Addiction, 88*, 791-804.

Schachter, S. (1971). Some extraordinary facts about obese humans and rats. *American Psychologist, 26*(2), 129-144.

Schroder, H., Fito, M., & Covas, M. I. (2007). Association of fast food consumption with energy intake, diet quality, body mass index and the risk of obesity in a representative Mediterranean population. *British Journal of Nutrution, 98*(6), 1274-1280. doi:10.1017/S0007114507781436

Schweighofer, N., Shishida, K., Han, C. E., Okamoto, Y., Tanaka, S. C., Yamawaki, S., & Doya, K. (2006). Humans can adopt optimal discounting strategy under real-time constraints. *PLoS Comput Biol, 2*(11), e152. doi:10.1371/journal.pcbi.0020152

Sellayah, D., Cagampang, F. R., & Cox, R. D. (2014). On the evolutionary origins of obesity: a new hypothesis. *Endocrinology, 155*(5), 1573-1588. doi:10.1210/en.2013-2103

Shafir, S. (2000). Risk-sensitive foraging: the effect of relative variability. *Oikos, 88*(3), 663-669. doi:DOI 10.1034/j.1600-0706.2000.880323.x

Shin, A., Lim, S. Y., Sung, J., Shin, H. R., & Kim, J. (2009). Dietary intake, eating habits, and metabolic syndrome in Korean men. *J Am Diet Assoc, 109*(4), 633-640. doi:10.1016/j.jada.2008.12.015

Sierra-Johnson, J., Unden, A. L., Linestrand, M., Rosell, M., Sjogren, P., Kolak, M., . . . Hellenius, M. L. (2008). Eating meals irregularly: a novel environmental risk factor for the metabolic syndrome. *Obesity (Silver Spring), 16*(6), 1302-1307. doi:10.1038/oby.2008.203

Simmons, D., McKenzie, A., Eaton, S., Cox, N., Khan, M. A., Shaw, J., & Zimmet, P. (2005). Choice and availability of takeaway and restaurant food is not related to the prevalence of adult obesity in rural communities in Australia. *Int J Obes (Lond), 29*(6), 703-710. doi:10.1038/sj.ijo.0802941

Smeets, M. A., & Dijksterhuis, G. B. (2014). Smelly primes - when olfactory primes do or do not work. *Front Psychol, 5*, 96. doi:10.3389/fpsyg.2014.00096

Smith, K. J., McNaughton, S. A., Gall, S. L., Blizzard, L., Dwyer, T., & Venn, A. J. (2009). Takeaway food consumption and its associations with diet quality and abdominal obesity: a cross-sectional study of young adults. *Int J Behav Nutr Phys Act, 6*, 29. doi:10.1186/1479-5868-6-29

Spangenberg, E. R., Crowley, A. E., & Henderson, P. W. (1996). Improving the store environment: do olfactory cues affect evaluations and behaviours? *Journal of Marketing, 60*(2), 67-80.

Speakman, J. R. (2013). Evolutionary perspectives on the obesity epidemic: adaptive, maladaptive, and neutral viewpoints. *Annu Rev Nutr, 33*, 289-317. doi:10.1146/annurev-nutr-071811-150711

Spence, C. (2015). Leading the consumer by the nose: on the commercialization of olfactory design for the food and beverage sector. *Flavour, 4*(1). doi:10.1186/s13411-015-0041-1

Spence, C., Puccinelli, N. M., Grewal, D., & Roggeveen, A. L. (2014). Store Atmospherics: A Multisensory Perspective. *Psychology & Marketing, 31*(7), 472-488. doi:10.1002/mar.20709

Stephens, D. W. (1981). The logic of Risk-sensitive foraging preferences. *Animal Behaviour, 29*(2), 628-629.

Subramanian, S. V., Perkins, J. M., Ozaltin, E., & Davey Smith, G. (2011). Weight of nations: a socioeconomic analysis of women in low- to middle-income countries. *Am J Clin Nutr, 93*(2), 413-421. doi:10.3945/ajcn.110.004820

Svaldi, J., Brand, M., & Tuschen-Caffier, B. (2010). Decision-making impairments in women with binge eating disorder. *Appetite, 54*(1), 84-92. doi:10.1016/j.appet.2009.09.010

Toates, F. (1998). The interaction of cogntive and stimulus-response processes in the control of behaviour. *Neuroscience and Biobehavioural Reviews, 22*(1), 59-83.

Tovey, M. (2017). *Obesity and the public purse. Weighing up the true cost to the taxpayer*. Retrieved from

Tremblay, M., Cocker, P. J., Hosking, J. G., Zeeb, F. D., Rogers, R. D., & Winstanley, C. A. (2014). Dissociable effects of basolateral amygdala lesions on decision making biases in rats when loss or gain is emphasized. *Cogn Affect Behav Neurosci*. doi:10.3758/s13415-014-0271-1

Turner, S. A., Luszcynska, A., Warner, L., & Schwarzer, R. (2010). Emotional and uncontrolled eating styles and chocolate chip cookie consumption. A controlled trial of the effects of positive mood enhancement. *Appetite, 54*, 143-149.

van der Heijden, A., Hu, F. B., Rimm, E. B., & van Dam, R. M. (2007). A Prospective Study of Breakfast Consumption and Weight Gain among U.S. Men. *Obesity (Silver Spring), 15*(10), 2463-2469.

van Strien, T., Cleven, A., & Schippers, G. (2000). Restraint, tendency toward overeating and ice cream consumption. *Int J Eat Disord, 28*(3), 333-338. doi:10.1002/1098-108X(200011)28:3<333::AID-EAT11>3.0.CO;2# [pii]

van Strien, T., Frijters, J. E. R., Roosen, R. G. F. M., Knuiman-Hijl, W. J. H., & Defares, P. B. (1985). Eating behaviour, personality traints and body mass in women. *Addictive Behaviors, 10*, 333-343.

van Strien, T., Herman, C. P., & Verheijden, M. W. (2009). Eating style, overeating, and overweight in a representative Dutch sample. Does external eating play a role? *Appetite, 52*, 380-387. doi:10.1016/j.appet.2008.11.010

Veugelers, P. J., & Fitzgerald, A. L. (2005). Prevalence of and risk factors for childhood overweight and obesity. *CMAJ, 173*(6), 607-613. doi:10.1503/cmaj.050445

Wallis, D. J., & Hetherington, M. M. (2004). Stress and eating: the effects of ego-threat and cognitive demand on food intake in restrained and emotional eaters. *Appetite, 43*(1), 39-46. doi:10.1016/j.appet.2004.02.001

Wang, Y. C., McPherson, K., Marsh, T., Gortmaker, S. L., & Brown, M. (2011). Health and economic burden of the projected obesity trends in the USA and the UK. *The Lancet, 378*(9793), 815-825. doi:10.1016/s0140-6736(11)60814-3

Wansink, B. (2004). Environmental factors that increase the food intake and consumption volume of unknowing consumers. *Annu Rev Nutr, 24*, 455-479. doi:10.1146/annurev.nutr.24.012003.132140

Wansink, B., Painter, J. E., & Lee, Y. K. (2006). The office candy dish: proximity's influence on estimated and actual consumption. *Int J Obes (Lond), 30*(5), 871-875. doi:10.1038/sj.ijo.0803217

Wansink, B., Painter, J. E., & North, J. (2005). Bottomless bowls: why visual cues of portion size may influence intake. *Obesity Research, 13*(1), 93-100.

Wardle, J. (2007). Eating behaviour and obesity. *Obesity Reviews, 8*(Suppl. 1), 73-75.

Warshawsky-Livne, L., Novack, L., Rosen, A. B., Downs, S. M., Shkolnik-Inbar, J., & Pliskin, J. S. (2014). Gender differences in risk attitudes. *Adv Health Econ Health Serv Res, 24*, 123-140.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and Validation of Brief Measures of Positive and Negative Affect: The PANAS Scales. *Journal of Personality and Social Psychology, 54*(6), 1063-1070.

Weller, R. E., Cook, E. W., 3rd, Avsar, K. B., & Cox, J. E. (2008). Obese women show greater delay discounting than healthy-weight women. *Appetite, 51*(3), 563-569. doi:10.1016/j.appet.2008.04.010

Westenhoefer, J., Broeckmann, P., Münch, A.-K., & Pudel, V. (1994). Cognitive control of eating behaviour and the disinhibition effect. *Appetite, 23*, 27-41.

WHO. (2016). Obesity and overweight.

Whybrow, S., Mayer, C., Kirk, T. R., Mazlan, N., & Stubbs, R. J. (2007). Effects of two weeks' mandatory snack consumption on energy intake and energy balance. *Obesity (Silver Spring), 15*(3), 673-685. doi:15/3/673 [pii] 10.1038/oby.2007.567

Winstanley, C. A., Dalley, J. W., Theobald, D. E., & Robbins, T. W. (2003). Global 5-HT depletion attenuates the ability of amphetamine to decrease impulsive choice on a delay-discounting task in rats. *Psychopharmacology (Berl), 170*(3), 320-331. doi:10.1007/s00213-003-1546-3

Yoon, J. H., & Higgins, S. T. (2008). Turning k on its head: comments on use of an ED50 in delay discounting research. *Drug Alcohol Depend, 95*(1-2), 169-172. doi:10.1016/j.drugalcdep.2007.12.011

Young, L. R., & Nestle, M. (2002). The Contribution of Expanding Portion Sizes to the US Obesity Epidemic. *American Journal of Public Health, 92*(2), 246-249.

Zhou, Y., Gao, X., Chen, H., & Kong, F. (2017). High-disinhibition restrained eaters are disinhibited by self-regulatory depletion in the food-related inhibitory control. *Eat Behav, 26*, 70-75. doi:10.1016/j.eatbeh.2017.01.010

Ziauddeen, H., Farooqi, I., & Fletcher, P. C. (2012a). Food addiction: is there a baby in the bathwater? *Nature Reviews Neuroscience, 13*(7), 514-514. doi:10.1038/nrn3212-c2

Ziauddeen, H., Farooqi, I., & Fletcher, P. C. (2012b). Obesity and the brain: how convincing is the addiction model? *Nat Rev Neurosci, 13*(4), 279-286. doi:10.1038/nrn3212