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**IMPULSIVITY AND EATING BEHAVIOUR: AN EXAMINATION OF  
SUBTYPES OF IMPULSIVE BEHAVIOUR AND OVEREATING IN HEALTHY  
FEMALES**

**By**

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Thesis submitted to the University of Sussex for the degree of  
Doctor of Philosophy

April 2010

Department of Psychology, University of Sussex

## **DECLARATION**

I hereby declare that this thesis has not been and will not be submitted, in whole or in part to another University for the award of any other degree.

Margaret Ann Leitch

15<sup>th</sup> April, 2010

## **ACKNOWLEDGEMENTS**

I would like to offer my gratitude to the participants who completed my studies. Clearly, this would not have been possible without their help. I would also like to thank my students in Research Methods who offered advice regarding various recruitment strategies, and how to secure participant arrival times. The latter was likely one of the bigger challenges in this undertaking.

My supervisor, Prof. Martin Yeomans, offered me a position as a Research Associate, and subsequently a D.Phil research post after completion of my Master's at Liverpool. Your mentoring style, and passion for science are two inimitable qualities. Thank you for sharing both with me.

My friends in the laboratory have had a huge impact on my life and world perspective, and I was only too happy to engage in (too many) long-ish debates. Lucy, Emma, Sarah, and Natalie thank you for your support, buying tea bags, and helping me out when things got a bit rocky.

Of course, none of this would have been possible without the support of my family. I would love for this section to be limitless, because I could fill another thesis on this exact theme. However, due to time and space constraints, it is important that I express my gratitude to Wendy, George, Kathleen, and Don. Your unwavering support allowed me to finish this project.

Finally, thank you to Ignacio. The completion of this project marks the end of one Chapter, and beginning of many others.

**UNIVERSITY OF SUSSEX**

**MARGARET ANN LEITCH**

**D.PHIL EXPERIMENTAL PSYCHOLOGY**

**IMPULSIVITY AND EATING BEHAVIOUR: AN EXAMINATION OF  
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A wealth of support has shown higher levels of state and trait impulsivity can be found among those individuals prone to developing problematic eating behaviors and obesity. Thus, upon commencing the investigations in this thesis, it was hypothesized that impulsivity is an individual difference implicated in overeating behaviour.

Increasing information indicates that there are divisions within impulsivity subtypes. Prior to this thesis, studies in the field of eating behaviour had not distinguished between subtypes of impulsivity. This was problematic because it limited researchers ability to describe how impulsivity is specifically involved in the perpetuation of overeating behaviour.

The purpose of this Thesis was to provide a methodical inquiry into the relationship between impulsivity, and its relation with overeating behaviour. This objective was achieved by separating three priorities, first to determine if impulsivity was higher in women who self report overeating, second to define differences between impulsivity classifications and determine if there was a consistent pattern between self reported overeating and a relation to a subtype of overeating behaviour, and third to designate a specific impulsivity subtype to individuals who self report overeating behaviour.

Six Experimental Chapters explored these three priorities. Two exploratory correlational/regression analysis were used to refine our ability to operationalize measures of self reported overeating and impulsivity (Chapters 2 and 5). Chapter 3 and Chapter 5 were devoted to assess the impact that ingestion of palatable food, and the violation of cognitive boundaries of restraint, have on subsequent impulsivity. The two remaining investigations were structured to assess the impact that environmental factors have on impulsive behaviour. In Chapter 4, a Controlled versus Unrestricted eating environment were manipulated to determine whether overeaters benefit from a structured breakfast meal prior to completing a battery of impulsivity tasks. In Chapter 7, anticipation for a rewarding food item was manipulated in two conditions. In this final Chapter, the impact that anticipation for rewarding food in self reported overeaters was assessed.

The battery of impulsivity tasks in this thesis include the Balloon Analogue Risk Task (BART), The Go No Go task, the Matching Familiar Figures task (MFFT), and two versions of the Delay Discounting Task (DDT). Impulsivity was classified along a spectrum of Reward Reactivity versus Inhibition subtypes, based on Evenden's (1999) classification of impulsive behaviour. Participants tendency to overeat was based on a dual classification of tendency to restrain eating (Three Factor Eating Questionnaire-Restraint) with tendency to overeat (Three Factor Eating Questionnaire-Disinhibition subscale). The outcomes of the five experimental investigations in this thesis demonstrated a reliable pattern by which participants with high Disinhibition scores had

significantly more impulsive responses on the MFFT task. These results indicated that inhibition impulsivity is the clearest individual difference to be found between healthy volunteers who self-report overeating. The role that Inhibition Impulsivity plays in the perpetuation of overeating behaviour is illustrated and discussed in each Experimental Chapter.

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## **Part 1: How psychological research clarifies individual differences that are related to the motivation for overeating**

Human obesity threatens to be one of the greatest preventable sources of mortality in both western(Lenz, 2009) and perhaps shockingly, developing societies(Misra, 2008). Obesity is becoming one of the greatest challenges to longevity of the twenty first century; one in ten deaths in the US can be attributed to obesity and the secondary health implications associated with overweight, including several forms of cancer, infertility, cardiovascular disease, and type two diabetes mellitus(Daniel, 2009), and this informationcompels health care professionals to act immediately.

The tremendous increase of overweight and obesity is well documented in health and psychological research fields: obesity has risen from 13% to 32 % between the 1960's and 2007 in the US, and currently 66% of American adults are overweight (Y. Wang & Beydoun, 2007). These figures are based on adults' self report assessment and it is therefore likely the percent of overweight is even higher than estimated; people typically under-report their weight in relation to height (Visscher *et al.*, 2006).The scope of this problem becomes even greaterwhen considering the economic implications of obesity; presently, 9% of medical expenditure in the US is attributable to overweight and obesity (Flegal, 2005), in a system which is almost entirely privatized. Since Britons and Europeans pay for a socially supported health care system, obesity is not only a health dilemma, but an economic one too. For these reasons, the current environment has been dubbed "obesogenic" or even "toxic" by many health care professionals (Silverglade, 2008).

How have so many people become overweight so quickly? Clearly, technological progress has fostered environmental changes, and the culmination of these changes has contributed to the surge in weight gain across populations. Obesity can be attributed to an imbalance between energy intake and energy expenditure fostered by the reduction of physical activity paired with increased access to food (A. Drewnowski & Rolls, 2005; Hill, 2009; Hill & Peters, 1998; Hill, et al., 1998; Lake & Townshend, 2006). Compared to other health epidemics, the mechanics of accumulating excess weight are

relatively basic; when the total calories consumed are greater than total calories used, a resulting Positive Energy Balance is achieved:  $E_{in} > E_{out}$  = Positive Energy Balance.

Maintaining a Positive Energy Balance over time leads to accumulation of adipose tissue (fat), which is well established as the primary cause of overweight or obesity (Doucet & Tremblay, 1997).

Maintaining a Negative Energy Balance ( $E_{out} > E_{in}$ ) over time would seem like a relatively uncomplicated strategy to reduce the amount of stored energy (adipose tissue) that one has accumulated, and therefore it would seem the change from being overweight to lean would be a relatively simple problem. However, obesity statistics illustrate the true scope of this problem: 85% of people who reduce their weight through calorie-controlled diets ultimately regain all weight lost within 2 years (Annunziato & Lowe, 2007; Avenell, et al., 2004). These statistics demonstrate the urgent need to clarify the underlying factors of the motivation to eat, and especially to overeat.

Clearly, our current environment enhances overeating for a large percentage of the population, yet many people still remain lean. Distinguishing the individual differences that contribute to overeating is a strategy that would enhance health care professionals' ability to effectively manage overeating which is one of the most obvious contributing factors in the development of overweight (C. Davis, Carter, J.C., 2009), and hence, obesity.

Despite progress made regarding our awareness of the detrimental consequences of a diet rich in fat and sugar (Berman & Lavizzo-Mourey, 2008; Gonzalez-Zapata, et al., 2008); many people continue to consume high energy dense (HED), palatable foods. The current food environment, with numerous opportunities to find HED and tasty low-cost food (A. Drewnowski & Rolls, 2005; Hill & Peters, 1998) contributes to weight gain, but far more pressing is that these foods *specifically* encourage consummatory responses (Blundell & Finlayson, 2004; Erlanson-Albertsson, 2005; Kelley, et al., 2002; M. R. Yeomans, Blundell, & Leshem, 2004) to which certain individuals may be especially sensitive. Therefore, certain individuals appear to be at a greater disadvantage in the current environment than others (Cohen, 2008; L. E. Stoeckel, Weller, R.E., Cook III, E.E., Twieg, D.B., Knowlton, R.C., Cox, J.E., 2008). Thus, investigating those



individual differences that are linked with overeating, is a critical area within eating behaviour research that demands greater attention.

The aim of this General Introduction is to provide context for psychologically based theories of eating motivation, and to explore psychologically based individual differences that contribute towards overeating. A critique of earlier homeostatic and physiologically based models is provided, followed by models of eating behaviour that include more nuanced views of the motivation to eat that incorporate psychological factors such as the oscillation between dieting/ overeating in addition to what underlies pleasure in eating HED foods. An important question to address is why the drive for pleasant experiences (such as eating palatable food) overrides physiological hunger signals? Moreover, an important concern is to identify the individual differences that express a vulnerability for overeating pleasant tasting, High Energy Dense food. The role that pleasure plays in eating has direct implications with the second major theme of this thesis, which is the role impulsivity has in perpetuating overeating behaviour.

Impulsivity is gaining momentum as a marker for susceptibility to weight gain (R. Guerrieri, 2007; R. Guerrieri, Nederkoorn, & Jansen, 2007a, 2007b; A. Jansen, et al., 2009; C. Nederkoorn, Braet, Van Eijs, Tanghe, & Jansen, 2006; C. Nederkoorn, Jansen, Mulken, & Jansen, 2006; C. Nederkoorn, Smulders, Havermans, Roefs, & Jansen, 2006; C. Nederkoorn, Van Eijs, Y., Jansen, A., 2004a) and the over-riding aim of the work presented in this thesis is to address whether impulsivity as a trait is significantly more pronounced in women who self report overeating, and then to identify the *type* of impulsive behaviour that is most directly related to overeating behaviour.

One finding over the course of the last five years, is the idea that overconsumption of HED food may demonstrate an individual's general preference for instant gratification (Epstein, Dearing, Temple, & Cavanaugh, 2008; Weller, Cook, Avsar, & Cox, 2008). As such, those people with "simple" obesity (please see page 8 for a definition), who trade off instant gratification (consumption of pleasant tasting food,) for abstaining a less instantaneously rewarding alternative, but ultimately more satisfying state (ie. a healthy body weight), consistently demonstrate choices that psychologists deem "impulsive".

Impulsive Choice refers to an exchange for instant, small rewards instead of delayed, larger ones. Impulsivity, and impulsive choice, is a problem for many individuals in the broader category of health-risking behaviours, which include smoking, increased alcohol consumption, and use of illicit drugs (Congdon, 2009; Crews, 2009; Dawe & Loxton, 2004). Determining the extent to which individuals who self report overeating also engage in impulsive choices, is thus a key research question in this thesis.

The work presented in this General Introduction is organized to present theories of the motivation to overeat, and secondly how greater impulsivity could override one's best intentions for healthy eating. In the second part of this Introduction, the extent to which impulsivity is involved in perpetuation of unhealthy eating behaviour is explored. In analyzing these issues, the hypothesis that impulsivity encourages overeating, in addition to the idea that unhealthy eating behaviour provokes greater impulsiveness is reviewed.

### *1.1a How Overeating contributes to Obesity*

The definition of overweight and obesity requires the use of a ratio known as the Body Mass Index (BMI), which is a way to compare weight (kg) in relation to height ( $m^2$ ), a BMI between 18.5- 24.9 is considered normal or lean, 25-29.9 overweight, and a BMI of 30 and over is considered obese. It is clear that maintaining a healthy body weight (i.e.  $BMI \leq 25$ ) is highly challenging for the majority of adults today (M. R. Lowe & Levine, 2005; Visscher, Viet, Kroesbergen, & Seidell, 2006).

At present, there are over 1 billion overweight adults, and 300 million obese adults. The majority of people in this group suffer "simple" obesity, which is now generally accepted to be the consequence of a Positive Energy balance (WHO, 2009). It does not include individuals who have developed a weight problem as a consequence of known biological risks, such as drug-induced obesity, morbid obesity, or Prader-Willi syndrome. Simple obesity could be summed up as an accumulation of adipose (fat) tissue as a response to habitual consumption of too much food relative to energy output (WHO, 2003).

In the case of simple obesity, positive energy balance is likely achieved through consumption of pleasant tasting HED food), and lack of exercise (WHO, 2003). It has been estimated that as little as one extra potato chip per day leads to a yearly 10-lb weight increase (Wansink & van Ittersum, 2007). As such the potential impact of overeating, even if occasional, is especially hazardous for those individuals who have a pronounced tendency for eating these kinds of foods. In other words, those individuals who show an inability to resist the temptation to overeat pleasant foods represent those with the greatest risk for developing obesity.

Efforts have been initiated to educate people about healthy eating (Hill, 2009), such as food labeling, which has become a major priority in Britain (Berman & Lavizzo-Mourey, 2008), Europe (Gonzalez-Zapata, et al., 2008), and North America (Berman & Lavizzo-Mourey, 2008). Thus, while education regarding certain types of food and healthy eating habits seems to be a priority at both community and federal levels, the core culprit of developing overweight, which is overconsumption of food (Bellisle, 2009; C. Davis, Levitan, Muglia, Bewell, & Kennedy, 2004; P. K. Davis C., Levitan R., Reid C., Twee S., Curtis C., 2007), is clearly a behavioural dilemma that has not yet been resolved.

## **1.2 Theories of Eating Motivation**

Early theories of Eating Motivation characterized an individuals' ability (or inability) to follow a calorie-controlled diet that was based on a physiological and biologically-based rationale (Nisbett, 1968a; Schachter, 1971; Schachter, Goldman, & Gordon, 1968; Schachter & Gross, 1968). Research in this field has progressed significantly, and these initial theories provided the stage for future progress into the research field of Eating Behaviour.

The work presented in this section describes the progress of our understanding from a physiological stance that utilized the concept of homeostasis to describe the origin of dieting behaviour to a more refined perspective, afforded by advances in research and technology, that incorporates psychological aspects of eating motivation and the perception of pleasure in eating.

### *1.2a Early Research into the Motivation for Overeating: Nisbett's Set Point Theory, and Schachter's Externality Theory*

The earliest model of eating motivation incorporated the idea that one's body size is determined primarily by genetic factors, and our metabolism was analogous to a thermostat. Nisbett's Set Point theory (1968) proposed that individual differences in body weight were a reflection of genetic or inherited body-weight "set points" (Nisbett, 1968a, 1968b). Body weight was proposed to be regulated by inherited metabolic rate and appetite; the thermostat analogy was used to describe how one would cope with large changes to their genetically predetermined "set point", based on the energy input, the individual's "set point" would regulate itself, and when not enough calories were consumed, the body strived to protect itself against starvation or deviation from this set point. According to this theory, weight gain was not a problem for individuals with a naturally low set point, however for those unfortunate individuals for whom obesity was a problem, being overweight or even unhealthy (a term that is arguably subjective pending on cultural standards) was an unavoidable fate. Nisbett interpreted the observation that overweight and obese individuals tended to self-report an inability to lose weight, despite being hungry or eating very little, as support for this theory.

In order to address the origin of the overweight individuals' increased body size, Schachter (1968) proposed a link between sensitivity to external cues (as opposed to internal, physiological hunger signals) and obesity. His work was the first to suggest that obese individual eat for non-physiological *external* motivations, in essence "internal state is irrelevant to eating by obese, and that external, food-relevant external cues could trigger eating for such people." (p. 97).

Subsequent research has verified this notion; obese individuals are indeed vulnerable to overeating after exposure to food cues, most especially the sight or smell of food, or designated eating times (eating dinner at a prescribed time, as opposed to when one is truly hungry) (Bellisle, 2009; Nijs, 2009; Pudel, 1977). In original investigations regarding the "externality" of obese individuals, Schachter pioneered a method of testing participants called a preload paradigm, which is now well known in Eating Behaviour laboratories.

Schachter's initial investigations into psychological factors of eating behaviour (Schachter, 1971; Schachter, et al., 1968; Schachter & Gross, 1968) included experiments whereby one condition had groups of obese and lean individuals who were fed roast beef sandwiches (deemed a "preload", defined as a fixed quantity of food that had to be eaten prior to an intake test) and groups of lean and obese participants who were not fed (a comparison control condition). Key interest was in how much food was consumed at a subsequent intake test, disguised as a taste test. In line with Schachters' view that the obese participants would be internally *insensitive*, the obese participants ate the same amount of food, regardless of the roast beef sandwiches (preload). In contrast, the lean participants ate significantly less after eating the preload.

This preload design has now been widely adopted as a test of response to nutritional load, with two quite different uses of preloads. Studies examining the effects of nutrient content on appetite tend to vary the amount of energy or macronutrient content in the test preloads, introduce a delay between preload and test, and then test for the degree to which subsequent intake is adjusted (Nijs, 2009; Pudel, 1977). In contrast, there are also a group of studies modelled more closely on impact of preloads (i.e. the extent of knowing you have eaten one food alters intake of the next). Such studies have been particularly important in the development of Restraint Theory, reviewed below (page 9).

Following his original success, a series of subsequent preload studies by Schachters' group have also confirmed this trend (Goldman, Jaffa, & Schachter, 1968; Nisbett, 1968a, 1968b; Pudel, 1977; Schachter, 1971; Schachter, et al., 1968; Schachter & Gross, 1968). Problematically, Schachter's observations did not explain the origins of obese individuals' heightened sensitivity to external as opposed to internal hunger signals.

Drawing upon the tenets of both Externality and Set Point theories, subsequent researchers proposed that the origin of overeating behaviour could be traced to an individuals' attempt to conform to an unnaturally lean body type or "low" set point. The idea that social pressure to achieve an unnaturally low Set Point inspired Herman & Polivy's Restraint Theory, and the Boundary Model of dieting, which has since dominated psychological models of individual differences regarding the tendency to overeat.

### *1.2b Does Dieting Lead to Overeating? Herman and Polivy's Restraint Theory and the Boundary Model of Dieting*

Dietary Restraint was originally defined as the cognitive restriction of food intake a person used to control their current body weight (C. P. Herman & Mack, 1975; C. P. Herman, Olmsted, & Polivy, 1983). Specifically, those defined as “high” on measures of “restraint” can be thought of as having a tendency to eat less than desired. Based on the original proposal that individual Set Points were a result of genetic influence, beyond individual control, Herman and Polivy (1980) were the first to propose that “Restraint” led to behavioural adaptations such as weight reduction, weight maintenance, and perhaps in extreme cases, eating disorders pending on the severity of the individuals’ displeasure with his or her body set point (Allison, Heshka, Gorman, & Heymsfield, 1993).

A 10-item psychometric questionnaire, called the revised Restraint Scale (RS) was devised by Herman and Polivy (1975) and was believed to assess two aspects of dieting behaviour, the first being a general Concern with Dieting (CD) and second, weight fluctuation (WF) (i.e. “Would a weight fluctuation of 5lb affect the way you live your life?” or, “What is your maximum weight gain in one week?”). Original investigations combined classifications of women as restrained or unrestrained depending on their scores on the RS, and laboratory measures of eating behaviour in situations which were predicted, based largely on Schachter and colleagues work on externality and Nisbett’s interpretation of the origin of obesity or “set point” theory, that Restrained women would consume more food than those who were not Restrained.

The RS was tested in the laboratory in order to verify its ability to predict *actual* versus *self-reported* eating behaviour. Using a variation of the Schachter’s “preload paradigm”, lean females with high scores on the RS were categorized as Restrained Eaters and those with low scores were classified as un-Restrained eaters (Herman & Mack, 1975). All participants were given either preloads of pleasant tasting, high calorie food such as a milkshake, or were not fed. Following this initial phase, subjects were asked to try certain types of ice cream for a “taste test” and were asked to consume as much ice

cream as desired for a 15-minute period. Authors found that preloads led to diverging eating patterns of ice cream between Restrained and non-Restrained eaters; Non-restrained eaters followed a predictable eating pattern and they ate less ice cream after eating a milkshake. Restrained eaters, however, ate less ice cream after not being fed, and more ice cream after receiving the milk shake preload.

The Restraint group followed what Herman & Polivy have deemed a “counter regulatory response”, which occurs when a person abandons cognitive control and engages in a “disinhibited” form of eating (C. P. Herman, et al., 1983). In light of these findings, a Boundary Model of dietary restraint was proposed (Herman & Polivy, 1980), and the critical factors relating restraint to over-eating were the situations leading to breakdown of restraint (defined as Disinhibitors). Although early studies used the findings from the preload model as evidence of disinhibition of eating, interpreted as cognitive “disinhibitors” based on the notion that forced consumption of one food leads to thoughts such as “I’ve blown my diet”, Herman and Polivy identified other stimuli that elicit the counter regulatory or hyperphagic response, such as emotional arousal, cognitive load, food cues, alcohol, anticipation of deprivation, and stress (Hawks, Madanat, Smith, & De La Cruz, 2008; Polivy, Coleman, & Herman, 2005; Polivy & Herman, 2005; Westerterp-Plantenga, Wouters, & ten Hoor, 1991).

The original phenomena generated using the RS has had substantial impact on investigations of eating behaviour by psychologists and the greater health care community such as dieticians and also within the medical community (Dritschel, 1993; Gorman, 1995; Hill, et al., 1998; Lluch, 2000).

A central tenet of Restraint theory is that dieting itself is futile, and the increase of effort, money, and time spent on various attempts to restrict food intake and reduce body size elicits the “counter regulatory response” which is in itself responsible for weight gain (Hawks, et al., 2008; C. P. Herman & Polivy, 1982; Ravussin & Swinburn, 1992). The full implications of Restraint Theory, is that cognitive restriction leads to overeating, by virtue of the idea that dieting has a negative impact on metabolic rate when weight is lost thereby making weight gain more likely (Brownell, Greenwood, Stellar, & Shrager, 1986). This cycle is therefore responsible for triggering negative psychological and physiological consequences (Polivy & Herman, 2002).

Problematically, disinhibited eating or “counter regulatory response” has never been observed in overweight populations in the lab (M. R. Lowe, Foster, G.D., Kerzhnerman, I., Swain, R.M., Wadden, T.A., 2001; McCann, 1992; A. J. Ruderman, Christensen, H., 1983; A. J. Ruderman, Wilson, G., 1979; T. Van Strien, Ouwens, M.A., 2003). Recent portrayals of Restraint have suggested it represents an individuals’ tendency for oscillating between times of caloric restriction and overeating (Larsen, 2007). Thus, interpreting the true meaning of the Restraint related data has attracted a significant amount of controversy within the field of Eating behaviour (M. R. Lowe & Kral, 2006; M. R. Lowe & Levine, 2005), and the term “Restraint” may need to be qualified in terms of *intended* attempts versus *behavioural changes* in regard to control caloric intake (Larsen, 2007).

There are several reports that cite other reasons than simply the breakdown of restraint that accounts for overeating behaviour (Habhab, Sheldon, & Loeb, 2008; M. R. Lowe & Kral, 2006; C. F. Smith, et al., 1998; Williamson, et al., 2006). Indeed, the scale with its two components of WF and CF may have been spurious, as Herman and colleagues (2007) recently noted that the RS “tends to select dieters who exhibit overeating and disinhibitory eating, dieting and restriction of intake, and body dissatisfaction, and drive for thinness”...(i.e. Unsuccessful dieters)” (T. Van Strien, Herman, Engels, Larsen, & van Leeuwe, 2007). This third factor, drive for thinness, is how authors defend the utility of the RS in lean, as opposed to overweight participants. Recent reports using the RS have attempted to bridge the difference in “successful” versus “unsuccessful” dieters in terms of behavioural versus intended changes to their diet (Larsen, van Strien, Eisinga, Herman, & Engels, 2007).

In light of the surge of obesity rates, restricting caloric intake and making a cognitive effort to eat less than is desired is surely one of the more adaptive ways to cope with the current abundance of highly caloric, delicious food items (Larsen, et al., 2007). In spite of the Restraint Scale’s ability to identify those who intend to reduce caloric intake there is a serious limitation to the scoring method of the scale, which may account for the difficulty in replication of Restraint-based results. Restraint scores are derived based on a composition of scores on both the WF and CD scales, in essence the RS is comprised of *one* score despite the presence of two subscales. The single factor



structure eliminates the ability to discriminate subgroups within High Restraint groups (ie. Restrained Eaters high in CD versus low in WF, or Restrained Eaters low in CD versus high WF are not distinguished) and this potentially diminishes the precision with which a scientist can identify an individual prone to overeating or restricting behaviour.

This summary highlights the necessity for a measure capable of accurate assessment of overeating, in addition to a measure that detects an individual capable of consistently restricting caloric intake, as opposed to a general term such as “Restraint”, as the original RS model (Herman & Mack, 1975) initially proposed.

#### *1.2c Refinement of Restraint Theory and the Three-Factor Model of Eating Motivation: A Double Classification model to address The Paradox of Restraint Eating*

As noted earlier, in addition to the RS, there are two other widely used questionnaire-based measures of eating behaviour and self-reported overeating. The Dutch Eating Behaviour Questionnaire (DEBQ), which claims to measure Externality, Emotionality and Restrained eating and also The Three Factor Eating Scale (TFEQ) which has three subscales originally labelled Restraint, Disinhibition, and Hunger. These scales expressly aim to measure eating behaviour on a series of explicit subscales, as opposed to relying on a unified factor as per the original Restraint Scale.

Westenhoefer (1991), having recognized the shortcomings in the RS noted earlier, originally suggested that the most accurate assessment of eating behaviour required a combination between measures of tendency to restrict and overeat, and therefore advocated a combination of scores on the TFEQ-D and TFEQ-R scales as a way of discriminating the unsuccessful dieters assessed by the RS (i.e. Those who score high on both TFEQ-D and TFEQ-R) from those who maintain a successful dieting stance (high TFEQ-R but low TFEQ-D). Note that these successful dieters would not be differentiated on the RS, as they would score high on the CD but low on WF.

(J. Westenhoefer, Broeckmann, Munch, & Pudel, 1994), replicated the original Restrained Eating preload paradigm (C. P. Herman & Mack, 1975) in order to address the paradox regarding to ice cream consumption after a milkshake preload. Instead of using the RS, participants’ eating behaviour was assessed in terms of scores on both the

TFEQ-R and TFEQ-D subscales. The final outcome was that participants with high scores on *both* TFEQ-R and TFEQ-D subscales were the only individuals who ate more ice cream after a 200 mL milkshake preload, although those participants with high TFEQ-D scores ate significantly more than those individuals with low TFEQ-D scores. Westenhoefer's (1994) research indicates that a double classification structure is the most accurate way to calibrate a persons' eating behaviour, and proneness to "disinhibited" eating. Herman & Polivy's (1980) definition of Restraint, therefore, presents a classification that is not homogenous, and thus counter regulation is likely to be contingent on the combination of two behaviours: overeating *and* restriction. Therefore, Westenhoefer proposed that a susceptibility towards eating behaviour was most likely for those individuals with High Restraint and High Disinhibition scores. Critically, this model identifies three other distinct groups, who's eating behaviour also follows more nuanced distinctions than were permitted with the previous RS model: High Restraint and High Disinhibition (HDHR, similar to RS restrained eaters), High Restraint and Low Disinhibition (successful dieters), Low Disinhibition and High Restraint (overeaters), and Low Disinhibition Low Restraint (those who eat in response to physiological hunger need state).

Westenhoefer's position indicates that the HDHR group is akin to the high RS group whereas those individuals with LDHR would be successful in their attempt to keep their weight within their desired realm. As predicted by earlier Restraint data, the HDHR and HDLR groups consumed the most ice cream after the preload, however, contrary to Restraint predictions, the LDHR group ate the least amount of ice cream demonstrating that a classification of "unsuccessful dieters" (HDHR) and "successful dieters" (LDHR) is very useful.

The TFEQ has been reported to be the most widely used psychometric eating assessment (Bryant *et al.* 2008). The strengths of the TFEQ have been confirmed in a variety of empirical and longitudinal studies (Haynes, Lee, & Yeomans, 2003; M. R. Yeomans, Tovey, Tinley, & Haynes, 2004). Critically, there have been some tactical errors with regard to classification of eating behaviour. In a recent review of the TFEQ-D, authors suggest this scale also suffers misnomers, as the term Disinhibition "implies breakdown of inhibition" which leads to confusion in light of the term "disinhibited eating" used in the RS literature (Hawks, 2008), to say nothing of the use of the term

“Restraint” to describe a series of eating behaviours that are different from the original RS definition.

Misleading names notwithstanding, there is significant empirical support for the utility of the TFEQ scale within the field of eating behaviour research. The TFEQ-D scale has shown robust predictive validity regarding overeating behaviour, and it has been suggested high TFEQ-D scores are representative of a trait vulnerability to opportunistic eating in an obesogenic environment (Bryant, King, & Blundell, 2008). Also, TFEQ-R has been interpreted as concern for overweight, but most importantly the TFEQ-R seems to be the only psychometric measure that predicts *behavioural strategies* that the individual uses to avoid weight gain, such as preference for low fat foods, and portion control (Laessle RG, 1989; Williamson, et al., 2006) . The third factor, TFEQ-Hunger refers to the extent that an individual perceives their eating motivation to be internally or physiologically motivated; for example, feeling so hungry that an individual eats more than three times per day.

Both TFEQ-D and TFEQ-R scales have been validated in empirical studies of overweight, lean, successful and unsuccessful dieters (Hainer, et al., 2006; Provencher, et al., 2008; Rutters, Nieuwenhuizen, Lemmens, Born, & Westerterp-Plantenga, 2009; Rutters, et al., 2008; J. Westenhoefer, et al., 1994; Williamson, et al., 2006). Critically, the TFEQ-R is the only measure of dietary restriction that has had significant positive correlations with actual caloric restriction in a population attempting to maintain weight loss (Williamson 2006(Rutters, et al., 2009), and significant support indicates the TFEQ-D represents of a set of stable characteristics including eating behaviour, eating pathology and ultimately lifestyle, in essence what ultimately determines an individuals BMI (Bryant, et al., 2008).

Comparing the responses of individuals assessed with the TFEQ on “disinhibitors” (ie. the term used in Restraint-based literature to describe cognitive factors that would lead to overeating) reveals an interesting pattern of results. Eating responses to stress (Rutters, et al., 2009), consumption after preloads (Ouwens, van Strien, & van der Staak, 2003; J. Westenhoefer, 1991; J. Westenhoefer, et al., 1994), and intake after palatability manipulations (M. R. Yeomans, Blundell, et al., 2004) have all been shown to vary as an interaction between TFEQ-R and TFEQ-D. For example, although studies

using the RS have reported robust increases in food intake in women defined as restrained (i.e. unsuccessful dieters) in response to stress (Herman CP, 1975; Mills & Palandra, 2008), studies using DEBQ-R or TFEQ-R measures of restraint alone failed to find these effects (M. R. Lowe & Kral, 2006). The lack of ability to replicate the findings using the term “Restraint” is rectified, though, when *both* the TFEQ-D and TFEQ-R subscales are taken into account (M. R. Yeomans, Coughlan, E., 2009).

In an experimental investigation manipulating stress and eating incorporating the 2x2 design using TFEQ-D and TFEQ-R, HDLR women consumed the most food when unstressed, but reduced intake in response to stress (Haynes, et al., 2003). In contrast to predictions made by Restraint theory, HDHR and LDLR women both increased food consumption in response to stress, but LDHR women were unaffected by the stress manipulation (Haynes, et al., 2003; Hays, et al., 2002). Thus, neither TFEQ-R nor TFEQ-D alone accurately described the response to stress: only when both factors were taken into account did an accurate picture emerge. Similar findings with a manipulation of palatability was found within the four TFEQ groups, comparing intake with a pasta sauce that was “bland” versus “palatable”, the HDLR group significantly increased in intake in the “palatable” condition (and were deemed, in essence “over responsive”) whereas the LDHR did not show any differences in intake (M. R. Yeomans, Tovey, et al., 2004). Interestingly, the HDHR group showed a tendency to eat more, but less so than HDLR, suggesting that their degree of self reported cognitive control of caloric intake mediated the desire to eat more palatable food, perhaps a rare example of true restraint under laboratory conditions.

These data demonstrate the necessity of discriminating self-reported behaviour with respect to caloric control versus overeating. The following section is devoted to the accuracy of self-reported overeating, as opposed to intended restriction, and its association with future weight gain.

### *1.3 Measuring overeating explicitly: the TFEQ-Disinhibition subscale*

Meta-analyses have consistently shown positive associations between scores on the TFEQ-D and BMI. In a study of 2509 adults (ranging from lean to obese) it was found that TFEQ-D scale was most predictive of high BMI, with overweight women reporting

high TFEQ-D scores (Bellisle, et al., 2004). A second, dietary intervention study has verified a similar pattern with positive associations between TFEQ-D and BMI, and also indicating a gender difference with women self reporting higher TFEQ-D and TFEQ-R scores compared to men (Provencher, 2003). In a meta analytic investigation of 1470 women, high scores on the TFEQ-D and TFEQ-H, but not the TFEQ-R were found to have a greater association with body size, whereas TFEQ-R related to body size through its interaction with TFEQ-D, showing individuals with high disinhibition and any level of restraint have higher BMIs than those individuals with low levels of TFEQ-D (Dykes, Brunner, Martikainen, & Wardle, 2004). Finally, in a 6-year investigation between eating behaviours and body weight changes, for overweight women a significant decrease in TFEQ-D was found among women who managed to control a habitual susceptibility to overeating whereas for men an increase in TFEQ-R was related to weight loss (Drapeau, et al., 2003). Taken together, these studies confirm both a strong relationship between the TFEQ and BMI, and also indicate gender differences act as an especially potent factor, with women self-reporting high TFEQ-D scores to be particularly vulnerable to future weight gain.

In preload studies using Herman & Polivy's milkshake paradigm, the TFEQ-D scores have been shown to be the best predictor of over consumption of ice cream (J. Westenhoefer, et al., 1994) and cookies (T. Van Strien, Cleven, & Schippers, 2000). Unsurprisingly, differences between TFEQ-D scores also reveal differing food preferences; cross-sectional studies found that those individuals with a high TFEQ-D are more likely to chose energy dense foods including processed meat, carbonated drinks, and sweet fruits and vegetables, and also have higher intake of sweet foods ice cream, and coffee (Contento, Zybert, & Williams, 2005; Lahteenmaki & Tuorila, 1995). In an investigation of chocolate consumption, it was found that women deeming themselves "chocoholics" who had the highest TFEQ-D scores, also consumed the most chocolate (Hetherington & MacDiarmid, 1993).

In summary, cross sectional and empirical data supports the idea that high scores on the TFEQ-D scale is associated with a general tendency to consume more of high ED, pleasant tasting food. It is worth considering why a person with a high TFEQ-D score is markedly more attracted to these higher energy dense (Bellisle, et al., 2004), and arguably more "rewarding" foods (Lundy, 2008).

A full investigation into the properties that makes certain foods more pleasurable than others is outside the realm of this thesis, and so a brief summary of the motivational components implicated in feeding and reward will provide a basis for the final aspect of this introduction. These components are necessary in order to support the hypothesis for this thesis, that impulsivity, in addition to high TFEQ-D scores, encourage overconsumption of energy dense, pleasant tasting food.

It is important to consider whether individuals who self report a tendency to overeat (high TFEQ-D, and to an extent high RS individuals) are also expressing an underlying sensitivity to rewarding stimuli, and the following subsection provides a brief review on the motivation to ingest pleasure-inducing substances.

#### *1.4 Food and Reward*

Over consumption of “palatable” foods has been implicated in the development of obesity (Yeomans *et al.*, 2004) and according to Cooling & Blundell (2005{Cooling J, 2001 #546}), obese individuals display behavioural risk factors, including patterns of eating, food selection and perhaps a “supersensitive hedonic capacity” (Yeomans *et al.*, 2004), which favor consumption of more pleasant tasting, thus likely higher ED, foods (Blundell, et al., 2005). To this point, evidence has supported the notion that high TFEQ-D scorers eat for the “rewarding” aspects of HED, palatable food. However, as previously stated, a systematic investigation of the original motivational cause for this relationship has not been made clear in the literature, and thus a synopsis of motivational origins of feeding behaviour is required.

It has been argued that those organisms capable of eating in the absence of hunger would have greater evolutionary advantage in their ability store energy for future times of scarcity (Blundell JE, 2001). With an abundance of readily available and affordable food in the modern environment, eating for pleasure is no longer restricted by economic considerations. Food is a readily available commodity, and in order to distinguish between eating for survival versus pleasure a “dual model” of hunger has been proposed, in attempt to distinguish between motivations underlying the need to eat in order to survive, versus eating for pleasure (Berthoud, 2007; M. R. Lowe & Levine, 2005).

The exact mechanisms that moderate food intake are not precisely understood, however with regard to pleasant and rewarding substances, Berridge & Robinson's model of psychological motivations to obtain rewards (2003), provides a platform allowing exploration into motives to eat for pleasure that implicate a hierarchical psychological process including learning, "liking" and "wanting" as well as the cerebral structures associated with these process.

The distinction between the two components identifies "Liking" as the expression of (positive) emotional affect in response to pleasurable (rewarding) behaviours in reaction to a stimulus. Examples include the facial expressions of decerebrated rats (Grill & Norgren, 1978), and babies smile after tasting a sucrose solution (Steiner, 1973). The implication is that Liking works in conjunction with neural circuits in the hindbrain, including the nucleus accumbens, ventral pallidum and limbic forebrain. Mu-opioid receptors, which are located in the olfactory bulb, nucleus accumbens, and several layers of the cerebral cortex, and some nuclei of the amygdala appear to have a critical role in eating for pleasure; for example, injection of DAMGO into the nucleus accumbens elicits voracious food intake, particularly of sweet high fat food (Kelley, et al., 2002; Zhang, Martin, Kelley, & Gridley, 2000). Notably, humans rate foods as less pleasant in taste when opioid receptors are blocked, leading to a broader hypothesis that opioids have a fundamental role in the neural expression of palatability (Hoebel, 1985; M. R. Yeomans & Gray, 1997; M. R. Yeomans & Wright, 1991). These findings help illustrate the extent that appetite is mediated by psychological factors, and why the taste of physiologically beneficial foods (such as sugar) elicits a psychological emotional feeling of pleasure.

The other crucial part of the model implicates "wanting", which Berridge (1996; 1998, 2003) suggest is a dissociated process from "liking", and critically, "wanting" has been shown to have distinct neural substrates from those underlying liking (see Searwards, 2004 for a review). This perception of "wanting" is drawn from research in the field of addiction. As with "liking", wanting is hypothesized to have an explicit (conscious) aspect and an implicit (unconscious aspect). According to Berridge and Robinson (1998{ , 2003 #58}) "wanting is a motivational, rather than an affective, component of reward. Its attribution transforms mere sensory information about rewards and their

cues (sights, sounds, and smells) into attractive, desired, riveting incentives.” The most crucial neurophysiologic components of wanting are the dopaminergic projections from the ventral tegmental area to the nucleus accumbens, part of the mesolimbic dopamine system (Dayan & Balleine, 2002; Wyvell & Berridge, 2000).

Repeated stimulation of the dopaminergic systems is believed to elicit neurophysiologic adaptations in other neurotransmitters; repeat exposures may lead to increasingly compulsive behaviour in pursuit of the reward to which the individual has become sensitized, as research in the drug literature has repeatedly shown that repeat drug exposure can have powerful effects (sensitization) of the “wanting” process (Avena, Rada, & Hoebel, 2007; Avena, Rada, Moise, & Hoebel, 2006; K. C. Berridge & Robinson, 2003; Berthoud, 2007; Boggiano, et al., 2007), where the “liking” remains unchanged (Cannon & Palmiter, 2003; Pecina, Cagniard, Berridge, Aldridge, & Zhuang, 2003).

According to this theory, repeated exposure to drug rewards leads to neuronal adaptations that favour or “sensitize” to that particular reward, focusing behaviour towards attaining that preferred substance, which later may lead to poor decision making and lifestyle choices in order to obtain it. Since the neural circuitry which is affected by drugs of abuse clearly did not evolve for that purpose, it has been widely assumed that drugs “short-circuit” motivational systems which evolved to control behaviours which are critical to species survival, including feeding, drinking and reproduction (Stalnaker, Roesch, Calu, et al., 2007; Stalnaker, Roesch, Franz, et al., 2007). It thus follows that the neural circuitry that underlies responses to cues related to drugs of abuse may also underlie responses to cues for rewarding food, and there is emerging evidence to support this idea: for example, dopaminergic activity in mid-brain areas associated with “wanting” appears to be modified in a similar way by someone who has a history of amphetamine use (which is known to cause sensitization) and in obese patients (Burke, Franz, Miller, & Schoenbaum, 2008; G. J. Wang, et al., 2001; G. J. Wang, Volkow, Thanos, & Fowler, 2004).

There is biological data that supports Berridge & Robinson’s predictions regarding neuronal changes in response to overexposure to reward. Significant negative correlations between concentration of dopaminergic receptors in the mesolimbic reward



pathway and BMI in both extremely obese individuals, and individuals who suffer from addiction to narcotics such as cocaine, has led researchers to speculate that obese individuals overeat in order to compensate for their insensitivity to the rewarding effects of food, relative to those individuals who do not overeat (Volkow, Fowler, & Wang, 2004; Volkow, Wang, Fowler, & Telang, 2008; G. J. Wang, et al., 2001; G. J. Wang, et al., 2004; G. J. Wang, et al., 2006; Y. Wang & Beydoun, 2007). In animal studies the relationship between repeated consumption of sucrose and behavioural sensitization has been validated empirically, for example rats after a month of 12-h exposure to *ad lib* high sucrose solutions, later responded to sucrose solution by “bingeing” (i.e. Unusually large bouts of intake), “withdrawal” (i.e. Signs of anxiety), and behavioural depression measured by enhanced responding for sugar (Avena, et al., 2007), which is also indicative of an addictive behaviour.

The neurobiological regulation of eating is infinitely more complex than drug behaviour; with eating there are multiple endocrine, peripheral, and central factors besides eating for its rewarding properties (Levine, Kotz, & Gosnell, 2003). However, the neurophysiological model outlined here explains the origins of “hedonically motivated” eating, and also compliments Cooling & Blundell’s (2001) evolutionary rationale for eating in the absence of hunger. This model explains *how* those organisms adapted the behaviour for eating in the absence of hunger and also underscores a cautionary note for individuals showing a “super sensitive hedonic capacity” (Yeomans, 2004), and also those individuals who self report a tendency to overeat (high TFEQ-D scores) as they may be at a greater risk to develop a pronounced preference for pleasant tasting HED, palatable food.

In this context, overeating “palatable” food could be an expression of underlying sensitivity to reward, and eating for pleasure could be classified as a risky type of behaviour. As such, it is worth considering other factors that are implicated in risk-behaviours, and one important factor is impulsivity.

## **Part 2: Impulsivity and its relation to Overeating**

Impulsivity is defined as a range of actions that are poorly conceived, prematurely expressed, unduly risky or inappropriate to situations leading to undesirable

consequences (Daruna, 1993). Impulsivity is normal and common in most species (Arons, 2007), however, increased impulsivity is linked as a key symptom of a large range of pathologies (Cloninger, 1987; Congdon, 2009; Pickering, 2001). Associations between impulsivity and appetitive addictions are both robust and bidirectional (Billieux, Van der Linden, & Ceschi, 2006; S. M. Brown, Manuck, Flory, & Hariri, 2006; Crews, 2009; Dawe & Loxton, 2004; Fernandez-Aranda, et al., 2006; C. Lejuez, Aklin, Zvolensky, & Pedulla, 2003). Critical to this thesis, impulsivity is significantly higher among women with binge-spectrum eating disorders (Rosval, et al., 2006; Steiger & Bruce, 2007; Steiger, Lehoux, & Gauvin, 1999; Steiner, 1973) , and impulsivity has recently been identified as a defining trait of obese individuals who have difficulty losing weight (C. Nederkoorn, Jansen, et al., 2006; C. Nederkoorn, Smulders, et al., 2006)

In light of the growing body of research supporting associations between impulsivity and vulnerability to appetitive addictive type behaviour, impulsivity has become a focus for considerable research interest in cognitive and affective neuroscience (Winstanley, 2007, Berridge 2009), and it has been suggested that impulsivity may be a characteristic that expresses an individual's capacity for developing addictive behaviours (Perry & Carroll, 2008) Impulsivity has recently attracted attention within the field of eating behaviour as an indicative characteristic of an individual's propensity for developing obesity (M. R. Lowe, van Steenburgh, Ochner, & Coletta, 2009).

A critical problem shared by both addicts of drugs, and those who are extremely overweight is the inability to resist temptation for consumption of either drugs or food, despite the obvious detriments to life quality and longevity. Despite considerable progress in understanding mechanisms of the rewarding effects of illicit drugs (K. C. Berridge & Robinson, 2003; Robinson & Berridge, 2000, 2001, 2003), there has been relatively little progress in understanding drug relapse or a clear model for extinguishing this un-adaptive behaviour (Koob & Le Moal, 2005; Schoenbaum, 2009). For these reasons, impulsivity, which can be a marker of poor decision-making, has a vital role in understanding an individual's vulnerability for developing appetitive addictive behaviour (Crews, 2009) and thus offers a novel characteristic to investigate in the context of individual differences associated with overeating.

Within the field of Eating Behaviour, researchers have begun to uncover important associations between impulsivity and obese or overweight populations. For example, Guerrieri et al (2008) defended the thesis that the obesogenic environment is particularly precarious for impulsive individuals, therefore illustrating an important interaction between environment and psychological traits that contribute to future weight gain (Nasser, Gluck, & Geliebter, 2004; C. Nederkoorn, Braet, et al., 2006; C. Nederkoorn & Jansen, 2002; C. Nederkoorn, Jansen, et al., 2006; C. Nederkoorn, Smulders, et al., 2006).

There are also reports indicating that impulsivity is significantly related to binge eating (C. Davis, et al., 2008; Fischer, Smith, & Cyders, 2008; Nasser, et al., 2004; Steiger, et al., 1999), which has important relevance with regard to the theme of the current thesis which is to explore whether impulsivity is also associated with a self reported tendency to overeat (in the form of high TFEQ-D scores). Researchers have suggested a sense of “urgency” contributes to risk in bulimic and bulimia-spectrum disorders (Dawe & Loxton, 2004). These studies may offer correlational support for the association between overeating HED food and impulsivity, however within animal research, where researchers have the ability to manipulate exposure to quantities of rewarding substances (like sugar (Avena, et al., 2007; Avena, et al., 2006), or cocaine (Belin, Mar, Dalley, Robbins, & Everitt, 2008) there has been a consensus that impulsivity, *specifically*, mediates the transition from experimental consumption, to habitual and compulsive use (Belin, et al., 2008; Berman & Lavizzo-Mourey, 2008). Taken together, these data present a novel idea which is that impulsivity itself is a critical individual difference positively related to appetitive addiction, and thus should be considered with regard to understanding the motivation or overeating.

#### *1.2.1a Current Limitations of Impulsivity Based research*

In contrast to the bounty of information regarding impulsivity and addiction, less is known about obese individuals, and even less has been explored in women who simply self report overeating, but are not (yet) overweight and their levels of impulsivity.

A concern within the field of impulsivity research in general, is that impulsivity is a “multi dimensional” construct (Amodio, Master, Yee, & Taylor, 2008; Aron, 2007; S. M. Brown, et al., 2006; Cardinal, 2006; Congdon, 2009; Corr, Pickering, & Gray, 1997;

Dalley, Mar, Economidou, & Robbins, 2008; Eagle, 1993; J. L. Evenden, 1999; Fischer, et al., 2008; Milich R, 1984), thereby challenging one's ability to categorize impulsivity in a precise manner. Although there are notable challenges regarding the classification of impulsivity, the greatest limitation of impulsivity research, is the inability to determine whether impulsivity predates addictive behaviour, or rewarding substances somehow enhance impulsivity (Congdon, 2009; Crews, 2009), and the heavy reliance upon comparisons between healthy versus clinical groups does not help to clarify this dilemma.

In reviewing impulsivity and eating behaviour literature, it seems there are two major obstacles that limit our ability to draw conclusions regarding the role impulsivity plays in overeating behaviour. First, there is very little information that does not place an emphasis on either clinical populations, sufferers of drug addiction, sufferers of eating disorders, or obese individuals and their impulsiveness. Secondly, given the “multi dimensional” nature of impulsivity, there is little (if any) clarification regarding *which* subtype of impulsivity is most reliably associated with overeating behaviour. Given the wealth of support that indicates impulsivity plays a key role in both appetitive addictive behaviour and overeating, refining the current depiction of impulsivity is essential.

#### *1.2.1b Classifying Impulsivity by way of Personality and Psychobiological rationales*

The task of clarifying Impulsivity, a term that encompasses a constellation of behaviours involved in virtually every aspect of abnormal behaviour, has attracted researchers from almost every facet of psychology, ranging from personality based theorists to scientists in the field of affective neuroscience. Maneuvering through the numerous portrayals of this construct, to obtain the clearest idea of what belies the “multidimensionality” of impulsivity is hugely challenging to researchers interested in this field (G. Smith, Fischer, S., Cyders, MA, Annus, AM, Spillane, NS, McCarthy, DM., 2007). Striking the most careful balance between psychologically versus biologically defined differences of impulsivity was thus an important consideration for the preparation of our distinctions between the “subtypes” of impulsivity.

Impulsivity reflects a lack of appropriate functioning in several psychological processes and currently there is significant research devoted to underpinning the neurobiological

basis for a seeming inability to plan for future outcomes (S. M. Brown, et al., 2006; Bruce, et al., 2005; Eisenberg, et al., 2007; J. Evenden, Ensler, Jackson, & Stephan-Dahlin, 1998; J. L. Evenden, 1998a, 1998b, 1998c, 1999; Hariri, et al., 2006; Kalenscher, Ohmann, & Gunturkun, 2006; Winstanley, 2007; Winstanley, Theobald, Cardinal, & Robbins, 2004; Winstanley, Theobald, Dalley, & Robbins, 2005).

Part of the challenge posed to investigating impulsivity in conjunction with a second behavioural problem, is that a *variety* of measures and definitions of impulsivity exist. Indeed, there are several reviews regarding characterizations of this construct (Ainslie, 1974; Arce, 2006; Aron, 2007; Dawe & Loxton, 2004; Dickman, 1985; Eagle, 1993; J. L. Evenden, 1999; Kertzman, Grinspan, Birger, & Kotler, 2006). Yet it seems there is still little consensus regarding a clear model of impulsivity research (Aron, 2007; Fischer, et al., 2008; Kertzman, et al., 2006).

Impulsivity has become a domain of psychology that is split by those researchers with a focus on personality based research, and psychobiologists who focus on the neurobiological aspects of disregulated behaviour. Early impulsivity research was dominated by personality-based researchers such as Eysenck, Cloninger, Gray, and Zuckerman. These scientists' early models of impulsive behaviour have many overlaps, but there are also critical differences in their individual theories. Therefore, it has been argued that generalizing among these various definitions of impulsivity constrains clarity within the fields of abnormal psychology and addictive behaviour (Dawe & Loxton, 2004).

One of the first psychologists to explore impulsivity was Hans Eysenck. Although impulsivity was not one of his primary personality dimensions, the Impulsiveness ( $I_7$ ) (Eysenck, 1967) is a frequently used measure of impulsivity (Dawe & Loxton, 2004). Eysenck's  $I_7$  measures rash, unplanned behaviour without consideration of the consequences (thus relating to his one of his primary dimensions of personality, Psychoticism). Following this model, Cloninger's personality taxonomy (Cloninger, 1987) includes a specific reference to Novelty Seeking. Zuckerman (1978, 1994) proposed a similar model of impulsivity to Cloninger, which included a specific reference to Sensation Seeking, a tendency to seek out intense novel forms of sensation and experience, and ability to do so at the cost of future risks involved. Finally, Gray's

model of Behavioural Approach Behavioural Inhibition systems makes specific reference to our fight/flight reflexes, attempting to specify the neurotransmitters associated with novelty and sensation seeking (Pickering, 2001), and distinguishing between two subtypes of impulsivity explicitly: those that are related to behavioural approach systems (fight), and those that are related to behavioural inhibition systems (flight).

There are two problems that afflict each of the personality-based models of impulsivity. First, the biological rationale behind each of these models was obtained using humans self report data on pen-and-paper questionnaires, at a time when biological information could not be obtained, and these data were subsequently refined using Factor Analysis. This alone may have produced some spurious findings, since social desirability is often-cited as a shortcoming in general. A final concern is that many of these depictions of impulsivity suggested specific neurotransmitters associated with impulsive behaviour, without technology capable of analyzing the scientists' original claims (Smith, 2009).

Between the four definitions of impulsivity suggested, Dawe and Loxton (2004) argued there is reasonable overlap, which compelled researchers to compile all of these personality-based measures. Their final product is a robust model of impulsivity that distinguishes Rash spontaneous impulsivity from Reward Sensitivity/ Drive, which has been accepted as a genuinely satisfactory method of differentiating among the impulsivity subtypes (Congdon, 2009; Crews, 2009; Dawe & Loxton, 2004).

#### *1.2.1c Varieties of Impulsivity*

Dawe & Loxton's (2004) successful review of personality-based definitions of Impulsivity clarified much of the multi dimensionality associated with (personality based) definitions of impulsivity. However, one of the limitations of their review, was a lack of emphasis on objective biological differences between Rash/ Spontaneous and Reward driven modes of impulsive behaviour. Perhaps a more objective way of measuring impulsivity, is via performance based tasks and utilizing progress in animal behaviour research.

One of the most revered reviews of impulsivity sought out by psychologists and psychobiological scientists is Evenden's (1999) now classic paper, *Varieties of*

*Impulsivity*. Paramount to the review, Evenden pioneered the concept that impulsivity is multi-dimensional, that there are distinctions between *state* versus *trait* measures of impulsivity, and crucially, that impulsive behaviour cannot be reduced solely to one unique neurobiological system *per se*, but rather is the result of several neurochemical influences. Impulsivity and its relation to personality based psychology, psychiatry, and behaviour were traced, although the focal point of research relies on serotonergic systems in relation to impulsivity. The paper has acted as a catalyst for the current thesis by virtue of the skillful categorization of impulsive action, and clarification of biological antecedents to impulsive behaviour.

According to Evenden, varieties of Impulsivity can be grouped into four broad categories, which were based on empirical data comparing animals performance on impulsivity tasks with amphetamines, ethanol, and stimulation of serotonergic systems using 5 HT<sub>2</sub> agonists. The conclusion, which was arrived after ten years of empirically based laboratory studies, depicts these four aspects of impulsive behaviour; Preparation (Lack of), Execution Outcome, Premature Responding, and (Lack of) Persistence. These four dimensions can be generalized into two basic groups; *Reward Reactivity* versus *Inhibition*.

Evenden's concept of *Reward Reactivity* and *Inhibition* subtypes of impulsivity provide a genuine and useful distinction, without relying heavily on a reductionist argument regarding the precise specific cerebral origins of impulsivity, yet providing a clear biological rationale for the distinction between these two terms (Amalric, 1995; Baunez, 1998; V. J. Brown, Brasted, P.J., Bowman, E.M., 1996; M. Carli, Evenden J.L., Robbins T.W., 1985; M. Carli, Evenden J.L., Robbins T.W., 1985; J. Evenden, et al., 1998; J. L. Evenden, 1998a, 1998b, 1998c). The major strength of this classification system lies in the simplicity of distinguishing between two robust categories, Reward Reaction versus Inhibition, and also the stance that impulsivity is the result of an interaction between neurochemical antecedents as opposed to limiting each subtype of impulsivity with a specific neural correlate or cerebral structure, which makes the theory adaptable to future developments in impulsivity research.

#### *1.2.1d Reward Reactivity*

Sensitivity to reward is a key manifestation of the concept of Reward Reactivity.

Reward Reactivity, in the original *Varieties of Impulsivity* (1999) paper by Evendon, relates to Execution Outcome and Preparation, two subtypes that are described by an individual who does not take all relevant information into account before making a decision, and prefers quick but less valuable outcomes as opposed to waiting for later but more valuable ones.

Reward reactivity can describe an inability to suppress an overt or already engaged behaviour, including resisting temptation, delay of gratification, motor inhibition and impulse control (Hughes, 1998; Logan, 1994; Luria, 1966, Mischel et al 1989, as cited by (Kipp, 2005). Delay of Gratification tasks have been shown to demonstrate reliability and validity of reward reactive behaviour, particularly among children. In these paradigms, the subject is confronted with a “Smaller Sooner” and a “Larger later” reward, when the experimenter leaves the room; the participant is faced with the choice between two options. Either the child waits for the experimenter to return and hand out the larger or more preferred award, or the child rings a bell and the experimenter returns directly to hand out the smaller reward (Metcalf & Mitchell, 1999).

#### *1.2.1e Inhibition*

The ability to suppress or override competing behavioural responses is a key component of the cognitive process. Without the ability to guide one's own cognitive awareness, one would be swamped with irrelevant information, and unable to resist inappropriate urges. Inhibition is related to Premature Responding, insofar as it marks an individual's tendency to respond before discriminating information given.

Researchers in cognitive and developmental psychology postulate that within the domain of *inhibition* subtypes of impulsivity, there are again two subsets of process, differentiating between *inhibitory control* which leads to impaired processing, resulting in activation, maintenance, and retrieval of irrelevant information during cognitive processing (Kipp, 2005), and *Interference*, which refers to susceptibility to disruption of performance under conditions of multiple distracting stimuli, process, or responses.



At the time of this thesis, a literature search revealed Evenden's model had been used in 37 empirical investigations, and 6 reviews, as a model to discriminate between the "multi dimensional" aspects of impulsivity. While there are several trait and state based models of impulsivity in the field of personality based psychology, comparatively speaking, they lack the same biological clarity of Evenden's original paper. For the purpose of this introduction, and this thesis, Evenden's model of differentiating between broad categories of Reward Reactive versus Inhibition subtypes was determined as the most relevant model to discriminate between subtypes of impulsivity.

#### *1.2.1f Psychological Theories of Impulsive Choice*

Evenden clarified in his (1999) review that there were "several neurochemical mechanisms can influence impulsivity, and impulsive behaviour has no unique neurochemical basis", (p. 348). However, the extent of research focused on these chemical mechanisms deserves some evaluation in the context of this thesis, particularly as recent investigations have found a link between limbic systems and impulsivity which has direct relevance to the idea that *pleasure* associated with food consumption could plausibly be related to an inability to control impulsive reflexes. The following section covers the original hypothesis regarding the origins of impulsive behaviour? that did not include research into areas of the brain beyond the frontal regions, and progresses to current debates of the origin of impulsivity that incorporate *both* frontal *and* limbic regions in the brain, which further supports the likelihood of impulsivity being a strong candidate marking an individual's vulnerability to acting for the acquisition of *pleasurable* substances.

Ultimately, the goal is to understand a person's choice to overeat, and since impulsivity may play a role in both acquisition of a preference for rewarding food choices (which are typically highly palatable, and Energy Dense), in addition to maintaining a diet rich in these types of foods it is important to examine recent findings in the field of impulsivity, which also include references to addictive behaviour research.

#### *1.2.1.g Exploring the Orbito Frontal Cortex and Decision Making*

Evidence taken from human and animal studies shows those patients with damaged Orbito Frontal Cortex (OFC) are more impulsive than healthy controls. Specifically, a damaged OFC inhibits certain forms of learning: participants with damage to this region show an inability to refrain from responding to formerly rewarding cues that are no longer reinforced (Dias, Robbins, & Roberts, 1996)(Berlin, Rolls, & Kischka, 2004; McAlonan & Brown, 2003); (Schoenbaum & Roesch, 2005; Schoenbaum, Saddoris, & Stalnaker, 2007); and this behaviour, critically, is similar to habitual responding to cues that are no longer rewarding, which is a key sign of addiction (Schoenbaum & Roesch, 2005).

Historically, psychologists were among the first scientists to take marked interest in the frontal function of the brain. Work in this area can trace its origins to a single infamous individual, Phineas Gage (1823-1860), who is now a fixture in neurological and psychological research (Haas, 2007). Phineas Gage, by some accounts, was the original patient in psychology, when his frontal lobes were damaged after a massive iron bar that was propelled through his left cheek and skull in an accidental explosion (Harlow, 1948; MacMillan, 2000). After this accident, Gage regained consciousness, and survived for 12 years (Haas, 2007) and while he continued working, the change in his personality was remarkable; according to original reports made by his physician before the accident, Phineas was careful, thoughtful, and considerate- after the accident his behaviour was erratic, he was impatient, and unable to control his urges; withholding from temptation was impossible. The specific damage to Phineas was isolated to his OFC, which has inspired thousands of investigations into frontal function, and was thought to demonstrate the dissociability of specific cortical regions in regard to behaviour and personality (MacMillan, 2000).

Technology has enhanced our ability to explore the brain, and scientists have greater observational ability of the cortex area than ever before (Stuss & Alexander, 2000). Evidence shows a damaged prefrontal and orbitofrontal cortex is associated with poor performance on impulsivity tasks also (Berlin, Rolls, & Iversen, 2005; Berlin, et al., 2004). Phineas Gage's story illustrates that severe damage to the frontal regions is isolated to impaired ability for future planning and to an extent, personality traits.

Neuropsychological work on frontal lobe dysfunction has shown that patients with lesions on a specific part of the OFC, their ventromedial prefrontal cortex (VMPFC), tend to strongly discount or neglect the future consequence of future decisions (Bechara, Damasio, & Damasio, 2000). It was traditionally believed that the prefrontal cortex and OFC controlled temporal reward and behavioural impulsivity.

The orbitofrontal circuit, in addition to the basolateral amygdala (ABL) and ventral striatum are all closely related and interconnected in a circuit which is crucial to behaviour acquisition and learning (Stuss & Alexander, 2000), it is within this circuit that the brain can organize and integrate afferent inputs (i.e. sensory, affective and associative information (Carmichael & Price, 1995a, 1995b).

The orbitofrontal cortex (OFC) has been suggested to represent reward (Izquierdo, Suda, & Murray, 2004); in other words, future outcomes to be used for guiding goal directed behaviour (Schoenbaum & Roesch, 2005; Schoenbaum, Roesch, & Stalnaker, 2006), providing a set of “rules” per se, in relating to environmental situations. Impairment of this area may tip the “decision balance”(Crews, 2009) in favour of inappropriate responses, and most especially the preference for smaller sooner, versus delayed, *objectively* larger rewards. A homely example is an overweight individual’s choice to eat a chocolate bar as a snack, as opposed to seeking a healthier lower ED alternative, while on a diet.

The OFC appears to represent *subjective* value during decision-making, and since the OFC has been suggested to moderate impulsive choice (Mobini, et al., 2002) if this system is damaged, not only is appropriate responding unlikely, but also a perception that the smaller sooner reward *is* (at that moment), *more* valuable than a larger one, later. Thus, the fact that a damaged OFC is associated with compulsive consummatory behaviours such as hyperphagia, gambling, and substance abuse (Congdon, 2009; Crews, 2009) may not be so surprising. These actions have little, if any, long-term benefit, but the lack of a functional OFC may prevent the individual from rationally processing this information, and instead acting on the instant desire for a rewarding substance.

### *1.2.1.hOther Psychological Mechanisms involved in Impulsivity*

Although the OFC is involved in all forms of decision-making, challenges have been made to the proposition that impulsive choice is mediated solely by the VMPFC and OFC, which are briefly described here. Critically, this position argues that the interaction between the frontal and limbic areas produces impulsive choices, which fits within Evenden's (1999) hypothesis that impulsivity generally emerges from the interaction of systems within the brain. Moreover, this lends direct biological support for the idea that eating for pleasure and impulsivity would share strong associations by virtue of the similarity in cortical areas in the brain.

In human literature, there is evidence that two sub-systems in the human brain interact when making decisions between outcomes that differ in temporal proximity. Using fMRI involving a choice between rewards with different delays, McClure *et al* (2004) reported data which dissociates the cerebral origin of the two components of impulsive choice; short term impatience is driven by the limbic system, whereas Rational thought, or what some psychologists call Economic Planning, was associated with the lateral PFC and OFC, which evaluate the exchange in small but soon rewards in preference to large rewards received later. Following in line with Evenden's (1999) earlier work, this data demonstrates that impulsivity depicts malfunctions in both frontal and limbic systems and may explain the need for distinction between the two subtypes of impulsivity.

Immediate rewards recruit activity in the Para limbic areas associated with midbrain neurons, including Nucleus Accumbens (NAc), medial Orbitofrontal Cortex (medial OFC), and medial Prefrontal Cortex (medial PFC), whereas Long term planning seems to draw on cerebral resources concentrating on the lateral Prefrontal Cortex (lateral PFC) and posterior parietal cortex (McClure, Laibson, Loewenstein, & Cohen, 2004). This conclusion is consistent with the idea of several competing decision making networks in the brain (J. L. Evenden, 1999; Logan, 1995; Logan, Cowan, & Davis, 1984; McClure, et al., 2004).

Animal based investigations reveal a similar pattern of biological correlates for decision making, which challenge the idea that solely damaged OFC functioning leads to greater impulsivity. For example, lesions of the rodent nucleus accumbens (NAc), but *not* medial PFC or anterior cingulate cortex, result in greater impulsivity (Cardinal, Pennicott, Sugathapala, Robbins, & Everitt, 2001), also lesions of the basolateral amygdala (BLA) increase impulsiveness, but lesions of the OFC and sub thalamic nucleus (STN) actually *decreased* impulsivity (Winstanley, Theobald, et al., 2005). In light of these findings, Winstanley and colleagues challenged that the NAc and BLA may be important for representing and maintaining the subjective incentive reward across delay, and STN may be relevant for basic Pavlovian associations, and finally that the PFC plays a role in monitoring and updating the representations of the expected rewards but is not the central mechanism for controlling impulsive action.

To summarize, while it was once assumed the OFC, VMPC and PFC controlled impulsive decision, it appears that the NAc, BLA, STN (and OFC) also play distinct, yet contributing roles in impulsive behaviour. Finally, it has also been suggested that the PFC is a part of multiple neural networks that cooperate or compete with the generation of choice behaviour (Winstanley, Baunez, Theobald, & Robbins, 2005).

Winstanley (2005) has suggested that the differential behavioural effects after manipulating parts of these networks (NAc, BLA, STN and OFC) depend on the network mechanism, type of impulsivity paradigm, or experimental manipulation- in other words, a reductionist technique such as those employed with the latter example of Phineas Gage, have little true validity in predicting or explaining the origin of impulsive choice. The development from the idea that impulsivity is an expression of frontal dysfunction to a view that incorporates the brain stem and limbic area is a critical development, as this second view incorporates those same regions proposed to be affected by repeat exposure to reward in Incentive Salience Theory (Berridge, 1996), which provides a clear biological rationale for the link between increased impulsivity and vulnerability to addictive behaviour.

Winstanley's (2005) position argues that the origin of impulsive choice is the expression of neural networks processing lower level automatic processes of reward desire (limbic system), which are weighed by the future consequence and rational

planning in the OFC. Regarding the control of food intake, an obese person's inability to resist eating highly palatable HED food may be traced to a higher limbic drive for food reward, matched with an myopia for future gain associated with withstanding from this (seemingly) small reward (which would originate from frontal regions such as the OFC or VMPFC).

### *1.2.2 Impulsivity, Decision Making, and Reward*

The direct comparison of obesity with addictive behaviour offers an awkward analogy; in favour of this comparison, both eating and consumption of elicited drugs are associated with pleasure (Greeno, Wing, & Shiffman, 2000). However, the consumption of drugs (such as cigarettes, narcotics or alcohol) does not enhance or contribute to survival, whereas eating is not really optional. Moreover, since the choice to overeat includes components from the central nervous system, physiological inputs, in addition to psychological motivational components (Lowe, 2009) it could be argued that overeating is a considerably more complicated dilemma. Notwithstanding, behavioural aspects of overeating pleasant tasting food do show some remarkable similarities with overconsumption of drugs of abuse. Consider that despite extremely costly investment into weight loss programs (estimated at \$40 U.S. billion per year (Reisner, 2008 [http://www.businessweek.com/debateroom/archives/2008/01/the\\_diet\\_indust.html](http://www.businessweek.com/debateroom/archives/2008/01/the_diet_indust.html) ) coupled with the fact that 85% of those individuals who try to lose weight gain it back within two years.

Most importantly, if overeating was such an easy habit to extinguish, it is likely the obesity crisis would not exist. Critically, impulsivity has a pivotal role in most forms of appetitive addictive behaviour. Since appetitive addiction includes a range of behaviours (including consumption of elicited drugs, smoking, and recently binge eating (Pelchat, 2009), examples will be taken from each of these fields to demonstrate the critical role impulsivity has in differentiating addiction prone versus resistant individuals.

Recent investigations have found impulsiveness underlies both the initial experimentation with drugs (Carroll, Anker, & Perry, 2009; Perry & Carroll, 2008), the inability to stop substance abuse (Belin, et al., 2008), and critically that certain subtypes

of impulsivity more suited to discriminate animals' risk for developing compulsive habits with regard to the consumption of drugs (Crews, 2009). Since habitual overconsumption of food is likely the most difficult behaviour to change in the case of obesity (C. Davis, Carter, J.C., 2009; C. Davis, et al., 2004; S. S. Davis C., Berkson M., 2004; Pelchat, 2009), isolating the subtype of impulsivity most reliably associated with overeating would enhance our understanding of the individual risk factors positively associated with the development of obesity.

The concept of “willpower” is a critical area of addiction based psychological investigations. Mischel (1974) originally investigated delay of gratification tasks, and how a 4-year old child's ability to control the urge to eat one marshmallow in the laboratory in preference for 2 marshmallows after a 15 minute time delay, could relate to better long term planning and goal achievement later in life. Mischel began his original investigation into delay-of-gratification tests with a group of preschool children and subsequent longitudinal demonstrated that 4-year olds who were able to withstand temptation for eating the 1 marshmallow were also more attention, had better concentration, exhibit greater self control, and also score higher on the SAT and perceived as more interpersonally competent by parents and peers (Mischel, Shoda, & Rodriguez, 1989). Data also confirmed that children who waited for 2 marshmallows were less likely to subsequently use drugs (Ayduk, 2000).

Impulsive choice, or inability to perform in delay-of-gratification tasks would fit within Evenden's definition of Reward Reactive Impulsivity, and is also associated with abuse of cigarettes (S. H. Mitchell, 2004), marijuana (Kollins, 2003), alcohol (J. M. Mitchell, Fields, D'Esposito, & Boettiger, 2005), and cocaine (Coffey, Gudleski, Saladin, & Brady, 2003). It has been shown that adolescents who were more impulsive (defined as a pervasive choice for Small Soon versus Large Later rewards) were less likely to achieve abstinence from a smoking cessation program compared to adolescents who were less impulsive (Krishnan-Sarin, et al., 2007). In terms of eating behaviour literature, obese women are also significantly more impulsive on tasks that assess preference for Small Soon versus Large Later rewards (Weller, et al., 2008) and what is most directly relevant to the theme of this thesis, is that lean women who self report high TFEQ-D scores are also significantly more impulsive on a measure of delay

discounting than those with low TFEQ-D scores (M. R. Yeomans, Leitch, & Mobini, 2008).

A relatively new tool to investigate Reward Reactivity, is the Balloon Analogue Risk Task (C. W. Lejuez, et al., 2002). This is a laboratory performance measure of impulsivity that simulates real-life risk taking situations as participants are rewarded by their election to continue clicking on a balloon (each click represents a theoretical monetary value), or save the money they have accrued. The larger the balloon, the more money it is theoretically worth but so too is the possibility that all money will be lost with one explosion thus jeopardizing the participants greater goal of gaining as much money as possible. Participants do not have any knowledge or strategy to win money on this game, as the task is set to a Variable Ratio schedule, with balloons popping at random. As with real life situations, risk is rewarded until a certain point. When one balloon explodes, the participant is presented with another opportunity to pump up the next balloon, until the task is finished.

Greater explosions on the BART have been associated with self-report and real world measures of riskiness; for example, ever-smoking adolescents (those who have smoked even one puff) compared to never smoking adolescents were significantly more impulsive and reported significantly higher sensation seeking scores (C. W. Lejuez, et al., 2002). Performance on the BART has been reported with self-reported addictive, health and safety risk behaviours in young adults and adolescence beyond those that would be accounted for demographics (C. W. Lejuez, et al., 2003; C. W. Lejuez, et al., 2002).

A key question then is whether the BART measures Reward Reactivity or Response Inhibition in relation to Evendon's classification. Although there are arguments that both elements of impulsivity could contribute to poor performance on this task, overall it seems likely that the BART will be more sensitive to Inhibition Impulsivity, as Balloon Explosions are a product of a participants' *inability to stop* inflating the balloon, rather than a myopia for future outcomes in the form of preference for Small rewards Soon in contrast to Large rewards Later. In this way, the BART does not fit within the parameters of impulsivity prescribed by the terms of Reward Reactivity; an adaptive strategy on this task would be to pump the balloon as much as possible, thus if



a participant ascribes to a “Large Later” type of rationale, they will be deemed as impulsive (by virtue accruing more balloon explosions). As such, those participants who are able to control their clicks to the balloon with pauses and consideration for the size of the balloon in relation to likelihood for its explosion, are more likely to succeed in this task. As such, the ability to control responding is the key variable in this task, which would mean it is a task of Inhibition impulsivity.

The simple distinction of Reward Reactive versus Inhibition subtypes of impulsivity has significant bearing determining animals that are at risk for habitual compulsive consumption of drugs to those who merely experiment but do not develop a life threatening addiction. For example, recent findings have demonstrated that impulsive animals, who fit within Evenden’s classification of *Inhibition* subtype as opposed to *Reward Reactive*, are more vulnerable to habitual consumption of drugs (Belin, 2009). The finding that animals that could be categorized into a specific province of impulsive behaviour, Inhibition Impulsivity, and also had a significantly greater propensity for developing an addiction to cocaine demonstrates the utility of refining the hypothesis that “impulsivity” is generally associated with addictive behaviour. The following section is devoted to several animal studies which also demonstrate the value of classifying the impulsivity construct.

#### *1.2.2.a Impulsivity and Addiction: Animal Research*

A full review of animal work on impulsivity is outside the scope of this thesis and readers are referred to several excellent recent reviews for more detailed analysis (Amalric, 1995; Baunez, 1998; S. M. Brown, et al., 2006; V. J. Brown, Brasted, P.J., Bowman, E.M., 1996; Cardinal, 2006; Cardinal, et al., 2001; M. Carli, Evenden J.L., Robbins T.W., 1985; M. Carli, Evenden J.L., Robbins T.W., 1985; Dalley, et al., 2008; Everitt, et al., 2008; Kalenscher, et al., 2006; Olmstead, 2006; Oxoby, 2007). However, some of the outcomes of these studies have relevance to the broader concepts explored in this thesis, and are consequently discussed here.

Work within animal based research is beginning to underpin the mechanisms that most directly contribute to impulsivity. Among the theories emerging from this work is the idea that concentrations of dopamine D<sub>2/3</sub> receptors in the striatum are associated with escalated use of rewarding substances (Everitt, et al., 2008). Authors have proposed that

the development of addiction can be broken into three discrete components; of course, somewhat rhetorically, researchers have proposed that environmental and genetic factors play a role, but critically, impulsivity is a third key factor for identifying those animals that have a tendency for being addiction prone (Belin, et al., 2008; Everitt, et al., 2008).

In a novel investigation into those factors that predict addictive behaviour, researchers selected a group of animals based on their personality and impulsivity characteristics, choosing animals that were sensation-novelty seekers versus animals that were incapable of restricting their behaviour on a 5 radial choice task, as defining two subtypes of impulsivity (Belin, et al., 2008; Boggiano, et al., 2007; Everitt, et al., 2008). The novelty seeking (measured by explicit, distinct locomotor activity in new environments) would equate to Reward Reactive impulsivity, whereas the locomotor inhibition (performance defined as inaccurate performance on a 5-choice reaction time task (5-CRTT) of sustained visual attention, which requires the animal to focus on a correct stimulus despite input from the other four areas on the five other choices) would fit within Evenden's description of Inhibition impulsivity.

The Novelty Seekers were called High Responders (HR), and the animals who performed poorly on the 5-CRTT were deemed High Impulsive (HI), and critically, the HR selected did not have poor performance on the 5-CRTT, and the HI were not particularly active in novel environments, so each HR/HI classification represented *either* novelty seeking or inhibition.

To compare the vulnerability to substance abuse, or more specifically, the transition from experimental use to habitual compulsive consumption, the animals were compared in their predilection for cocaine self administration, and develop the addiction criteria established by the DSM in regard to self administration. Results showed that HR rats were more prone to *acquire* the behaviour of self-administration than Low Responders, although there was no difference between the impulsive groups. However, after a 40 day free access self administration period, it was found that HI rats showed higher addiction scores (assessed by an Addiction Score, an algebraic sum of normalized values for each of a series of addiction-like behaviours, which in rats is nose poking for cocaine). Authors suggest that one variety of impulsivity, an inability to wait and to

chose the correct alternative from an array of potential choices (based on performance on the 5-CSRTT), is a key behavioural marker specific for the vulnerability to progress to compulsive cocaine use, and that detecting pre-existing impulsivity provides a critical marker for addictive behaviours. This recent example substantiates the utility of differentiating between subtypes of impulsivity.

Finally, the importance of distinguishing between *acquisition* of a rewarding behaviour versus compulsive overconsumption is an important distinction. These results raise an important issue, which is the extent that Reward Reactivity can predict propensity for habitual consumption of a rewarding substance, versus simply experimentation with it. Critically, it is compulsive, habitual consumption of pleasant food (C. Davis, Carter, J.C., 2009), not just a preference for it, which facilitates the development of overweight. Therefore, these data compel us to adopt a strategy that explores individual factors that are specifically related to habitual consumption, as opposed to preference for rewarding foods. In this way, we are looking for factors that would be related to Berridge's concept of *wanting* as opposed to just *liking* of pleasant tasting food.

Belin *et al.*'s (2009) paradigm contrasting HR with HI, to our knowledge, has not yet been replicated in human studies. This may relate to the idea that Reward Reactivity and Inhibition are still expressed as more or less the same construct (ie. Impulsivity), but also the nature of the experiment, obviously, would be impossible for ethical reasons. However, the specific distinction between subtypes of impulsivity with regard to propensity for addictive behaviours is likely to increase in the future (G. Smith, Fischer, S., Cyders, MA, Annus, AM, Spillane, NS, McCarthy, DM., 2007). The objective of this final section is to provide a review of impulsivity literature in the field of eating behaviour research. Notably, the majority of studies lack comparisons between the subtypes of impulsivity, which limits our ability to observe or hypothesize *which* form of impulsivity is most likely associated with overeating.

#### *1.2.2b Impulsivity, Pleasant Tasting Food and Obesity*

In one of the earliest investigations of impulsive choice in lean and obese children (Bonato & Boland, 1983), researchers found that obese children showed a significant

preference for Small Soon rewards, particularly when the rewards involved choices for pleasant tasting food compared to either “nutritious” food, or activities. Lean children showed a stronger preference for non food items and activities, which demonstrates that impulsivity is pronounced for pleasant tasting food stimuli in obese children (Bonato & Boland, 1983)

Critically, the food environment plays a part in an individual’s ability to access highly caloric, HED food. The hypothesis that our environment provokes impulsivity in obese individuals has been explored with clear support for an interaction between the environment and increased impulsivity (R. Guerrieri, 2007), and research demonstrates that both obese children and adults have pronounced levels of impulsivity compared to lean counterparts (R. Guerrieri, 2007; R. Guerrieri, et al., 2007a, 2007b; C. Nederkoorn, Braet, et al., 2006; C. Nederkoorn & Jansen, 2002; C. Nederkoorn, Jansen, et al., 2006; C. Nederkoorn, Smulders, et al., 2006). In a group of school children, consumption was measured in a 2x2 design exploring the difference in eating behaviour between impulsive versus non-impulsive children in a varied versus monotonous food environment. The *impulsive* children only consumed significantly more calories in the varied food environment.

The Go No Go task has been shown to be a strong marker of impulsive behaviour in obese children (Nederkoorn et al 2006a, Nederkoorn, Smulders, Havermans, Roefs & Jansen, 2006b). The Go No Go task is explained in future sections in more detail, but is essentially a measure of ones’ ability to control prepotent motoric responses.

Participants are asked to withhold responding on “No Go” stimulus, which are stimuli that are marked by a colour change, or tone of a bell. This “No Go” signal adjusts dynamically to the participants behaviour over the course of a series of trials, until it is empirically determined where their precise “mid point” in the trial exists; it is suggested longer time needed to inhibit prepotent response is associated with greater impulsivity (Please see Logan, 1994 for a review). Nederkoorn and colleagues found that obese children were impaired in general response inhibition as measured by the Go No Go paradigm compared to control participants (C. Nederkoorn, Braet, et al., 2006). One interesting hypothesis raised in this investigation, is the idea that Go No Go performance is coupled with one’s ability to resist temptation. Researchers found that high impulsive scores on the Go No Go were associated with inability to lose weight on

a calorie controlled diet, thus providing a specific demonstration of the way that impulsivity impedes one's intentions to control food consumption (Nederkoorn et al 2007).

An interesting development within eating behaviour research shows that when measures relating to *both* eating behaviour *and* impulsivity are taken, the ability to predict actual food intake was significantly enhanced. Jansen (2009) confirmed those participants who had slow reaction times on a Stop Signal Task (a task similar to the Go No Go, but with an emphasis on reaction time and accuracy, and does not have the component of the dynamically adjusting midpoint) and who had scored highly on the Restraint Scale ate significantly more pleasant food when in the laboratory: on average the high Impulsive high Restraint individuals ate 100 kcal more after a 280 kcal preload, compared to low impulsive, and low RS groups (A. Jansen, et al., 2009) .

The final example demonstrates that screening for impulsivity may have greater predictive validity for overeating behaviour in the lab than even self-report questionnaire measures (Guerrieri, Nederkoorn et al. 2007). Scientists' found that the Restraint Scale compared to a measures of impulsivity, had significantly less ability to predict actual caloric intake in the laboratory. Participants state impulsivity was assessed by their performance on a Stop Signal Task, and trait impulsivity was assessed with Eyesenck's Impulsivity Inventory. Dietary restraint was measured using the RSS. In order to understand the relationship between these variables, a multiple regression used to asses which factors best predicted eating in an ad lib consumption task. The final outcome indicated that both measures of impulsivity (state and trait) compared to the RSS, had greater R-values on the regression thus indicating better predictors of food intake in the laboratory (R. Guerrieri, et al., 2007a, 2007b).

#### *1.2.2c Impulsivity: Cognitive Performance in Lean versus Obese groups*

There is a general assumption that overweight and obesity present a physiological danger related to cardiovascular health and diabetes, rather than being a physiological problem that contributes to lack of impulse control (Elias, 2003). However, the investigations presented in this final section examine the specific hypothesis that being overweight is somehow related to greater levels of impulsivity, with evidence showing

that impulsivity is, specifically, a domain of executive function that is affected by weight gain.

Initial studies examining executive function and differences between lean and obese produced inconsistent findings, particularly in regard to academic performance and intelligence (X. Li, 1995; Y. Li, Jackson, J., Zhang, J., 2008; Mo-suwan, 1999). In two separate studies (X. Li, 1995; Y. Li, Jackson, J., Zhang, J., 2008; Lokken, 2009), children's cognitive performance was explored in order to determine if any underlying differences in executive function could be detected between lean and obese groups. There was an intelligence test, a verbal fluency test, an attention test, and two impulsivity tasks the Wisconsin Card Sorting Task (WCST) and the d'' test. Critically, The WCST and the d'' tasks were they only measurements that produced significant differences between groups. The WCST is a clinical test aimed to measure cognitive flexibility and shifting ability, it assesses a subjects ability to recognize a rule, maintain, and change it when it becomes un-useful to completing the game, which involves sorting cards based on perceptual differences (colours, form, and number). The d'' attention endurance test is another clinical measure that is used to assess concentration and distractibility within children and adult populations. In this task, children are asked to detect d-symbols with two marks (d'') among similar ones in 14 lines having 20 s for each line; this yields two errors, either omitting the target symbol, or circling the wrong one. Authors found, independently, that there were no differences in premorbid intelligence, or verbal fluency, but obese participants had significantly less ability to focus attention, and also performed significantly worse on both the WCST and the d'' task.

A cross sectional study taken between 1988-1994 to examine Academic Performance and Cognitive Function included a sample of 2519 children between the ages of 8-16 who completed a brief neuropsychological test battery and measures of height and weight were also recorded (Li, 2008). The association between BMI and Academic Performance was not significant, however the association between Cognitive Function and BMI was positively associated after adjusting for parenting/familial characteristics, sports involvement, physical activity, hours spent watching TV, psychosocial development, blood pressure and serum lipid profiles. After controlling for a variety of psychological and physiological covariates authors concluded that obesity has an

independent association with visuospatial organization. Visuospatial organization could have direct links with Inhibition subtypes of impulsivity, which is typified by an inability to focus on specific stimuli.

Data taken from adult obese populations corroborate similar patterns of results (Boeka & Lokken, 2008). In this final example, cognitive performance was compared within a group of obese individual (68 males and females), authors controlled for hypertension, diabetes, and sleep apnea in order to assess the role obesity, exclusively, has on cognition. Interestingly, obese adults, like children (Boeka, 2008), had significantly worse scores on the Wisconsin Card Sorting Task, in addition to a second measure of attention the Rey Complex Figures Task (1941), assessing perceptual and organizational skills and nonverbal memory (Boeka, 2008).

Taken together, these studies support for the hypothesis that overweight is specifically related to greater impulsivity, which was independent of other physiological confounds such as sleep apnea. One final issue to address, is whether those individuals who self report overeating (but are not yet overweight) are also more impulsive. The final experiment covered in this General Introduction took place in our laboratory, and the purpose was to examine whether impulsivity varied in those healthy women who self reported overeating versus those who do not. The TFEQ scale was used to operationalize overeating behaviour with the TFEQ-D subscale and both a performance-based measure of impulsivity was used (the Delay Discounting Task, a measure of impulsive choice and preference for Small Soon rewards in contrast to Large Later), in addition to two self report measures (the Barrett Impulsiveness Scale (BIS-11), and the Dickman Impulsivity Inventory).

Data from this original investigation demonstrated a main effect difference using the TFEQ-D subscale, with women who scored high on this measure performing significantly more impulsively on the DDT, and self-reporting significantly higher impulsive scores on the BIS-11 subscales of Motoric and Non-planning impulsivity. This investigation offers one of the first empirical demonstration of the notion that impulsivity differences can be detected based on an individuals' self reported tendency to overeat. Since impulsivity is implicated in acquisition of pleasant substances, and since our understanding of the way the TFEQ-D can be used to predict future weight

gain, it is important to determine if impulsivity is greater in those women who self report overeating, but most importantly to determine *which* subtype of impulsivity is greatest in these women.

### 1.3 Conclusions

Impulsivity has been implicated as a key risk factor in the development and maintenance of appetitive addictive behaviour (Belin, et al., 2008; Crews, 2009; Jentsch & Taylor, 1999; Winstanley, Baunez, et al., 2005; Winstanley, et al., 2004; Winstanley, Theobald, et al., 2005), and more recently, overeating (P. K. Davis C., Levitan R., Reid C., Twee S., Curtis C., 2007; S. S. Davis C., Berkson M., 2004; Dawe & Loxton, 2004; R. Guerrieri, 2007; R. Guerrieri, et al., 2007a, 2007b; A. Jansen, et al., 2009; M. R. Lowe, et al., 2009; C. Nederkoorn, Braet, et al., 2006; C. Nederkoorn & Jansen, 2002; C. Nederkoorn, Jansen, et al., 2006; C. Nederkoorn, Smulders, et al., 2006; C. Nederkoorn, Van Eijs, Y., Jansen, A., 2004a; Steiger, et al., 1999; Weller, et al., 2008). Literature within the field of eating behaviour has provided important groundwork with regard to the role that impulsivity plays in the risk for overeating, but there has not yet been any clarification regarding the *subtype* of impulsivity most reliably associated with overeating. Moreover, since literature in the field of addictive behaviour has begun to emphasize a distinction between the subtype of impulsivity as it bears consequence on vulnerability to habitual compulsive consumption (as opposed to experimental use) (Belin, et al., 2008), it will be important to explore within those participants who self report a tendency to overeat if they are also more impulsive in terms of Reward Reactivity versus Inhibition subtypes, thereby clarifying our ability to determine whether individuals who self report a tendency to overeat are merely expressing a preference for pleasant substances or may be at greater risk for later problems with continuous overeating habits. To date, the explicit objective of refining a specific impulsivity subtypes in relation to overeating has been a priority within the field of Eating Behaviour. This limits our understanding of individual vulnerability towards development of obesity.



Refining the current state of research that implicates impulsivity as a risk factor for the development of obesity will be useful to both researchers in the lab and to individuals who struggle to manage overeating behavior. In the latter case, applying research from the field of impulsivity in a unique way offers insight into the underlying motivations associated with reward driven behavior. For individuals who struggle with being overweight, the knowledge that impulse control may have a significant impact on their inability to manage overeating, and perhaps offer some alternatives to therapies suitable for managing overweight.

The research organized in this Introduction demonstrates the importance that self report classification of individual differences relates to the risk for overeating behavior. Detecting an individual's tendency for overeating may provide some of the most relevant ways to prevent obesity, and hinges on psychological factors such as a high TFEQ-D score, and more recent evidence suggests impulsivity may also be related to overeating. Two important questions remain; first, whether lean individuals who self report overeating are, consistently, more impulsive. Second, it is necessary to determine which subtype of impulsivity is most reliably associated with overeating, as this may bear important relevance to future ability to control habitual overeating. If consistent differences in healthy women who self report overeating can be discriminated by differences in impulsivity, this will act as an important development within the field of individual differences related to overeating and the field of Eating Behaviour research.

#### **1.4 Aims of Thesis**

There were two aims of this thesis. Firstly, this thesis sought to clarify the extent of the relationship between impulsivity (both Reward Reactive and Inhibition subtypes) and their association with overeating. Experiment 1 (Chapter 2) explored between several measures of self reported overeating and restriction measures and their association with a series of impulsivity assessment measures. Following from this, Experiment 2 (Chapter 3) tested whether actual overeating (in addition to self-reported overeating) had a significant association with impulsivity.

Experiment 3 (Chapter 4) and Experiment 4 were devoted to exploring the findings of Experiment 2 in greater detail. In Experiment 3 (Chapter 4) the influence of a controlled

versus unrestricted eating environment, and subsequent impulsivity, was explored. The objective of Experiment 4 (Chapter 5), tested the specific impact that the preload and snack from Experiment 2 had on impulsive performance.

Experiment 5 (Chapter 6) explored the relationship between TFEQ and RS scales in relation to inhibition impulsivity. A regression analysis was used to observe differences in predictive ability of the TFEQ versus Restraint Scale in terms of Inhibition Impulsivity using the Go No Go task.

The final Chapter of this thesis (Experiment 6) tested if anticipation for food contributed to increased impulsivity in self reported overeaters. In addition to a novel experimental design, this final investigation provides a detailed assessment of participants' food preferences via Finlayson's (2008; 2008) Liking/Wating Computer Procedure which objectively provides information regarding implicit and explicit motivation for eating rewarding and pleasant tasting food.

Providing a thorough investigation of the link between impulsivity and self-reported overeating was the chief aim of this thesis. Initial observations confirm that impulsivity is associated with overweight and obesity (please see section 1.2.6, 1.2.6a), whether impulsivity is a stable individual difference that can be detected in participants who self report overeating (but are not yet overweight) is a notion that has not yet been challenged. This thesis aimed to provide a detailed assessment of the nature of the relationship between impulsivity and overeating, which was achieved by empirically exploring within self-report eating and impulsivity measures (Experiment 1 and Experiment 4), and second by manipulating experimental environments to explore the contingencies between self reported eating, impulsivity, actual food intake (Experiments 2 and 4), and the role of environmental influences (Experiment 3 and Experiment 6). Collectively, the experiments in this thesis reveal self reported overeaters demonstrate significantly greater impulsivity. The nature of this relationship is explored to improve the resolution of how psychological individual difference contribute to the behavioural chain of overeating in the current obesigenic environment.

# **Impulsivity and Overeating; an Exploration of State and Trait measures of Impulsivity and their relationship with self reported Eating Behaviour.**

## **2.1 Introduction to Experiment 1**

The context for Experiment 1 was the need to identify individual characteristics that might make some individuals more prone to overeat, as discussed in detail in the General Introduction. People who are struggling to maintain a healthy body weight will attest to the considerable challenge of altering behaviour to decrease energy intake or increase expenditure (Evans, 1999) Annunziato & Lowe, 2007). The lack of clarity regarding effective therapies to maintain weight loss (Brownell & Rodin, 1994; M. R. Lowe & Levine, 2005; Montague, 2003) combined with the ongoing search for predisposing factors associated with obesity (Doucet & Tremblay, 1997; Hill, 2009; Ifland, et al., 2009; Montague, 2003), further emphasize the importance of identifying and characterising individual differences that are associated with overeating behaviour (Annunziato & Lowe, 2007; C. P. Herman, Koenig-Nobert, Peterson, & Polivy, 2005).

The review in Chapter 1 identified impulsivity as a possible component regarding how individuals react to pleasant tasting food. Our hypothesis is that impulsivity may be viewed as an individual difference that discriminates between those who are more or less prone to overeat. This Chapter details a first examination of the relationship between self-reported measures of different aspects of eating behaviour and a number of different self-report and performance based measures of impulsivity. The overall aim was to further clarify the types of impulsive behaviours that share the greatest association with self reported overeating, building on the related literature reviewed earlier (Chapter 1 section 1.2, 1.2a, 1.2b, 1.3 and 1.4). Theoretically, this could lead to exciting advances both in detection and prevention of related disorders associated with overeating such as obesity, or in extreme cases, eating disorders.

An important consideration in the design of Experiment 1 was the recognition that impulsivity is a multi dimensional construct (Aron, 2007; S. M. Brown, et al., 2006; Dawe & Loxton, 2004; Eagle, 1993; J. L. Evenden, 1998a, 1998b, 1998c, 1999; Kertzman, et al., 2006; M. R. Yeomans, et al., 2008), and more critically, using global terms such as “impulsiveness” or “impulsivity” as opposed to clearer specification of a

subtype of impulsivity may lead to theoretical and empirical imprecision (G. Smith, Fischer, S., Cyders, MA, Annus, AM, Spillane, NS, McCarthy, DM., 2007). To date, there is no consensus regarding the subtype of impulsivity relates most reliably with overeating. So, despite the increasing evidence of a general link between impulsivity and overeating, (Dawe & Loxton, 2004; Engel, et al., 2005; Fischer, et al., 2008; R. Guerrieri, 2007; R. Guerrieri, et al., 2007a, 2007b; A. Jansen, et al., 2009; M. R. Lowe, et al., 2009; Mobbs, Van Der Linden, & Golay, 2007; Nasser, et al., 2004; Rosval, et al., 2006; Steiger, et al., 1999), specification of the subtype of impulsivity most clearly related with overeating still remains to be addressed.

There are three basic approaches in the literature for assessing the relationship between impulsivity and eating. The first approach is to define participants by weight category (normal, overweight or obese) and then to examine whether these groups differ on measures of impulsivity. Thus, prospective studies have reported that impulsivity is significantly greater in obese women (Braet, Claus, Verbeken, & Van Vlierberghe, 2007; C. Nederkoorn, Smulders, et al., 2006; Rosval, et al., 2006). The problem with this approach is that it cannot determine whether impulsivity lead to weight gain and consequent obesity, or whether weight gain increased the tendency to respond impulsively. The second approach is to classify participants by their clinical status in relation to eating, particularly in relation to disorders associated with overeating such as bulimia nervosa and binge eating disorder. Again, women with bulimia spectrum disorders score higher on measures of impulsivity (Engel, et al., 2005; Nasser, et al., 2004; Steiger, et al., 1999) which is consistent with the hypothesis that impulsivity will be higher in women who self report over eating. Indeed, a comparison between clinical populations who suffer from bulimia spectrum disorders (Rosval, et al., 2006), and normal weight populations who self report over eating (Lyke & Spinella, 2004), show remarkably similar response styles particularly on one self report measure of impulsivity, the Barrett Impulsivity Scale- 11 (BIS-11). The third approach is to examine behaviour in groups who are yet to become obese or develop a clinical eating problem, and to explore the relationship between impulsivity and self-reported eating in the absence of weight confounds. That is the approach adopted in this Experiment.

The consistency of the relationship between high scores on the BIS-11 and overeating (A. Jansen, et al., 2009; Lyke & Spinella, 2004; Spinella M., 2004) merits further

consideration. In the first example, authors sought to explore Executive Function in dieters, and compiled the scores of 112 individuals on the TFEQ and BIS-11 measures (Lyke & Spinella, 2004). The key question was whether impulsivity was more closely related to a tendency to self-restrict intake (indexed by TFEQ-R) or to overeat (TFEQ-D). Using a correlational analysis, there was no significant relationship between any BIS-11 measure of impulsivity and TFEQ-R scores, but there were significant positive correlations between the BIS-11 motoric and cognitive subscales and TFEQ-D scores (Lyke & Spinella, 2004; Spinella M., 2004).

A second example wherein a multitude of *both* trait and state measures were employed in relation to the TFEQ scale was conducted at the University of Sussex (Yeomans et al. 2007). This study was conducted with lean healthy females, and the TFEQ scale was used to define overeating (TFEQ-D) and restricting (TFEQ-R) behaviour. As with the previous study (Lyke and Spinella, 2004), impulsivity was assessed via the BIS-11, in addition to a second questionnaire, the Dickman Impulsivity Inventory (Dickman, 1985), that defines impulsivity along an axis of “functional” versus “dysfunctional” subtypes. The two self report measures satisfied our criteria of distinguishing between *Inhibition* versus *Reward Reactivity*; the BIS-11 as a measure of Inhibition, and the Dickman Inventory as a measure of reward reactivity (Smillie & Jackson, 2006). Unique to this study was the inclusion of the Delay Discounting Task (DDT), a measure of ‘impulsive choice’, which assessed participants preference of immediate Small Soon rewards, as opposed to delayed, Larger Later ones, and although is a measure using hypothetical rewards is a clear marker of impulsive behaviour (Cardinal, 2006; Cardinal, et al., 2001).

Results using the three measures of impulsivity in relation to the TFEQ revealed an interesting pattern. Consistent with previous research (A. Jansen, et al., 2009; Lyke & Spinella, 2004; Spinella M., 2004), and one subsequent investigation (A. Jansen, et al., 2009) a positive correlation was found between the TFEQ-D and the BIS-11 motoric subscale. In terms of behavioural performance, high TFEQ-D women showed greater impulsivity too; high TFEQ-D scorers discounted monetary rewards significantly faster than low TFEQ-D scorers. Interestingly, no differences were detected between participants on the Dickman Impulsivity Inventory, which suggests a disconnect between methods of assessing impulsivity; the performance based DDT measure was

capable of detecting impulsivity differences, and so too was the BIS-11. Therefore, it may be the case that specific self-report questionnaires are more suitable to detecting individual impulsivity differences than others. Alternatively, if self-report measures of reward reactivity measures of impulsivity do not discriminate between obese or lean, as has been the case in previous research (C. Nederkoorn, Smulders, et al., 2006), then perhaps measures of Inhibition are more representative of the impulsivity subtype associated with overeating.

This introduction demonstrates a clear opportunity to refine our current understanding of impulsivity and overeating, by specifically examining a host of measures that assess impulsivity in terms of Reward Reactive versus Inhibition distinctions, in addition to a group of eating behaviour self-report measures to assess overeating.

Having established two overarching sub-types of impulsivity (Reward Reactive and Inhibition), and noted the current ambiguity within the literature relating to these two types of impulsivity in relation to overeating, the primary aim of Experiment 1 was to explore more fully how different measures of eating relate to multiple-measures of these two impulsivity constructs. In order to achieve this, a battery of both eating behaviour *and* impulsivity tasks was created. Independent comparisons within each of the eating and impulsivity constructs were sought, based on their ability to detect Reward Reactivity versus Inhibition, and finally the inter-relationship between all eating and impulsivity measures was explored using a multiple-correlation design. The prediction, based on recent studies (A. Jansen, et al., 2009; Lyke & Spinella, 2004; Nasser, et al., 2004; C. Nederkoorn, Braet, et al., 2006; C. Nederkoorn, Van Eijs, Y., Jansen, A., 2004b; Spinella M., 2004), was that scores on the TFEQ-D would show the strongest associations with impulsivity measures, particularly on the BIS-11.

## **2.2 Methods**

### *2.2.1 Participants*

People were recruited in two ways: through a database of potential participants maintained by the Ingestive Behaviour Unit at the University of Sussex, or through the University of Sussex Psychology Volunteer Participant database, a broader database of

people who have expressed an interest in participating in studies in Psychology. Both groups were sent an email addressed to students interested in obtaining £5.00 or course credit rewards for an hour spent devoted to completing a series of tasks and questionnaires, the nature of the tests were described as “assessments of cognitive performance” to those participants who made additional enquiries regarding the experiment. Specific wording of the email and the information sheet can be found in Appendix 2.1. The final sample consisted of 100 women volunteers ranging age from 19-32 years ( $m = 22.5$ ), and a Body Mass Index ranging from 19 to 26 ( $mean = 22.68$ ). Body Mass Index is calculated based on a ratio of mass (kg) to height (meters<sup>2</sup>). Of the 100 women tested, none would have been defined as underweight ( $BMI < 18.0$ ), four as overweight ( $BMI$  ranging from 25.00 to 29.99) and none were obese ( $BMI > 30.00$ ). The University of Sussex Ethics committee approved the experimental protocol.

#### *2.2.2 Measures of Impulsivity and Eating Behaviour*

Participants were required to complete a booklet of self-report impulsivity and eating Behaviour questionnaires, a full description of each task is provided here.

##### *2.2.2a Behavioural Activation System/ Behavioural Inhibition System (BAS/BIS)*

The BAS/BIS has been proposed as a framework to understand how behavioural regulation relates to personality and psychological dysfunction (Gray, 1972, 1982, 1987; Gray & McNaughton, 2000, Pickering & Gray, 1999). The BAS/BIS questionnaire is divided into four subscales, with a likert-type response scale, and participants are required to indicate an answer between 1-4, with 1 indicating they agree “very much” and 4 indicating they “do not agree at all”.

The BAS/BIS attempts to identify behaviour along fight (BAS) versus flight (BIS) systems; the Activation system (BAS) is related to motivation and reward. It is associated with optimism, joy, and aggression (Cable, Reis & Elliot, 2000; Gray & McNoughton, 2000, Wingrove & Bond, 1998). Extreme scores on the BAS are related to impulsivity disorders (Wallace Newman & Bachorowski, 1991), such as attention-deficit/hyper activity disorder (Mitchell & Nelson-Gray 2006).

The Inhibition system (BIS) is related to avoidance, and stopping behaviour that might result in pain or loss. The BIS is conceptualized as a system that is sensitive to

punishment, for example high BIS activation is associated with enhanced attention, vigilance and very high BIS scores correspond with anxiety related disorders (Fowles, 1988; Quay, 1988). Low BIS scores are related to first order psychopathy (Newman, MacCoon, Vaughn, & Sadeh, 2005). There has been some controversy regarding the true nature of the BIS and its' ability to measure behavioural *inhibition* (Gray's original position in addition to (Avila, 2001; C. Avila, Parcet, M.A., 2001; Casada JH, 2005; Cools R, 2005), or behavioural *avoidance*(Elliot AJ, 2006; Gable SL, 2000; Heimpel SA, 2006) has been the source of some debate within impulsivity research.

In relation to the current conceptualization of impulsivity having two primary sub-types, Reward-Reactivity and Inhibition, the BAS/BIS includes components that are associated with both subtypes; the BAS represents an individual's Reward Reactivity whereas the BIS is indicative of an individual's level of Inhibition. A copy of the BIS/BAS is included in Appendix 1c.

2.2.2.b Sensitivity to Punishment, Sensitivity to Reward Questionnaire (Torrubia, 2001)  
A second questionnaire that was designed to dissociate behaviour along approach and avoidance schema is the Sensitivity to Punishment/ Sensitivity to Reward Questionnaire (Torrubia, 2001). This is a 42-item questionnaire split into two parts assessing Reward and Punishment Sensitivity. This measure is simply scored based on participants' YES/NO responses, and the 21 questions based on Reward Sensitivity are added, as are the 21 Punishment Safety Questions for two distinct scores.

The SPSRQ has shown to have significant positive associations with BMI (Frankin & Muris, 2005), which could indicate that Reward Reactive impulsivity is the best way to classify impulsivity amongst participants with a tendency to overeat.

In relation to the current conceptualisation of impulsivity, SPSQ responses were predicted to be a measure of Reward Reactivity, and thus a positive relationship with self report measures of overeating were predicted. Please see Appendix 1d.

2.2.2.c The Barrett Impulsivity Scale-11, a self report Measure of Inhibition(Patton, Stanford, & Barratt, 1995)

The Barrett Impulsivity Scale-11 (BIS-11: (Patton, et al., 1995) is an impulsivity scale comprised of three factor-based subscales, with a total of 30 items. Participants are



required to answer likert-type scale questions with four response choices (I agree Very Much, I somewhat I agree, I do not agree, I do not agree at all), and these responses are given a number (1 responding with “I agree”, and 2 responding with “I somewhat agree” and so on).

The three dimensions of the BIS 11 are notably distinct from the other previous impulsivity trait measures (BAS/BIS and SPSRQ). The emphasis with the BIS-11 is placed on perception and attention, and thus it could be argued the BIS-11 is a measure of Evenden’s Inhibition Impulsivity. The Attention subscale reports the tendency towards rapid shift in attention and impatience with complexity, the Motor Impulsivity scale measures a tendency to act without forethought, and the Non Planning scale evaluates long term consequences of action. The three scales can be taken as a composite score, or used in isolation to concentrate on one specific aspect of Inhibition.

Research in Eating Behaviour has demonstrated the utility of the BIS-11 to discriminate between healthy versus obese or clinical populations. For example, differences have been found between women with active symptoms of Bulimia Nervosa compared to lean, using the combination of all three measures (Bruce, et al., 2005), in addition to overweight women who binge eat compared to overweight women who do not (Arias, et al., 2006). Higher scores on the Motoric subscale have been found between bulimic populations compared to lean or restrictor types (Steiger, 2005), and also have been shown in women with high TFEQ Scores (Lyke & Spinella, 2004).

Compared to the other two measures of impulsivity, the BIS-11 has been used most frequently in tests determining differences between lean and overweight or disordered eating groups. The discriminative ability of the Motoric subscale of the BIS-11 between eating disordered (Akkermann K, 2009; Bruce, et al., 2005) and obese populations supports (R. Guerrieri, et al., 2007b) lends greater support to the notion that overeating behaviour is specifically associated with Inhibition impulsivity and as such, we predicted that the BIS-11 would have the greatest number of associations between the self report measures of overeating behaviour. Please see Appendix 1e.

### 2.2.3 Performance Based Measures of Impulsivity

Participants were required to complete two performance-based measures of impulsivity. The DDT was used as a performance based measure to assess Reward Reactivity, and the BART was selected as a measure of Inhibition.

#### 2.2.3.a The Delay Discounting Task and Temporal Discounting of Rewards

The Delay Discounting Task (DDT) was selected as a means to analyze impulsive choice behaviour in light of the large body of evidence reporting associations between an inability to withstand temporal delays in favour of greater monetary gain (what the DDT measures) and appetitive addictive behaviour (Dixon MR, 2006; Dom, Hulstijn, & Sabbe, 2006; Perry & Carroll, 2008) in addition to our own finding that steeper discounting rates are associated with self-reported overeating behaviour (Yeomans, 2008). The DDT requires participants to make a series of choices between Smaller Sooner Rewards vs. Larger Later rewards.

In the DDT used in this experiment, rewards were expressed as hypothetical monetary denominations ranging from £0.01- 10.00. The two reward choices were identified by red or green font on the computer, and these colors corresponded with a button box with one red and green button. Participants indicated their preferred reward from a random presentation of pairs of reward by pressing the appropriately colored green or red button. Participants were reminded that time was not a constraint, and to simply choose the most appealing alternative. The task was conducted on a computer (Macintosh G3) custom-programmed using Psyscope 1.2. The programme displayed a series of binary choices between a fixed reward (£10) presented after a variable delay or an alternative immediate reward ranging from £0.01 to £10.50, with reward increments increasing by £0.50. The delays ranged from immediate (0 delay) to one year (365 delay), with 22 steps in order calibrate participants performance based on each of the reward values (ranging from £0.01- 10.50 GBP). In total, participants were presented with 132 choice trials, representing all possible combinations of rewards and delays.

In order to quantify scores appropriately on the DDT task, the Indifference Point Method was employed (Ho, Mobini, Chiang, Bradshaw, & Szabadi, 1999). The Indifference Point method relies on analyzing the entire DDT responses in terms of the monetary value point when the individual consistently begins to choose the Smaller Sooner reward in preference to the Larger Later reward, which are taken at 0, 7, 30, 90, 180, 365 day intervals. For example, if an individual is asked whether she would like “1 pound now, or 10 pounds now” she will consistently indicate she wants £10.00, however, this changes consistently if she is asked whether she would like “£1.00 now, or £3.00 in one year”, if she chooses the £1.00 reward in this case, if asked again whether she would like “£1.00 now, or £2.00 in one year” it is also likely that she will choose £1.00. To reiterate, the point where she consistently chooses the Smaller Sooner reward over the Larger Later reward monetary value is empirically determined as the Indifference point.

The temporal relationship between Smaller Sooner vs. Larger Later rewards becomes significantly important in the calculation of impulsivity. The Indifference Points are plotted on a curve, the X-axis is comprised of the time intervals (0, 7, 30, 90, 180, 365), and the Y-axis denotes the monetary value at which point the participant began choosing Smaller Sooner rewards. Since the person will theoretically obtain all of the money stated in the paradigm, an individual who consistently chooses Larger Later reward will reap the largest rewards, and if this were to occur, the slope of the line plotted by this individual's Indifference Point values would not result in a steep curve at all. Conversely, if temporal delay is an important factor for an individual, then the slope of the curve will be quite steep. An individual who rapidly discounts rewards based on the length of time until they receive the reward is believed to be more impulsive, since the best overall strategy is of course to choose the Larger Later reward consistently.

There are two ways to quantify the slope achieved by the six indifference points (calculated at time point 0, 7, 30, 90, 180, and 365 day intervals), using either Area Under the Curve (AUC) of these points, or calculating the slope of the hyperbolic curve best suited to them.

$$V = A / (1 + kD)$$

In this case,  $V$  is the discounted value of the delayed reward,  $A$  is the amount of the reward,  $k$  is calculated for each individual based on their responses on the DDT task (as such it is empirically defined), and  $D$  is the delay duration. Large  $k$ -values are indicative of an individual who discounts rewards rapidly. These indifference points were plotted as a function of delay interval. Impulsivity thus can be operationalized in two ways; the first method involved fitting a hyperbolic curve to data from each participant using Cradlefields Graphsite program, and then taking the hyperbolic coefficient as a measure of delay discounting. The second method simply calculated the Area Under the Curve, which has been described as an alternative (Robles & Vargas, 2008). In light of previous findings (M. R. Yeomans, et al., 2008), we predicted to replicate a significant difference between high versus low TFEQ-D scorers with steeper discounting rates (ie. higher  $k$ -values, and lower AUC values).

#### 2.2.3b Balloon Analogue Risk Task (BART) (C. W. Lejuez, et al., 2002)

The Balloon Analogue Risk Task (BART) was used to assess risk-taking Behaviour (Aklin, Lejuez, Zvolensky, Kahler, & Gwadz, 2005; C. Lejuez, et al., 2003; C. W. Lejuez, Aklin, Bornovalova, & Moolchan, 2005; C. W. Lejuez, et al., 2007; C. W. Lejuez, et al., 2003). The goal of the BART is to “earn” as much money as possible, by pumping a hypothetical balloon up (displayed on a VDU). Each time the participant opts to pump up the current balloon, the amount of money earned on that trial increments by £0.05, and the participant has the option to “transfer” their accumulated money from that trial to their bank at any point, ending that trial. However, if they continue to pump up the balloon there is a risk that the balloon will burst, and all money gained on that trial is consequently lost. The procedure consists of 30 balloons, and the participant can potentially earn £60.00 over the entire course of the 30-balloon trial. However, the order in which balloons were presented is set on a random schedule, of which participants are made aware, so it is almost impossible to obtain the full reward. After each explosion or money collection on each balloon, the participant was presented with a new opportunity to “earn” money with a new balloon until all 30 balloons has been presented.

With this task, the number of total explosions can be used to assess risk-taking behaviour (C. Lejuez, et al., 2003; C. W. Lejuez, et al., 2005; C. W. Lejuez, et al., 2002). The BART has been shown to differentiate between participants with both

behavioural problems and addictive behaviour. For example, the BART discriminates between smokers and non smokers (C. Lejuez, et al., 2003), with smokers more likely to make risky decisions on the BART, and has also been shown to differentiate between youths with ADHD and impulsive control Behaviour problems (C. Lejuez, et al., 2003), again with greater risk taking exhibited by those diagnosed with ADHD. For these reasons, the BART was chosen as a performance based measure of impulsivity, and it was hypothesized that individuals with markedly higher overeating tendencies would also have higher Explosion scores, thus, a positive correlation was hypothesized. How the BART performance relates more closely to Inhibition versus Reward Reactivity is more difficult to characterize than the DDT, which is clearly a measure of Reward Reactive impulsivity. Our classification of the BART as a measure of Inhibition lies in the sense of urgency that would compel an individual to continue pumping, despite the growing risk with each pump to increase the size of the balloon. The participant has no idea if the balloon will explode with further clicks, and therefore those participants who manage to control the risk of exploding balloons by saving money (and withholding a prepotent response to continue clicking and thereby avoiding exploding balloons) are less impulsive.

The selection of tasks included in this investigation is the most comprehensive range of impulsivity tests that have been reported within eating behaviour research. Our hypothesis is that individuals with high TFEQ-D scores will be significantly more impulsive, however our ability to specify which of the two subtypes of impulsivity will be most greatly associated with TFEQ-D scores is impeded by the lack of comparisons within the literature. This investigation will provide the first comparison between impulsivity measures, defined in terms of *either* Reward Reactivity or Inhibition, in order to address this shortcoming in our current knowledge.

#### *2.2.4 Self Report Measures of Eating Motivation*

The debate surrounding the efficacy of various measures of successful dieting was explored thoroughly in Chapter 1, explicitly focused on the differences between The Restraint Scale, versus the Disinhibition measure of the TFEQ. It seems the resolution of whether the RS versus TFEQ provides the most accurate scale hinges on the idea the RS is indeed a measure of *both* restrained eating and tendency for

overeating (T. Van Strien, et al., 2007). As such, interpretation of any correlations between RS scores and impulsivity measures would be difficult because of the confounding of the scales of Weight Fluctuation (WF) and Concern for Dieting behaviours (CD). For this reason, the primary focus was on the TFEQ restraint and disinhibition sub-scales. However, some authors have argued that TFEQ-D combines two aspects of eating (externality and emotional eating) and so a second questionnaire that measures these components separately (the DEBQ) was also included. Moreover, a great deal of the literature on impulsivity and eating has used clinical groups, and a more clinical measure of binge-eating, the BES, was also used to assess whether binge-eating within a non-clinical population also related to impulsivity.

#### 2.2.4a Three Factor Eating Questionnaire (TFEQ)

The Three Factor Eating Questionnaire (TFEQ) (Stunkard & Mesick, 1985) has been established to be the most reliable and valid measure of eating and dieting behaviour (Williamson, et al., 2006) The TFEQ is split into three subscales of eating: Restrained Eating, Disinhibited Eating, and Hunger. Participants are required to answer “True/False” to a series of 42 questions, and then are required to complete responses on a 5-item likert-type response scales for a further 8 questions. The TFEQ divides eating behaviour into three distinct subscales of Restraint (to measure dieting type behaviour), Disinhibition (to measure the tendency to overeat), and Hunger (self explanatory). The TFEQ has proven to have predictive validity in assessing restrained-type eating behaviours among dieters, obese, and lean participants (Williamson, et al., 2006). In the General Introduction, the benefit of the TFEQ-D subscale’s explicit measurement of overeating was explored, and subsequent use of the TFEQ scale has been shown to predict lifestyle outcomes such as overweight and obesity in females (Bellisle, 2009; Bellisle, et al., 2004; Bryant, et al., 2008), in addition to a preference for high fat, high sugar foods (Drapeau, et al., 2003). Please see Appendix 1a.

#### 2.2.4b Dutch Eating Behaviour Scale (DEBQ) (van Strien, 1986)

As a second measure used to explore eating behaviour, The Dutch Eating Behaviour Scale (DEBQ) (van Strien, 1986), was also used. The DEBQ is comprised of 33 questions, which are scored on a 5-point likert scale, and the questionnaire is divided

into three subscales including Restraint, Emotional, and External eating behaviour. Higher scores are indicative of higher Restrained, Emotional or External eating habits.

The DEBQ-R and TFEQ-R subscales are better indicators of an individual's ability to *successfully* restrict calories (Laessle RG, 1989) than the RS. Compared to the RS, which proposes Restraint to be a unitary construct, the DEBQ-R and TFEQ-R both measure calorie-restricting behaviour in isolation. Therefore, the DEBQ's division of behaviours related to overeating in terms of Emotionality and Externality, compared to the single TFEQ-D subscale, may provide greater detail in respect to the motivation to overeat.

In support of the DEBQ-Externality and DEBQ-Emotionality scales, is the idea that *both* emotional and external eating play independent roles in the choice to overeat and being overweight (Anschutz, 2009; Braet, 2008; Van Strien 1997; Van Strien, 2000). Replicating the original RS paradigm, but scoring self reported eating behaviour via the DEBQ scale has shown that increased icecream consumption is associated with higher scores on the DEBQ- Emotionality subscale (Van Strien, 1997). Replicating this data was the finding that participants with high DEBQ-Emotionality scores also ate significantly more cookies after consumption of a milkshake preload (Van Strien, 2000). More recent data has supported the distinction between Emotionality and Externality scales in light of the finding that they correspond with gender differences and overweight status (Braet C, 2008); in a sample of 101 adolescents, authors found that overweight girls compared to lean had higher DEBQ-Emotional scores, whereas overweight boys had higher Externality scores compared to lean. Please see Appendix 1f.

#### 2.2.4c Binge Eating Scale

Finally, the Binge Eating Scale /Eating Habits Checklist was used as the only clinical measure used to explore binge-eating habits. It should be noted this was the only clinical questionnaire used in the experiment, and some questions may have been inappropriate for the target sample given the strong emphasis placed on binge eating. The questionnaire is a 16 item multiple choice questionnaire, and higher points are assigned to the binge-type eating responses, as higher scores denote binge-eating

tendencies. Scores above 17 points are believed to be associated with binge eating. Some questions directly ask the participant about binge eating habits, for example Question 11 states two of the following alternatives:

1. *I don't have any problem stopping eating when I feel full.*
2. *I usually can stop eating when I feel full but occasionally overeat leaving me feeling uncomfortably stuffed.*
3. *I have a problem stopping eating once I start and usually I feel uncomfortably stuffed after I eat a meal.*
- 4). *Because I have a problem not being able to stop eating when I want, I sometimes have to induce vomiting, use laxatives, or diuretics to relieve my stuffed feeling.*

The BES is included in Appendix 1g.

The three questionnaires were selected because they provided a variety of measures of factors associated with *overeating* as well as measures of *restricting* eating behaviour. The TFEQ-D subscale has shown to be a robust measure of overeating behaviour in relation to weight gain (Bellisle, 2009; Bellisle, et al., 2004; Bryant, et al., 2008) and also broader lifestyle choices (Drapeau, et al., 2003) that are related to obesity and overeating. In order to explore the construct of the TFEQ-D in greater detail, the DEBQ-Emotional and DEBQ-External scales were selected as a way to examine whether *specific* aspects of the motivation to overeat share greater associations with impulsivity. In addition, the correlation nature of this design prevented our ability to select participants based on Westenhoefer's suggested criteria of TFEQ-D and TFEQ-R scores, the DEBQ provided an alternative way of capturing motivations for overeating that did not require the combination of scales.

#### 2.2.5 Procedure

Participants were recruited via the University of Sussex email recruitment scheme, in addition to the database of volunteers established by the experimenters within the Ingestive Behaviour Unit. Participants were explained they were required to come to the Sussex Ingestive Behaviour Unit for approximately one hour to complete a series of questionnaires to examine gambling and risk taking behaviour, all participants received £5.00 or course credits for their time and effort. It was also made clear that



participants had the right to withdraw from testing at any time, should they desire to do so. The consent form is included in Appendix 1b.

Once participants had arranged to participate, they were given an appointment time between 11.00 am and 2.00 pm to attend the Ingestive Behaviour Unit. On arrival, the nature of the experiment was explained in full, and participants were required to sign a consent form (Appendix 2.1). They were then directed into a quiet room or individual cubicle to complete the Self Report Questionnaires. The self-report questionnaires were presented in a randomized order (rotating between the TFEQ/DEBQ/BES presented first second and third) and also the same was done for the impulsivity questionnaires (BAS-BIS/ SPSRQ/BIS-11) to reduce the likelihood that completing one measure would always impact on responses to subsequent measures.

Upon completion of the Self Report Questionnaires, participants were then directed to complete the Behavioural Impulsivity Tasks, which were set up in individual cubicles where the DDT or BART tasks were presented on a Macintosh G3 computer (for the DDT task) or on a PC computer running MS XP (for the BART task). Participants were explained how to use the DDT button box, and were required to complete practice trials for each program in front of the experimenter to ensure full understanding of the task was established. Once the participant had performed the practice version of each task, the experimenter left the cubicle, and the participant was left to her own devices to complete the task in her own time. The two performance based impulsivity tasks (DDT/BART) were organized so that all participants performed either the DDT or BART first, ie. in A-B-A-B fashion, to avoid order effects within participants .

Once the participant had finished both DDT and BART tasks, she notified the experimenter, and she was debriefed about the true nature and purpose of the experiment. The participant's height and weight measurements were taken, and depending on stated preference she was then paid or given course credits. The participant was thanked, and escorted outside of the laboratory.

## **2.3 Data Analysis**

Analyses were aimed at confirming the inter-relationships between the key eating and impulsivity variables to ensure that current data set had the expected characteristics, for

example, that measures of dietary restraint (both on DEBQ and TFEQ) were expected to show a strong positive correlation as they measure very similar behaviours, and past studies show these restraint measure ought be highly correlated (Larsen, et al., 2007; T. Van Strien, et al., 2007; Wardle, 1992). Pearson correlations within the eating variables were conducted to (a) ensure consistency in responses by testing the relationship between the two restraint measures and (b) to examine the degree of inter-relatedness in the different measures of binge and over-eating. For impulsivity, the study was based on the assumption that the measures of behavioural impulsivity, for example the DDT, BART, SPSRQ and BAS would be related as they both aspects of inability to resist temptation, impulsive choice, or reward sensitivity which was hypothesized to be separate from measures of cognitive impulsivity, measured by the BIS II. Correlation analyses tested these inter-relationships, and also examined whether responses on the BART task were related to these measures of impulsivity. The hypothesized relationship between eating and impulsivity was then tested by a further set of correlations, relating eating measures to the measures of impulsivity.

For the DDT, since indifference points were calculated at all six delays, correlation analyses were not appropriate. Therefore, to test whether classification as tending to overeat- binge or restrict eating was associated with greater tendency for impulsive choice in the DDT, women were classified as high or low on each if the eating measures using a median split, and then DDT indifference points contrasted between groups with delay as a within-subjects measure in a 2-way ANOVA. Individual Area Under the Curves were calculated, and so were individual k-values, which were both used as a dependent variable in a between 2x2 between subjects ANOVA design, as per Westenhoefer's recommended split (HDHR, HDLR, LDHR and LDLR).

## **2.4 Results**

### *2.4.1 Correlation Analysis of Eating and Impulsivity Measures*

Means, standard deviations, and ranges for all of the measures are presented in Table 2.4.1a. Based on ranges and standard deviations, there appeared to be adequate variability in all measures of eating, and impulsivity to assess inter-relationships. Means

are comparable to these measures with previous studies (Lyke & Spinella, 2004; Cheung, 2004; S. Mitchell, Stevens, 2008; C. Nederkoorn, Smulders, et al., 2006).

TABLE 2.4.1A: DESCRIPTIVE STATISTICS FOR SELF REPORTED EATING BEHAVIOUR AND IMPULSIVITY

Variables	Number of Items	Mean (SD)	Range
BMI	n/a	22.52 ( $\pm$ 3.34)	18-26
TFEQ-Disinhibition	16	7.13 $\pm$ 3.54	0-16
TFEQ-Restraint	21	7.51 $\pm$ 5.5	0-21
DEBQ-Restraint	11	2.25 $\pm$ .97	0-4.3
DEBQ-Emotional	11	2.34 $\pm$ .96	0-5.14
DEBQ-External	11	2.47 $\pm$ .60	0-4.4
BES		13.82 $\pm$ 3.58	0-30
BAS-Fun Seeking	4	8.36 $\pm$ 2.18	4.0-14.0
BAS-Drive	4	8.88 $\pm$ 2.24	4.0-13
BAS-Reward	5	8.45 $\pm$ 2.16	5.0-11
BAS-BIS	7	7.65 $\pm$ 1.84	7.0-27
SPSRQ-Reward	24	11.33 $\pm$ 4.01	1.0-21
SPSRQ-Punishment	24	11.19 $\pm$ 4.75	4.0-21
BIS II Cognitive	10	17.65 $\pm$ 3.43	10.0-27.0
BIS II Motoric	10	22.37 $\pm$ 4.09	9.0-33.0
BIS II Non Planning	10	23.78 $\pm$ 4.69	14.0-37.0

*Note:* BMI= Body Mass Index; TFEQ= Three Factor Eating Questionnaire; DEBQ= Dutch Eating Behaviour Questionnaire; BES= Binge Eating Scale; BAS= Behavioural Activation System, BAS/BIS= Behavioural Inhibition System; SPSRQ= Sensitivity to Punishment, Sensitivity to Reward Questionnaire; BIS= Barratt Impulsivity Scale- 11

Table 2.4.1.b: *Corelation Analysis between Self Reported Eating Behaviour*

Variables	BMI	TFEQ-D	TFEQ-R	DEBQ-R	DEBQ-Emotional	DEBQ-External	BES
BMI	1.000	0.174*	0.115	0.100	0.110	0.089	0.021
TFEQ-D	0.174*	1.000	0.193**	0.186**	0.208**	0.094	-0.016
TFEQ-R	0.115	0.193**	1.000	0.53**	0.15*	0.023	-0.011
DEBQ-R	0.102	0.186**	0.530**	1.000	0.403**	0.138*	-0.120
DEBQ-Emotional	0.108	0.208**	0.150*	0.403**	1.000	0.280**	
DEBQ-External	0.089	0.094	0.023	0.138*	0.280**	1.000	-0.030
BES	0.021	-0.016	-0.011	-0.120	-0.146	-0.030	1.000

*Note:*  
 \* $p < 0.05$   
 \*\* $p < 0.01$

#### 2.4.1a Relationships Between Measures of Self Reported Eating Behaviour

Table 2.4.1.b illustrates the correlations found between measures of self-reported eating behaviour. The two measures of dietary restraint were significantly correlated (TFEQ-R, and DEBQ-R,  $r = 0.53$ ,  $p = 0.001$ ), as expected. In terms of correlations between putative measures of tendency to overeat, the TFEQ-D scale was the only subscale which correlated with BMI ( $r = 0.173$ ,  $p \leq 0.05$ ). There was a positive significant correlation between the TFEQ-D and DEBQ-Emotional scale ( $r = 0.208$ ,  $p \leq 0.001$ ), yet there was no significant relationship between TFEQ-D and DEBQ-External Scale ( $r = 0.094$ ,  $ns$ ). Surprisingly, there was no significant correlation between the TFEQ-D measure and the BES ( $r = -0.25$ ,  $ns$ ), which may be indicative of the current population's tendency for overeating, but not clinical binge eating *per se*.

#### 2.4.1b Relationships between Measures of impulsivity

A Pearson's bivariate correlation was conducted to explore inter-relationships between measures of Inhibition versus Reward Reactive impulsivity (Table 2.4.1c). In light of the distinct nature of Inhibition versus Reward Reactive impulsivity, it was predicted the BIS-11 would not share many significant associations with the either of the BAS/BIS and SPSRQ measures. Results generally confirm this hypothesis since there

Table 2.4.1.c: *Relationships Between Measures of Self Reported Impulsivity and BART explosions*

Variables	BIS-Cog.	BIS-Motoric	BIS-NP	SPSRQ-Reward	SPSRQ-Punishment	BAS-Fun	BAS-Reward	BAS-BIS	BART Explosion
BIS-Cognitive	1.00	.34**	.344*	.185	.124	-.32	.152	-.065	.223*
BIS-Motoric	.34**	1.00	.378*	.002	-.280**	-.23*	-.037	-.77	.122
BIS-Non Planning	.34**	.378*	1.00	-.085	-.043	.19	-.117	.11	.198
SPSRQ-Reward	.185	.002	-.085	1.00	.141	-.347**	-.364**	.478**	.237*
SPSRQ-Punish	.124	-.28**	-.043	.141	1.00	.207*	-.09	-.026	.095
BAS-Fun	-.032	-.23*	0.19	-.347**	.207*	1.00	.179	.372**	.052
BAS-Reward	-.152	-.037	-.117	-.364**	-.091	.179	1.00	.331**	-.048
BAS-BIS	-.065	-.077	.11	-.478**	-.026	.372**	.331**	1.00	-.14
BART explosion	.223*	.122	.198	.239*	.095	.052	-.048	-.14	1.00

Note:

\* $p \leq 0.05$ , \*\* $p \leq 0.001$

were very few significant correlations found between the subscales of the BIS-11 with the subscales of the SPSRQ or BAS/BIS. Notably, there were two exceptions as the BIS-11 motoric subscale was negatively correlated with SPSRQ-Punishment ( $r = -0.28$ ,  $p \leq 0.001$ ) and also with the BAS-Fun seeking scale ( $r = -0.23$ ,  $p \leq 0.05$ ).

#### *2.4.1c The BIS-11 with other measures of Impulsivity*

Despite the general lack of significance between the BIS-11 and other self-report measures, there was one significant negative correlation between the SPSRQ-Punishment and BIS-11 Motoric subscale ( $r=-0.28$ ,  $p \leq 0.001$ ) which may reflect a similarity between avoidance for unpleasant consequences (high SPSRQ-Punishment) in light of greater propensity for errors that are made in light of inability to focus attention (high BIS-motoric).

#### *2.4.1d Relationships between measures of Reward Reactivity of Impulsivity*

The SPSRQ-Reward subscale correlated positively with virtually every other measure of reward reactivity substantiating the idea the SPSRQ is a measure of reward reactivity. The largest association with the SPSRQ-R was with the BIS component of the BAS/BIS scale ( $r= -0.478$ ,  $p \geq 0.001$ ), followed by the BAS-Reward Sensitivity Scale ( $r=0.365$ ,  $p \leq 0.001$ ), and finally the Fun seeking scale ( $r=0.347$ ,  $p \leq 0.001$ ).

#### *2.4.1e: Associations between BART explosions and Self Report Impulsivity Measures*

The results of correlations between the BART and self-report measures of Impulsivity challenge our assignment of this task as a measure of Inhibition. There were significant positive associations between the BART and BIS-11 Cognitive subscale ( $r=0.23$ ,  $p \leq 0.05$ ) but also between the BART and SPSRQ-Reward ( $r=0.23$ ,  $p \leq 0.05$ ). The implications of these data are explored in greater detail in the General Discussion.

#### *2.4.1f: Correlations between self report measures of impulsivity and eating behaviour*

As predicted, there were significant correlations between some measures of eating and impulsivity, with the greatest number of significant associations between measures of impulsivity and eating found for the TFEQ-D subscale. The majority of significant relationships between eating measures and impulsivity measures were for the TFEQ-D subscale and BIS-11 subscales. The TFEQ-D and BIS-11 total ( $r= 0.304$ ,  $p=0.012$ ) BIS-cognitive subscale ( $r= 0.250$ ,  $p=0.05$ ), BIS II Motoric ( $r=0.246$ ,  $p=0.009$ ), BIS Nonplanning ( $r=0.203$ ,  $p= 0.043$ ) were all positively correlated, which is consistent with

the idea that overeating assessed by the TFEQ-D is best described by “inhibition” subtypes of impulsivity, at least on self report measures. There was also a significant correlation found between scores on TFEQ-D and the BIS component of the BAS/BIS scales ( $r=0.227, p\leq 0.05$ ), which also supports the idea that Inhibition (or rather a failure to inhibit) as opposed to Reward Reactivity is a trait more reliably associated with self reported overeating.

The strongest correlation was between the BART and TFEQ-D ( $r=0.671, p=0.001$ ). Moderate positive relationships were also found between the BART scores with other measures of eating behaviour DEBQ R scores ( $r= 0.328, p= 0.005$ ), TFEQ-R scores ( $r=0.312, p=0.005$ ), and finally the DEBQ-Emotional ( $r= 0.244, p= 0.05$ ).

The TFEQ-R subscale also showed some significant correlations with impulsivity measures, but only on measures of Reward Reactivity. The most significant correlations were found between the TFEQ-R and the SPSRQ-R ( $r=0.258, p\leq 0.001$ ), and TFEQ-R and the BIS component of the BAS-BIS ( $r=-0.227, p\leq 0.05$ ).

There was only one significant correlation between scores on the BES and impulsivity, based on the SPSRQ-Punishment scale ( $r=-0.457, p=0.000$ ), indicating those individuals with high scores of Binge Eating were more sensitive to avoiding Punishment.

Table 2.4.1.d: Full Correlation Table of Eating and Impulsivity Measures

Impulsivity Measure													
Eating Behaviour Measure	n	BIS II Cog	BIS Motor	BIS NP	BIS Total	SPSRQ-Reward	SPSRQ-Punishment	BAS Fun	BAS Drive	BAS Reward	BAS-BIS	BAS Total	BART Explosions
TFEQ-D	100	*0.250	*0.246	*0.203	**0.304	0.166	0.17	-0.045	-0.126	-0.104	*-0.227	-0.124	**0.671
TFEQ-R	100	-0.21	-0.058	-0.129	-0.098	**0.258	0.011	-0.104	-0.057	-0.017	*-0.227	-0.103	**0.312
DEBQ-Restraint	100	0.075	0.064	-0.011	0.05	*0.217	0.051	-0.124	-0.092	0.008	*-0.218	-0.133	**0.328
DEBQ-Emotional	100	0.163	**0.271	0.161	**0.262	0.141	0.051	*-0.22	-0.092	0.008	*0.227	*0.211	*0.244
DEBQ-External	100	0.053	0.148	0.12	0.146	*0.198	0.09	-0.162	-0.085	-0.14	*0.227	-0.128	0.124
BES	100	-0.074	0.058	-0.143	-0.074	-0.036	**0.457	-0.004	0.08	0.08	0.038	0.043	-0.052
BMI	100	*0.216	0.132	0.08	0.179	-0.112	-0.021	-0.04	0.054	-0.07	-0.052	0.002	0.195

\*significant at p=0.05

\*\*significant at p=0.001



#### 2.4.1g Exploring Self Report Measures of Eating Behaviour and Impulsivity with Performance on the DDT

To allow detailed analysis of DDT data, median splits were used to distinguish High and Low scorers on the eating and impulsivity self-report measures and subsequent Indifference Points were calculated for each of these subgroups. Median splits were conducted with all of the participant's BAS-BIS, SPSRQ, and BIS-11 (and associated subscales) and subsequent indifference points were calculated for the high/low scorers in each of these groups, which were then analyzed in a Group (High/Low Impulsivity Self Report Score) x Indifference Point (calculated at time points 0,7,30,90, 180 and 365 day interval). The same procedure was followed for the measures of self reported eating behaviour, with the subscales of the TFEQ, DEBQ divided by median split and subsequent ANOVA analysis was undertaken to examine for differences in linear discounting rate. Upon completion of the initial linear analysis of Indifference Points, those subscales where significant linear differences were found, were analyzed again using the k-value calculation in order to improve the precision of our understanding of the relationship between Impulsive Choice and Eating Behaviour.

#### 2.4.1.h Impulsivity Self Report Measures and the DDT task: Analysis of Indifference Points

Table 2.4.1e:DDT Indifference Points for High vs. Low BAS/BIS groups

		Reward		Drive		Fun seeking		Inhibition	
		Low n=46	High n=54	Low n=46	High n=54	Low n=38	High n=62	Low n=58	High n=42
Delay 0	Mean	9.89	9.95	9.97	9.87	9.99	9.87	10	9.99
	SD	0.88	0.51	0.58	0.8	0.32	0.85	0.39	0.45
Delay 7	Mean	8.08	8.86	8.63	8.35	8.88	8.27	8.54	8.9
	SD	2.59	1.53	1.88	2.34	1.56	2.35	2.29	1.89
Delay 30	Mean	6.78	7.71	7.45	7.44	7.66	7.06	7.41	7.54
	SD	2.64	2.22	2.35	2.58	1.83	2.74	2.51	1.54
Delay 90	Mean	5.43	6.77	6.4	5.95	6.75	5.81	6.41	6.25
	SD	2.82	2.58	2.72	2.81	2.47	3.13	2.87	2.14
Delay 180	Mean	5.14	6.02	5.91	5.37	6.15	5.3	5.86	6.5
	SD	2.72	2.93	2.93	2.84	2.36	3.13	2.91	3.2
Delay 365	Mean	3.9	5.38	5.38	4.11	4.97	4.54	4.86	5.14
	SD	2.91	3.16	3.06	3.08	2.98	3.22	3.25	2.94

In order to enhance the understanding that the DDT is a measure of reward reactivity or the behavioural subtype of impulsivity, ANOVA analyses was completed on the

DDT indifference points for each of the subscales of the BAS/BIS and BIS-11 measures. Median splits were conducted with each of the subscales of the BAS/BIS and BIS-11, and the indifference points for each subgroup were calculated. Table 2.4.1.c provides descriptive data for the BAS/BIS and BIS-II scales, and the subsequent indifferent point analysis. Following this, a 2\*6 mixed ANOVA analysis was conducted with each of the impulsivity subscales to determine if significant differences emerged between specific subtypes of impulsivity, and their relation with impulsive choice on the DDT.

Confirming our hypothesis that the DDT is a measure of reward reactivity, there were no differences found between scores on the BIS-11 (or any subscales) although there were two significant relationships between scores on the DDT and the BAS/BIS subscales.

There were significant differences between high scorers on the BAS fun seeking subscale (n= 62) whose indifference point analysis indicated significantly more rapid discounting than did low scorers on this scale (n=38) ( $F(5, 95)=3.62, p \leq 0.003$ ). High scorers of the BAS-Reward subscale (n=54), compared to low scorers (n=46), also discounted monetary rewards more rapidly ( $F(5, 95)= 2.48, p \leq 0.031$ ). There were no differences in discounting behaviour between high and low scorers on the other measures (the BIS-11 subscales, BAS-BIS, or BAS- Drive scale). These data offer further support for the position that the DDT is a measure of reward reactivity, which has been suggested in many other experimental contexts in human and animal based literature (Cardinal, 2006).

2.4.1.i Relationships between self reported overeating and performance on the DDT

Table 2.4.1.f: DDT Indifference Points of High vs. Low TFEQ groups

	TFEQ-D		TFEQ-R	
	High n= 58	Low n= 42	High n= 65	Low n= 35
Delay 0	Mean	9.86	10.06	9.88
	SD	0.91	0.23	0.79
Delay 7	Mean	8.144	8.94	8.4
	SD	0.34	0.61	2.24
Delay 30	Mean	7.01	7.79	7.33
	SD	2.75	2.11	2.54
Delay 90	Mean	5.62	6.87	6.21
	SD	2.9	3.2	2.77
Delay 180	Mean	5.3	6.1	5.56
	SD	3.09	2.73	2.97
Delay 365	Mean	4.57	4.98	4.8
	SD	3.22	3	3.2

Table 2.4.1.g: DDT Indifference Points of High vs. Low DEBQ groups

	DEBQ-External		DEBQ-Emotional		DEBQ-Restrained	
	n= 47	n= 53	n= 45	n= 55	n= 62	n= 38
<u>Delay 0</u>	10.05	9.87	9.87	10.03	9.95	9.98
	0.92	0.45	1.17	0.41	0.78	0.27
<u>Delay 7</u>	8.38	8.78	8.9	8.46	8.59	8.34
	1.05	1.11	1.8	2.19	2.14	1.89
<u>Delay 30</u>	7.05	7.75	7.54	7.24	7.39	6.83
	2	1.39	2.46	2.47	2.41	2.91
<u>Delay 90</u>	5.63	6.65	6.51	5.97	6.19	5.36
	1.23	2.32	2.69	2.89	2.83	3
<u>Delay 180</u>	4.95	6.29	5.76	5.61	5.7	5
	2.07	2.23	3	3.02	2.87	3.21
<u>Delay 365</u>	3.98	5.57	4.83	4.78	4.85	4.1
	2.07	2.11	3.03	3.09	3.13	3.1

Results showed that the TFEQ-D and DEBQ-Externality scale were the only subscales capable of discriminating High and Low scorers in relation to reward discounting on the DDT.

It had been hypothesized that the DEBQ provides a more nuanced account of the motivation to overeat in light of its' Externality and Emotionality subscales, results presented in this final section are organized so that the linear differences between the TFEQ-D is reported followed by the DEBQ-Externality. Finally, the  $k$ -value of each TFEQ-D and DEBQ-Externality subscale was analyzed to illustrate the differences in hyperbolic discounting curves between the High, versus Low, scorers on this measure.

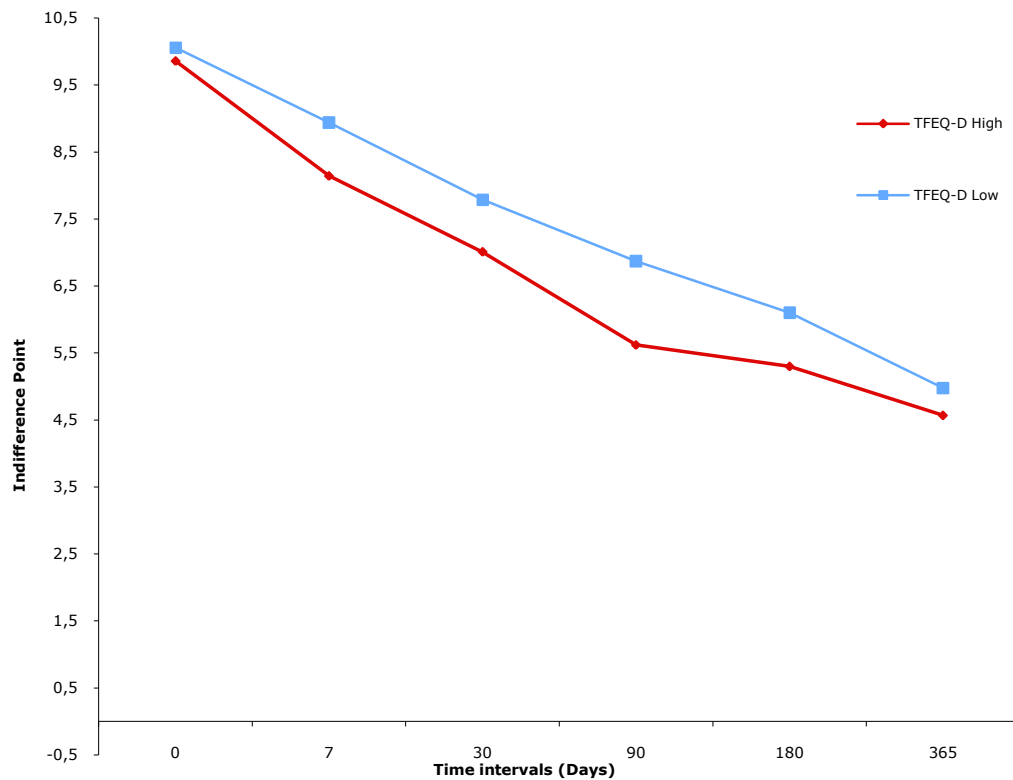
#### *2.4.1.j ANOVA analysis between High vs. Low Scorers on the TFEQ-D and DDT Indifference Points*

A 2\*6 mixed ANOVA analysis was conducted to test whether individuals with high scores on the TFEQ-D ( $n=58$ ) show a significantly more rapid rate of discounting rewards compared to those with low scores on the TFEQ- D measure ( $n= 42$ ) on the DDT task.

Although there was no overall significant main effect of classification as high or low on the TFEQ-D measure (Fig 2.4.a.1,  $F(1, 96) = 2.27, p = 0.135$ ), the quadratic relationship between Delay Discounting and Disinhibition scores was significant ( $F(1, 96) = 4.24, p < 0.05$ ), with the high TFEQ-D group showing more rapid discounting, indicative of more impulsive choice.

In contrast, analysis of DDT data with participants classified as high or low on the TFEQ-R scale found no significant main effect or interaction for restraint. Thus, impulsive choice on the DDT appeared to relate to high scores on TFEQ-D but not TFEQ-R, suggesting impulsivity is more associated with tendency to overeat than restrict intake.

*Figure 2.4.a :TFEQ-Disinhibition and the DDT task: High vs. Low Scores and Indifference Point Slope*

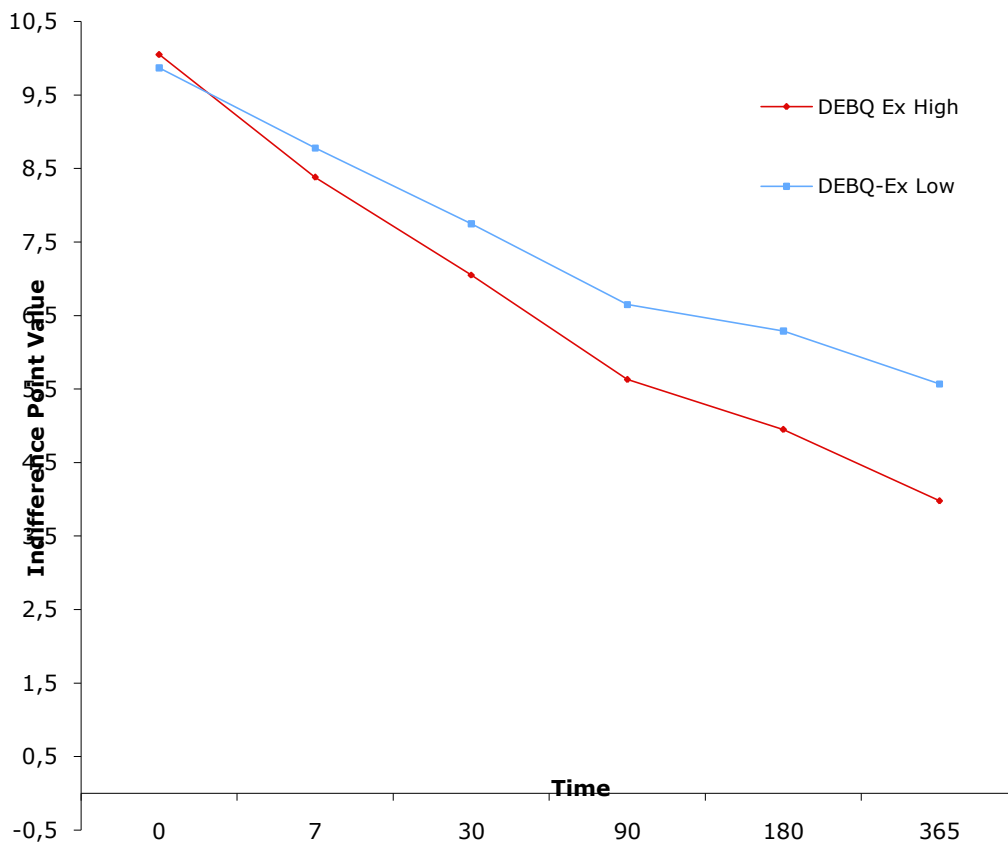


#### *2.4.1.k DEBQ-Externality groups and performance on the DDT Scores on the DDT*

DEBQ-Externality measure was analyzed in the same format, whereby a median split was conducted on each of the distinct subscales (Restraint, Emotional, and External eating).

A 2\*6 mixed ANOVA with participants classified using the DEBQ-External scale (Figure 2) found a significant main effect of group ( $F(1, 98) = 4.96, p = 0.033$ ), and a significant interaction linear contrast for the group by delay interaction ( $F(1, 98) = 7.67, p = 0.007$ ). Figure 2.4b denotes the difference in slope gradient between individuals with High vs. Low scores on the DEBQ-External, and their indifference point values on the DDT task.

Figure 2.4b: Indifference Point Slope calculated between DEBQ-External groups



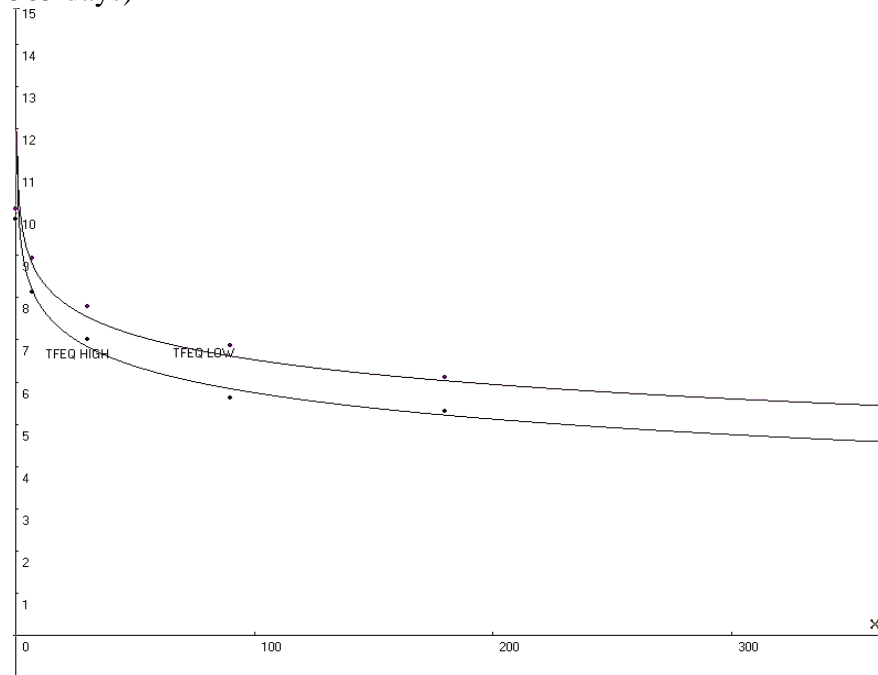
Analysis was conducted with the other DEBQ scales (DEBQ-Restraint, and DEBQ-Emotional) and BES scale, although no significant differences between High or Low groups emerged.

#### 2.4.1.1 ANOVA Analysis for *k*-values between High/ Low scorers on TFEQ-D measure

In these final analyses the *k*-value for the slope of the curve, which is calculated based on a line best fitted to the six indifference data points, was calculated using the Graphnet software program. Exploration of the indifference points supported the hypothesis there would be differences in discounting between the groups, and based on previous findings (M. R. Yeomans, et al., 2008), it was hypothesized those women scoring high on the TFEQ-D would discount monetary rewards significantly faster.

Our results, however, do not support this hypothesis. While the results show trends to support the hypothesis high TFEQ-D scorers would have higher  $k$ -values, this was not significant ( $F(1, 94) = 1.18, ns$ ).

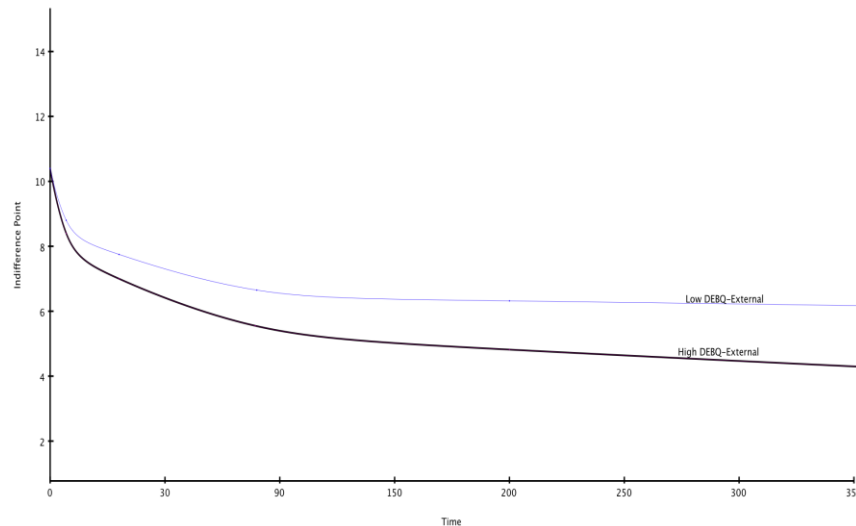
*Figure 2.4c: Hyperbolic function fitted to the indifferent point data for TFEQ-D groups (high and low). The y-axis represents the subjective value of the delayed reward (10 GBP) and the x-axis represents the delays of the reward (0,7,30, 90, 180, 365 days)*



#### *2.4.1.m ANOVA Analysis for $k$ -values between High/ Low scorers on DEBQ-External measure*

Using a median split to determine high and low groups on the DEBQ-External measure, data demonstrates that the High DEBQ-External discount hypothetical monetary rewards faster ( $F(1,94) = 4.69, p=0.033$ ). This finding suggests externality is linked with performance on the DDT, which is to say those individuals who report higher levels of susceptibility to eating in the presence external stimuli, are more impulsive in terms of their propensity for making impulsive choices, and trading Small Soon rewards for Larger Later ones more rapidly, which was significant.

*Figure 2.4d:* Hyperbolic function fitted to the indifferent point data for TFEQ-D groups (high and low). The y-axis represents the subjective value of the delayed reward (10 GBP) and the x-axis represents the delays of the reward (0,7,30, 90, 180, 365 days)



## 2.5 Discussion

The present study found clear positive associations between self-report measures of overeating and increased impulsivity. Moreover, the relative strengths of the TFEQ-D compared to the other measures of overeating were verified in a series of ways, indicating this is clearly the most sensitive and suitable subscale for investigating the relationships between overeating and impulsivity.

Our hypothesis, that the TFEQ-D would be positively associated with impulsivity, was confirmed. Although there were significant relationships between the other measures of eating behaviour with the battery of impulsivity tests, the associations were typically smaller in either magnitude or significance, and none of the scales had the variety of associations with the impulsivity tests as did the TFEQ-D. Another strength of the TFEQ-D measure was its significant positive relationship with BMI, and lack of association with binge eating the BES, indicating the current population's tendency for overeating, but not binge eating *per se*.

Although the TFEQ-D subscale was the obvious choice for self-report assessments of overeating behaviour, the specification of impulsivity subtype best associated with



this scale is less clear. There were associations with *both* Reward Reactivity and Inhibition subtypes, and drawing any firm conclusions at this early stage would be hasty in light of the strength of the associations between the two measures of impulsivity with overeating. In terms of self-report measures, there was a greater range of associations between overeating measures and the BIS-11 subscales, thus upholding the position that the *Inhibition* subtype of impulsivity is the best way to describe impulsivity in relation to overeating behaviour.

One of the biggest challenges of classifying the subtype of impulsivity best associated with TFEQ-D scores, was that the classification of the BART was not as clear as we had originally hypothesized. The strength of the relationship between the BART and TFEQ-D indicates that a shared characteristic may underlie a person's tendency to overeat, in addition to controlling the prepotent urges (with regard to the balloon pumping exercise in the BART). Whether the BART truly conforms to a definition of Inhibition subtype of impulsivity, though, is difficult to confirm. The BART in many ways satisfies elements that are expressive of *both* Reward Reactivity and Inhibition subtypes of impulsivity.

Analysis indicated that BART had associations with both the SPSRQ-Reward subscale and the Motoric Subscale of the BIS-11. Interestingly, this pattern of results with the BART has also been found independently of our investigations. In a recent comparison of risk taking in adolescents compared to adults, the BART was used in conjunction with the BIS-11 and Sensation Seeking Scale, a measure of reward reactivity (S. Mitchell, Stevens, 2008). Significant relationships were found between BART explosions and BIS-11 subscales of Cognitive and Motoric impulsivity, in addition to Eysenck's (1971) Sensation Seeking subscales of Thrill and Adventure seeking. Mitchell (S. Mitchell, Stevens, 2008) The authors did not deliberate on this finding further, but it does offer an external source of support for the notion that the BART is not exclusively a measure of Inhibition or Reward Reactive impulsivity.

The BART provides an experimental platform to explore risk taking. Risk taking, similar to impulsivity, includes aspects of "multi dimensionality (Llewellyn, 2008). While sensation seeking has been implicated in risk taking behaviour other underlying factors, such as urgency, have also been implicated (Llewellyn, 2008).

Subsequent to this investigation, several post hoc initiatives to clarify the best measure of impulsivity on the BART have been made, thereby refining the quantification of “risk” behaviour. Namely, an emphasis on using the variable for Adjusted Average Pumps to the balloon, as opposed to the actual explosions (Bornovalova MA, 2008; White, 2008) had been suggested as way to enhance clarity regarding impulsivity. Using this alternative approach with the BART for future investigations will be a priority, but was impossible with the current investigation as a result of our method of data coding and inability to access the Adjusted Average pumps variable in subsequent analysis.

Classifying subtypes of impulsivity associated with overeating behaviour is a challenging endeavor, which has begun to attract the interest of a collection of personality based psychologists (Fischer, 2008; Cassin & von Ranson, 2005; Dawe & Loxton, 2004; Whiteside & Lynam, 2001.) In personality-based research, the association between bulimia spectrum disorders and punishment avoidance has been considered at various times (Whiteside & Lynam, 2001; Dawe & Loxton, 2004; Cassin & von Ranson, 2005) as a means to refine the ever-present question of *which* measure of impulsivity is associated with disturbed eating stages. In a recent meta analysis of impulsivity and bulimic spectrum disorders (Fischer, et al., 2008), authors determined that a form of impulsivity, “negative urgency”, which is associated with pain avoidance, is significantly related to binge type eating..

The findings in the current study corroborate the position that binge-type eaters have a greater inclination to avoid punishing experiences, demonstrated by the significant association between the BES and SPSRQ- Punishment scale. In the current study, the exclusion of people suffering eating disorders (past or present) was made explicitly clear, thus the magnitude of scores on the BES measure, predictably, would be small. With a small range of scores on this measure, we did not anticipate significant associations to be found. However, even with a potential floor effect (i.e. Small scores, in light of few clinical binge eaters), there was a significant relationship with the SPSRQ-Punishment thereby validating the idea that Binge Eating is associated with a pronounced tendency for avoidance of punishing (or perhaps unrewarding) situations.

The final component of the exploration was performance on the DDT in relation to participant's self reported eating behaviour. The results on the DDT were surprising: using the AUC method of analysis, we found a significant quadratic difference between High and Low TFEQ-D groups, and high TFEQ-D participants discounted monetary rewards more quickly than low TFEQ-D participants. This result fit within our original hypothesis. However, using a method that has been hypothesized to be more precise than the AUC calculation, the  $k$ -value calculation (Ho, et al., 1999), we did not find a significant difference in the slopes of the hyperbolic curves created with the indifference points. In light of a recent finding that obese women discount monetary rewards more rapidly than lean females (Weller, et al., 2008), and our previous findings showing women with high TFEQ-D scores discounted monetary rewards more rapidly on the DDT measure (M. R. Yeomans, et al., 2008) we had hypothesized the relationship between self reported overeating and rapid reward discounting to be relatively stable. Thus, the results found in the current investigation were quite surprising.

One explanation for our lack of association between TFEQ-D with discounting rates using the  $k$ -value method, may lie in the fact that the TFEQ-D could (arguably) be dissociated by two subscales, in essence the DEBQ-Emotionality and DEBQ-Externality scale, and our previous sample of women (Yeomans, 2008) were self reporting higher levels of Externality compared to Emotionality. This hypothesis is upheld by the findings in the current investigation, but they are limited exclusively to performance on the DDT.

The inability to incorporate Westenhoefer's (1994) dual classification method of eating motivation stands as one of the greatest limitations of the previous investigation. The case for using a classification method that incorporates an individual's choice to restrict *and* overeat would have been useful in this investigation, however the disparity between group sizes once recoded along these guidelines was too uneven and produced. In the current investigation, participants were classified as either high or low scorers based on median splits in terms of scores on the TFEQ-D, TFEQ-R scales (in addition to each of the DEBQ subscales). Recoding participants based on *two* subscales, yielding four subgroups, greatly changed the size of each group, skewing statistical analysis. For future designs,

participants will be screened based on their TFEQ-D and TFEQ-R scores in order to observe impulsivity between HDHR/HDLR/LDHR and LDLR, thereby enhancing our understanding of self reported eating motivations and association with impulsive behavior.

Critically, we did not find the DEBQ score, or the dual model of describing motivations for overeating to enhance detection of impulsivity. Our lack of significant differences between high and low scorers on the DEBQ-Emotional and External scales on the BART is consistent with other literature in the field of eating behaviour; for example evidence that rejects the dual-model of tendency to overeat relates to the efficacy of the External subscale of the DEBQ (Lluch, 2000; Snoeck, 2007; J. Wardle, 1987; Wardle, 1992). For example, Wardle (1987) found that overweight women were no more external than lean women. In a following study, Wardle (1992) also found that British teens who were overweight were not more external than lean participants either. Replicating these findings, is the highly similar result in the French Stanislas Family study (Lluch, 2000). A large Dutch study with over 10,000 adolescents found a negative association between external eating and overweight levels (Snoek, Van Strien, et al 2007). Finally, in a cross comparison of Korean Twins, it was also found that the DEBQ-Externality scale was unrelated to overweight status (Sung J, 2009). These data demonstrate that self-reported responsiveness to food may not be a worthy distinction in the motivation to overeat, and hence explains why the DEBQ categorization method may not offer any advantage compared to the approach of the TFEQ.

Unlike the BART, classification of the DDT as a measure of Reward Reactivity is considerably less complicated in light of a wealth of information classifying the psychological (Mischel, et al., 1989; Trope, 2000) and psychobiological foundations (Cardinal, 2006; Cardinal, et al., 2001; Hariri, et al., 2006) of Impulsive Choice. In the current investigation, there was a total lack of association between the BIS-11 and DDT, which could be interpreted as support for the position that the two tests measure distinct aspects of impulsivity. This dissociation between the DDT and self report measures of inhibition, such as the BIS-11, has also been found in other research fields, examining behavioural economic choices in relation to personality traits

(Oxoby, 2007), also supporting the idea that the DDT capture Reward Reactive behavior.

In the current investigation, we found indication of a relationship between high TFEQ-D scores and greater temporal discounting of monetary rewards on the DDT. Notably, the association between high TFEQ-D scores and monetary discounting was found using the AUC method of scoring the DDT. In line with our previous investigation (2008) a trend for greater discounting in high TFEQ-D participants was found, although this relationship only approached significance.

In light of the association between TFEQ-D scores and the BART, a significantly greater trend for discounting monetary rewards among high TFEQ-D scorers, and the significant positive correlations between the TFEQ-D with self report measures of impulsivity, there are several important considerations to make for future clarification of the subtype of impulsivity associated with overeating. A major limitation to this study, in hindsight, was that the performance-based measure of *Inhibition* impulsivity, the BART, arguably detected aspects of Reward Reactivity (Bornovalova MA, 2008). If we had included a third performance based measure to explicit in its detection of Inhibition impulsivity, a stronger resolution regarding the subtype of impulsivity associated with overeating could be made.

A second limitation to this initial investigation, was that the basis of “overeating” was determined entirely on self-report measures. An important consideration for future studies will be to test the hypothesis that overeating behaviour (and not just self reports) are associated with impulsivity. Preload type paradigms could be used for this purpose, as have been used in previous studies in the field of eating behaviour (please see 1.2a of the General Introduction). Finally, incorporating a more rigid recruitment strategy would greatly enhance the experimental design and the ability to clarify the specific aspects of eating motivations are most directly related to impulsivity. One way to achieve this objective is via Westenhoefer’s (J. Westenhoefer, et al., 1994) dual classification model, and in future investigations the recruitment of participants based on their specific self reported eating motivations will be a key priority.

After exploring the magnitude and significance of each of the impulsivity tests with self reported overeating behaviour, two important resolutions can be made from this

data. The first, is that the TFEQ-D measure is most appropriately suited to detecting overeating behaviour in lean, non-eating disordered, healthy females. The second, is the need to declare which of the two Impulsivity subtypes is most closely related to TFEQ-D scores, with hindsight knowledge that the BART is a measure of risk taking, but perhaps not exclusively a measure of Inhibition impulsivity. Thus, a performance based measure of Inhibition impulsivity is an obligatory requirement for future investigations.

The following investigation illustrated the complexity involved with analyzing both self-reported overeating behavior in addition to assessing impulsivity. Most obviously, the TFEQ-D subscale emerged as the most sensitive measure for detecting impulsive behavior in light of positive correlations between the TFEQ-D and BIS-11, and also the significant positive association found between high TFEQ-D scores and BART explosions. The precise resolution as to whether TFEQ-D scores are representative of greater Reward Reactivity versus greater Inhibition was impossible to determine with this initial investigation since the BART measure cannot be described as pure measure of Inhibition impulsivity. Moreover, the finding that high TFEQ-D participants demonstrated greater discounting on the DDT challenges this position.

The exploratory format of this investigation provided the basis for understanding the inter relationships between self-reported eating behavior and impulsivity. A critical development will be to determine if *actual* overeating behavior is related to greater impulsivity. Two strategies to improve the future studies will be the incorporation of Westernhoefer's(1994) dual classification method, in addition to the inclusion of a specific measure of Inhibition impulsivity.

**Overeating and Impulsivity: after consumption of a fixed preload, women with high TFEQ-D scores consume more palatable food and are more impulsive than women with low TFEQ-D scores**

### **3.1 Introduction to Experiment 2**

The present study aimed to replicate and extend the key findings from Experiment 1, but used a wider range of performance based impulsivity tasks, a restrictive classification method for participants based on TFEQ-D and TFEQ-R scores, in addition to a genuine assessment of overeating.

In Chapter 2, (Experiment 1), there was a significant positive association between a questionnaire measure related to overeating (the TFEQ-D subscale) and measures of impulsivity in lean healthy women. The TFEQ-D subscale, compared to a variety of other measures (DEBQ and BES), was the most sensitive at discriminating impulsive behavior, yet these data found significant associations between the TFEQ-D measure and both reward reactivity *and* inhibition measures of impulsivity (BART, BIS-11 Total, Non-planning and Cognitive subscales in addition to the Behavioral Inhibition Scale subscale of the Behavioral Activation Scales), which indicates that there is an opportunity to refine our method of classifying eating behavior in order to specify which subtypes of impulsivity are most reliably associated with overeating.

Significant research has been devoted to the deconstruction of the motivation to overeat, and the overwhelming consensus is that the motivation to overeat is not based on a unitary classification method. Therefore, our finding that the TFEQ-D scale is related to *both* Reward Reactivity and Inhibition impulsivity may indicate that we need to refine our classification method to determine if specific subtypes of impulsivity are related to more nuanced classifications of eating motivation. Since the design of the previous experiment was correlation, we were not able to select specific populations of participants to conduct an experimental comparison of between group differences, and so the following experiment was constructed in order to address that concern.

A significant limitation of the previous study was that both performance- based measures may have related to Reward Reactivity sensitivity rather than providing a

distinct contrast with a measure of Inhibition. The DDT is a well-established assessment of Reward Reactivity, whereas the BART has aspects of detection for *both* Reward Reactivity and Inhibition (Bornovalova MA, 2008; Llewellyn, 2008; White, 2008) and so the failure to include a performance based task to assess Inhibition, exclusively, limited our ability to make a firm conclusion in regard to the specification of Impulsivity in relation to overeating. The pattern of correlations between the TFEQ-D with self report measures indicated that self report overeating was more associated with Inhibition subtype of impulsivity, although a clear performance based measure of Inhibition is required to confirm that hypothesis.

The current experiment examined influences on eating behavior in greater detail by including preselected populations, and also a real life measure of overeating a pleasant tasting, High Energy Dense (HED) food, and a performance based measure of Inhibition impulsivity. By adopting a between-groups design based on pre-selection of women classified as high or low on both TFEQ-D and TFEQ-R, the study reported here overcomes the problem of how to assess potential interactions between these factors might be related to impulsivity. The introduction of the Matching Familiar Figures Test (Kagan, 1968) to the impulsivity test battery allowed evaluation of the extent to which individual differences in tendency to overeat may relate to a failure to inhibit responding.

The Matching Familiar Figures Test (MFFT) (Kagan, Lapidus, & Moore, 1978) is a well known cognitive task, which, outside the realm of eating behavior is widely used as a performance based measure to assess “reflection-impulsivity” (N. Salkind, 1978; N. Salkind, & Wright, JC, 1977; N. Salkind, Nelson, F., 1980). The MFFT can be used to explore ‘the preferential mode of information processing a subject manifests in the majority of reasoning, learning, and memorizing experiences during an assigned task’ (Southgate, 2001), and the basic premise of the task requires the participant to select an identical picture to the target stimulus, from an array of highly similar pictures, a.k.a. “figures”. The figure that “matches” is the correct choice. The MFFT was initially proposed for use in intelligence type testing, and developmental psychology (N. Salkind, 1978{Markus, 2007 #417}). However, the MFFT has been shown to discriminate impulsive responding between addiction prone individuals and healthy non drug taking controls (Morgan, 2007) and further to differentiate



impulsive responding between binge eaters versus non-binge control populations (Kaye, 1995), demonstrating its utility in the current investigation among self reporting overeating (yet lean) females.

Although the MFFT has not been used widely in eating behavior research, the few studies that have used it have produced generally consistent findings; impulsivity was found to be significantly higher among those participants who were overweight (Braet, et al., 2007) or binge eating (Kaye, 1995). On the opposite end of the binge-eating spectrum, it has been found that hyper vigilance (defined as significantly greater precaution before selecting a stimulus on the MFFT) was reported among anorectic populations compared to control groups (Toner et al., 1987). In other words, at a basic cognitive level that is not related directly to food or eating, those populations who overeat appear to have a lesser ability to inhibit responses on this task. One study has, however, found that bulimic spectrum participants have performed *less* impulsively on the MFFT (Roberts, 2007), although authors attribute this to the use of a pen-and-paper, as opposed to digital, format of MFFT task. That the MFFT has produced consistent results is certainly a detail that should not be overlooked. Within the field of Eating Behavior, there are instances of other performance-based tasks that assess inhibition that have generally failed to reproduce findings (A. Jansen, et al., 2009; C. Nederkoorn & Jansen, 2002; C. Nederkoorn, Jansen, et al., 2006; C. Nederkoorn, Smulders, et al., 2006). In light of these features, and general consistency the MFFT is able to discriminate between overeating populations based on their higher degree of Inhibition impulsivity, the MFFT was selected as a performance based measure of Inhibition for the current study.

The modifications of the current experiment include the inclusion of the MFFT measure, in addition to the introduction of an actual measure of overeating based on a preload paradigm that has previously been used to discriminate between successful from unsuccessful dieters (C. P. Herman & Mack, 1975), and finally selection of participants based explicitly on Westenhoefer's double classification model of TFEQ-D and TFEQ-R scores. The only self-report task used was the TFEQ, in light of the outcome of Experiment 1, and based on the aggregate benefits of past research asserting its efficacy for assessing overeating (Bryant, et al., 2008; Lahteenmaki & Tuorila, 1995; Williamson, et al., 2006).

The controversies surrounding the specific motivations for overeating have been documented within several investigations in the field of Eating Behaviour research. Subsequent to the original Restraint investigations (Laessle RG, 1989; Larsen, et al., 2007; Lluch, 2000; M. R. Lowe & Kral, 2006; M. R. Lowe & Levine, 2005; T. Van Strien, et al., 2000; J. Wardle, 1987; Wardle, 1992), there had been significant controversy regarding the validity of the RS construct in light of consistent findings that when the DEBQ and TFEQ restraint scales were used to assess “restrained” behavior, the “counter regulatory response” was rarely found (Laessle RG, 1989) this is documented in detail in Chapter 1 (section 1.2b, 1.2c).

Westenhoefer (1994) replicated Herman & Mack’s (1975) original ice-cream and milkshake preload paradigm, but instead of using the RS to classify the unitary construct of Restrained Eating, he classified participants based on *both* TFEQ-Restraint and TFEQ-Disinhibition scales. Westenhoefer’s model thereby implicated a double-classification structure to account for motivations of overeating. In this way, four groups emerge with this dual classification method: the High TFEQ-Disinhibition groups can be split into HDHR and HDLR, whereas the Low TFEQ-D groups can be split into LDHR, and LDLR. Critically, Westenhoefer’s model would predict that the two high TFEQ-D participants will eat more, but that the HDHR participants are more vulnerable to the psychological distress associated with dieting behavior, and also vulnerable to the threats to dietary restraint highlighted in the Counter Regulatory model of eating (Herman & Polivy, 1980). Westenhoefer’s method allows for distinctions not possible with the homogenous Restrained eating construct; for example those with LDHR classification would represent what Westenhoefer deemed as “successful dieters”, and the LDLR group represents individuals who regulate their eating behavior by physiological signals, and HDLR are simply individuals prone to overeating.

In light of the dual classification method initially proposed by Westenhoefer, a priority for the current investigation was to classify participants based on both their TFEQ-D and TFEQ-R responses to assess whether it was solely the style of eating detected by the TFEQ-D score that is associated with impulsivity, or whether the dual-classification of eating behavior identifies how an impulsive personality may

lead to a particular vulnerability for diet breakdown, if for example those classified as HRHD show the most impulsive responding in general.

The latter suggestion is supported by some published work, but could not be tested adequately in Experiment 1. One previous study suggested that women who scored highly on dietary restraint (as defined by the RRS) showed greater impulsivity on a response inhibition task (C. Nederkoorn, Van Eijs, Y., Jansen, A., 2004a). Since high RRS restraint may be similar to HRHD on the TFEQ, this would imply that impulsivity measured by the MFFT would depend on both the TFEQD and TFEQR classification. Experiment 1 found only limited evidence for a relationship between impulsivity and Restraint using the TFEQ-Restraint and DEBQ- Restraint measures. Moreover, the relationships found using the TFEQ-R scale were only within the Reward Reactive bracket of impulsivity tasks, not a measure of inhibition. However, the correlation design prevented investigation of the interaction between TFEQ-D and TFEQ-R. Therefore, the aim of the current experiment was to preselect groups based on their TFEQ-D and TFEQ-R scores, to gain a definitive perspective on impulsivity with regard to self reported eating behavior.

A more rigorous test of the relationship between impulsivity and *actual* overeating would be to include an actual measure of food intake under controlled conditions, which is also necessary to determine if impulsivity is associated with *self report* overeating, and whether our self report measures are indicative of a more objective test of overeating behavior. A test which is known to be sensitive to likelihood to overeat, and also sensitive to the classifications of individuals based on *both* their TFEQ-D scores in addition to their TFEQ-R scores is based on Herman & Polivy's original preload paradigms. One of the most widely used tests of the breakdown of control of eating in the laboratory is based on Herman & Polivy's original preload paradigm (see General Introduction 1.2b), and this test was modified to provide an objective measure of overeating in the current investigation. The rationale for using this test was to further substantiate whether groups comprised of a tandem score of TFEQ-D and TFEQ-R scores have significantly differed eating patterns based on consumption of a pleasant tasting preload, and further to investigate whether they performed significantly more impulsively after consuming a high calorie preload.

Inclusion of a test of actual eating in a context predicted to act as a disinhibitor was seen as a good test of whether impulsivity does relate to actual disinhibited eating in its original sense of a breakdown of restraint, or in contrast a general tendency to overeat, measured using the TFEQ-D, which both predicts intake (Bryant, et al., 2008; Haynes, et al., 2003; Laessle RG, 1989; J. Westenhoefer, et al., 1994) and impulsivity under these circumstances.

The classic preload design has two conditions: The first is exposure to a taste test of some kind of pleasant tasting food. The second includes a controlled meal (in studies examining overeating, typically pleasant tasting food such as ice-cream has been used (C. P. Herman & Mack, 1975; Herman CP, 1975; C. P. Herman & Polivy, 2005; C. P. Herman, Polivy, Pliner, Threlkeld, & Munic, 1978; C. P. Herman, Polivy, & Silver, 1979; Ouwens, et al., 2003; Schachter, 1971; Schachter, et al., 1968; T. Van Strien, et al., 2000; Wardle, 1992; J. Westenhoefer, et al., 1994) prior to exposure of the same pleasant tasting food used in the first condition. The amount eaten in the Taste Test condition are contrasted to observe whether an individual is eating based on internally derived hunger signals (eating more in the Non- preload condition) or based on the breakdown of cognitive dietary control (eating more in the Preload condition). . Further modifications to Herman and Mack's original design were made in the form of a wider array of *ad lib* snacks available for consumption after the ice cream preload. This included two other savory snack foods, which was based on the idea that overeating can be attributed to a variety of different food preferences, based on savoury and sweet characteristics {Finlayson, 2006; Rolls BJ, 1984}.

The aim of the current investigation was to relate the degree of disinhibited eating to impulsivity, and therefore, all participants were given the classic experimental condition of a forced preload and then voluntary intake test, with intake in that test taken to be a measure of disinhibited eating. In light of the substantial support for the TFEQ-D as a measure for the tendency to overeat (for a review, please see Bryant, 2008 or section 1.2 of the General Introduction), we hypothesized those participants scoring highly on this measure will also consume significantly more calories in the snack taste test (disinhibited eating paradigm).

Based on Westenhoefer's distinctions within the high TFEQ-D groups, we hypothesize several specific patterns of behavior in relation to each TFEQ group. We predict the HDHR group (similar to the high RS classification) will consume more calories than either of the low TFEQ-D groups, but will consume less than the HDLR group, who do not restrict caloric intake at all. It was predicted that the HDHR group would experience a greater threat to cognitive control of eating, hence a greater conflict with the preload and *ad lib* snack will lead to a reduced ability to control impulsive urges, and this will increase impulsivity in the impulsivity performance component of the investigation. We predict that the LDHR group will perform more impulsively than the LDLR group, but in light of their ability to maintain their dietary goals, their behavior may not be negatively impacted as severely as the HDHR group who we predicted would most definitely overeat in the *ad lib* snack component.

We predicted that the high TFEQ-D groups would be more impulsive than the low TFEQ-D groups based on the outcome of Experiment 1, but specifically that the HDHR group would be the most impulsive reflecting a disinhibition of controlled behavior as a response to the violation of a dietary boundary had been made.

To summarize the previous findings, the aim of Experiment 2 was to contrast the hypothesis that high TFEQ-D participants would consume more food and would also respond more impulsively on a battery of performance based tests. The alternative hypothesis would be that overeating in this classic disinhibition task would be predicted by the TFEQ-R rather than TFEQ-D, and consequently that women scoring high on both TFEQ-R and TFEQ-D would be the ones showing most impulsive behaviour based on their inability to sustain their restrained eating attitude. This approach provides a behavioral platform for exploration into both eating and impulsive behavior in healthy volunteers, and refines the basic hypothesis that impulsivity is associated with overeating.

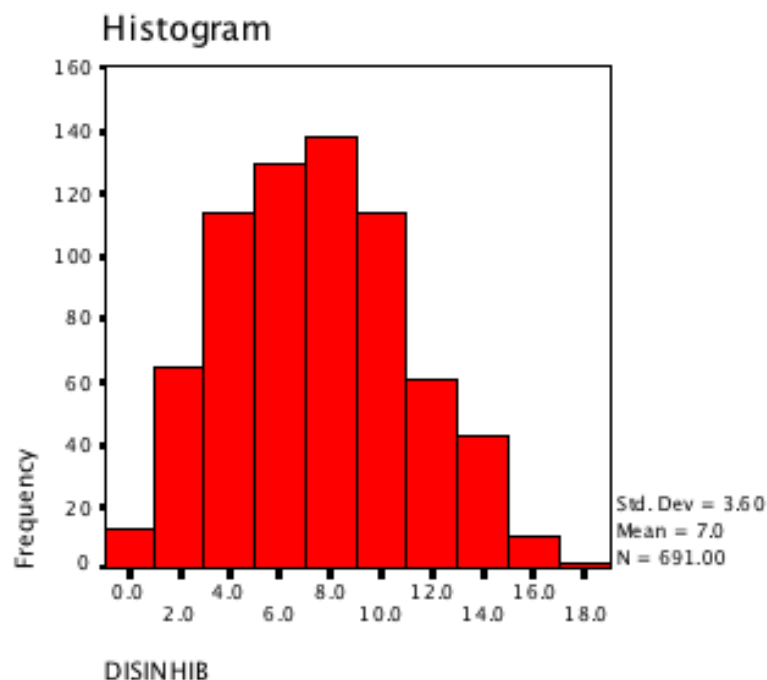
### 3.2 Methods

#### 3.2.a Participants

The key focus of this experiment was to contrast impulsivity measures between women scoring high or low on the TFEQ-D scale in order to try and replicate the

findings based on the correlational approach used in Experiment 1. To ensure substantial differences between high and low TFEQ-D scorers, upper and lower tertiales of the TFEQ scale were taken from 780 women volunteers from the same study population who had previously completed the TFEQ scale. The full distribution of TFEQ-D scores in these participants is shown in Figure 3.2.1. For this study, High Disinhibition was defined as having a TFEQ-D score as 9 or higher (the upper tertiale), whereas those with a score of 5 and lower (the lower tertiale) were selected for the Low group. A similar approach for TFEQ-R would have been ideal, but in practice the numbers of potential participants in HRLD and LRHD groups would have been too small for such a study to be feasible. Therefore the Restrained scores (TFEQ-R) were determined by using a median split based on the same population (those with 7 or lower were classified as Low Restrained, and those with 8 and higher as High Restrained).

*Figure 3.2.a: Upper and Lower tertiales for TFEQ-D scores*



Sixty-four normal-weight female students were recruited to participate in a study investigating “mood and food preferences” at the University of Sussex Ingestive Behaviour Unit, 16 women in each of the defined combinations of TFEQ-D and TFEQ-R scores. Four participants had problems with one of the current soft ware

programs, which meant that exactly fifteen participants were included in each of the four TFEQ classification groups (High Disinhibition + High/ Low Restraint, and Low Disinhibition + High/ Low Restraint scores). There were no significant differences found on the TFEQ-D scores between the two “high-D groups”, however there were significant differences found between the high versus low groups. Table 3.2.1.a summarizes group BMI and TFEQ score means.

Table 3.2.1a: *Characteristics (mean  $\pm$  SD) of the four groups of participants*

	HD-HR	HD-LR	LD-HR	LD-LR
	<i>n</i> =15	<i>n</i> =15	<i>n</i> =15	<i>n</i> =15
BMI	23.28 $\pm$ 2.9	23.7 $\pm$ 5.1	23.3 $\pm$ 2.5	22.1 $\pm$ 3.4
TFEQ-R	13.2 $\pm$ 3.9	2.7 $\pm$ 2.2	12.4 $\pm$ 3.5	2.8 $\pm$ 2.2
TFEQ-D	11.7 $\pm$ 2.3	10.1 $\pm$ 1.0	3.9 $\pm$ 2.9	3.2 $\pm$ 1.9

### 3.2.b Controlled breakfast and Disinhibited Eating Test

To ensure control of energy intake was maintained, participants were served a standard breakfast consisting of 60 g Crunchy Nut Cornflakes, 200 g Sainsbury’s Orange Juice, 160 g of milk (1682 kJ, 400.4 kCal total).

The Disinhibited eating test required participants to consume a preload (ice-cream sundae) followed by ad libitum intake of a number of snack foods. The food used for the preload was a chocolate sundae (120 g Vanilla ice cream, Wall’s brand (280 kCal), and 30 g chocolate sauce topping Sainsbury’s brand (90 kCal), with the total 150g preload containing 370 kCal. Participants were required to sample *ad libitum* a selection of four 60-gram samples of typical snack foods. The snacks used were Chocolate Buttons (Cadbury’s brand: 486 kcal/ 100g), savoury biscuits (Mini Cheddars, McVitie’s brand :517 ckal/100g), dry roasted peanuts (Sainsbury’s: 854ckal/100 g), and sweet biscuits (McVitie’s Go Ahead Apple Cinnamon low fat biscuits: 389kcal/ 100 g). Each of the snacks were placed in white Styrofoam trays labeled A, B, C, and D. Snack Foods were selected based on sweet and savory properties, and had been piloted for pleasantness in previous investigations within the laboratory. The labels were counterbalanced across participants to avoid order of effects of tasting, as participants were likely to follow consumption of snacks in alphabetic order.

During the snack taste test, participants were required to rate each of the snacks' using *Visual Analogue Scales* (VAS) placing an "X" along a 100-mm scale where "Not at all" and "Extremely" anchored each end of the scale. VAS were used to measure pleasantness, sweetness, novelty, and bitterness for each snack food sample.

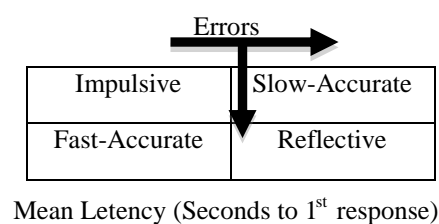
### 3.2.3 Testing Measures

#### 3.2.3a The Matching Familiar Figures Task (MFFT) (Kagan, et al., 1978)

The MFFT(Kagan, et al., 1978)is a standard cognitive behavioral measure of impulsivity, which describes the cognitive process involved in "reflecting the accuracy of available hypothesis" (Kagan & Messer, 1975 p. 224, as cited by (N. Salkind, Nelson, F., 1980). The aim of the task is to choose an identical matching picture to a target stimulus, from an array of highly similar pictures. The task includes 2 measures: the time taken to choose which of the 6 displayed options matched the previous target (response time/latency) and whether the selected picture was correct (accuracy/errors). Those who react quickly, and make errors, are deemed to be impulsive.

Several adaptations of Kagan's original Matching Familiar Figures (MFFT) have been made (Salkind, 1980); the most widely used model of the MFF is based on Cairns and Cammock's modifications (Cairns, & Cammock, 1978; 1982)which includes the addition of five additional items. Various reviews of this task confirm its ecological validity (Buela-Casal, 2000; Miyakawa, 2001), and comparisons between the two tasks directly show that the MFFT-20 is more consistent in detecting error rate and latency, and generally a more sensitive measure compared to the original 15-item task(Loper, 1980). Dimensions of "reflective impulsivity" are shown in Figure 3.2.b, based on Kagan's original definition of this dimension of impulsivity.

*Figure 3.2.b: Response Styles on the MFFT-20*



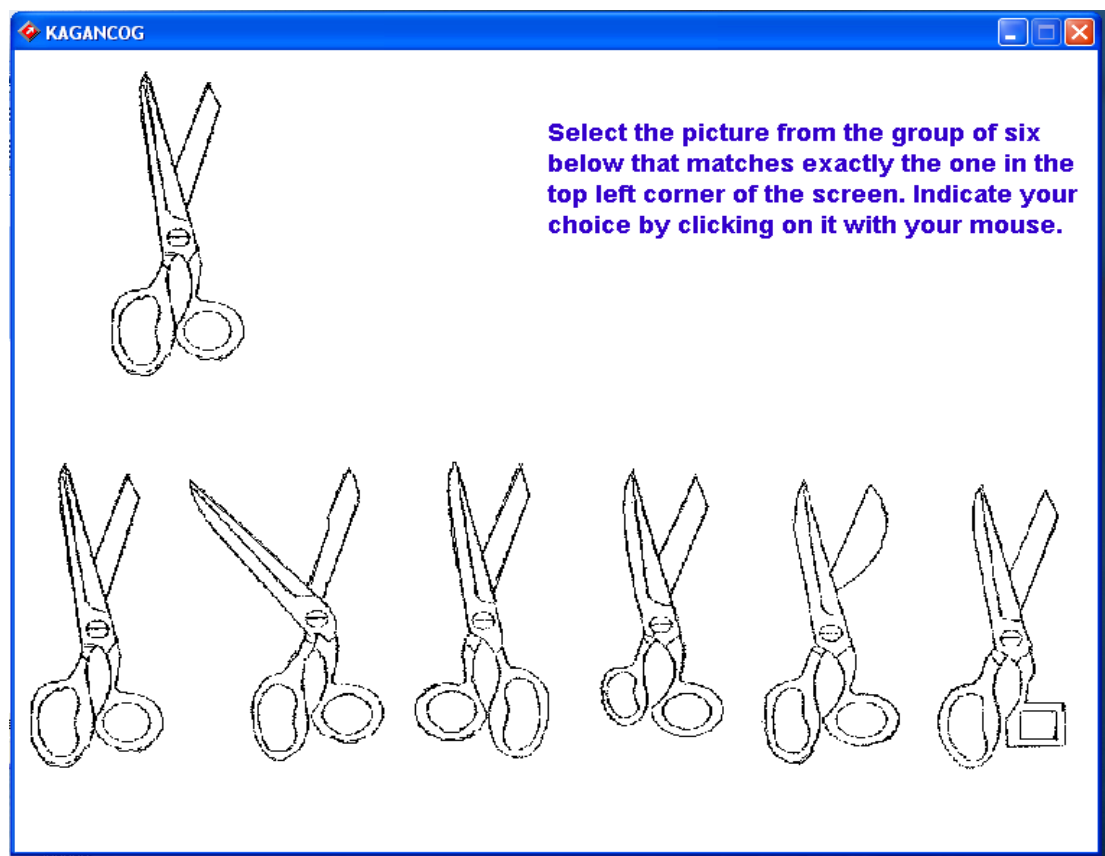


As demonstrated in Figure 1, Reflective Impulsivity is based along the premise of the two composite dimensions (latency and total errors) working in tandem to create 4 subgroups. In the top left quadrant are impulsive responses (those who's time to first response (latency) is low, and who's errors are also high), in the second quadrant, bottom left are the Fast Accurates (who's latency is high, but errors are low). On the right top quadrant are the Slow-Accurates, (whose latency is low, and number of errors is low). Finally, those whose responses place them in the bottom right quadrant are interpreted as the Reflective group whose time to first response is slower, but errors committed are also low. The difficulty of determining "low" and "high" was previously concealed (Block, 1980; Egeland, 1976), as median splits were the original way to determine the quadrants. As an alternative to this method, Salkind and Wright (1977) proposed a way to compare within the sample with greater accuracy, by using an equation called the *i*-score, the impulsivity-score, which is defined as the standard score of MFFT errors minus the standard score of MFFT latency ( $Z_E - Z_L$ ) (Ault, 1976; N. N. Salkind, C.F., 1980): higher *i*-scores are indicative of greater impulsivity. This method has been used in numerous impulsivity experiments (Buela-Casal, 2000; Kaye, 1995; Morgan, Impallomeni, Pirona, & Rogers, 2006; Yakir, et al., 2007), and while errors and latencies are customarily reported, the *i*-score has been validated as a more reliable index of these two dimensions (Messer, 1981).

The controversial nature of the MFFT reported in previous studies (Braet, 2007) relates to earlier suggestions that the test varies with visual search strategy (Ault, Crawford & Jeffry, 1972) and meta-cognitive abilities relating to appropriateness of inhibiting responses (Brown, Bransford, Ferrera & Campione, 1983), and subsequently researchers proposed it is a better measure of general cognitive functioning and information-processing than strictly impulsiveness (Block, 1986). For the present investigation, these so-called shortcomings actually address our primary aim, which is to assess cognitive process, in essence an inhibition subtype of impulsivity. The use of the MFFT in adult populations, particularly to assess drug and addiction prone populations (Quednow, 2007, Morgan, 2006), obese versus lean (Braet, 2007; Toner, 1987), and binge versus non-binge populations (Toner *et al.*, 1987, (Kaye, 1995) further emphasize its utility for the current experiment.

To obtain the most sensitive and accurate format of the test, a digital version of the MFFT-20 was obtained. Human errors recording time and actual error rate had been cited as a limiting factor in previous investigations (Southgate, 2007), and it has been suggested that digital, as opposed to pen and paper versions, increased the accuracy of detecting reflective impulsivity (Glow, 1981). The digital format of the MFFT can be achieved by scanning the original MFFT pictures into Director, a program produced by Macromedia. In the computerized version of this task, participants are asked to click on one of the six potential alternative pictures to indicate their response, and the program automatically keeps track of the total number of errors and the amount of time to first choice (the latency), in a text file, which can be then converted into Excel Formatting. Please see Figure 3.2.c for a sample screen of the program.

*Figure 3.2.c: Participants' Sample Screen for one of the stimulus on the MFFT*



In order to complete the task, participants are first asked to try two sample questions before the actual test. The participants click the start button between each set of pictures to initiate the internal system clock to track time to the first response. The

program then asks the participant to click NEXT to move on to the next set of pictures until all twenty have been completed.

3.2.3b Three Factor Eating Questionnaire (A. J. Stunkard & Messick, 1985)  
Please see section 2.2.4 in Chapter 2.

3.2.3c Balloon Analogue Risk Task (BART) (Lejuez et al., 2002)  
Please see section 2.2.3b in Chapter 2.

3.2.3d The Delay Discounting Task (DDT)  
Please see section 2.2.3a in Chapter 2.

### *3.2.4 Procedure*

Participants arrived at the laboratory between 8.00 and 10.00 am, after reading and completing the Participant Consent Form (Appendix 2a). Having fasted from 11.00 pm the night before (except for water), they arrived at the lab at the mutually convenient time to be greeted by the experimenter. Upon arrival they were served a standard breakfast, which they were required to consume in full. Participants were weighed and reminded to refrain from eating or drinking anything besides water for the following three hours. Once participants returned, they were asked to provide a saliva sample to ensure compliance with the three hour fast, and were explained the nature of each individual test by the experimenter. They completed the impulsivity tasks in the order BART, DDT and MFFT, with the BART and DDT tasks taking roughly ten minutes each, and the MFFT task roughly 5 minutes, resulting in a full testing time of 30 minutes.

After the impulsivity tests were completed, the participant was presented with the sundae preload and given as much time as necessary to eat all of it. She was then presented with the tray of Snack Foods, and VAS rating scales to rate properties of each snack food. While the experimenter explained to the participant she was getting final payment forms, it was made explicitly clear to the participant that she was not to leave the room until the experimenter returned. The participant was then left alone with the snack foods for exactly 20 minutes.

Once the full 20 minutes had elapsed, the participant was debriefed and thanked for her participation, and was paid £10.00 for participation. The remaining tray of food was taken from the cubicle and food consumed was measured and recorded. All measurements of food weight were made using a Precisa 1600 digital balance accurate to 0.01g.

### *3.3 Data Analysis*

Results were analyzed by means of between subjects, two-way ANOVA with TFEQ-D (high/low) and TFEQ-R (high/low) classification as independent between subjects variables.. Each performance measure from the three impulsivity tasks was analyzed in this way, with dependent variables including MFFT total errors, MFFT total time, MFFT *i*-score, BART total explosions, BART Adjusted Average Pumps, DDT Area Under the Curve and DDT *k*-values. The same analysis approach was taken for the intake test, intake of each snack food, and total intake both in terms of energy and weight consumed were analyzed. Finally, the responses on the VAS scales were also analyzed by way of 2\*2 between subjects ANOVA with VAS measurement (pleasantness, sweetness, et al) analyzed as the dependent variable.

In order to explore the relationship between overeating, and self-report overeating and impulsivity scores, a stepwise regression was used. The first block of the regression analysis included TFEQ-D score, and the other four variables (BART adjusted pumps, BART explosions, DDT AUC value, DDT *k*-value, and the MFFT errors, MFFT time, and MFFT *i*-score) were entered in a stepwise method, which is an appropriate technique for investigations of an exploratory nature (Field, 2007).

### *3.4 Results*

#### *3.4.a Impulsivity Performance*

Table 3.4.1 shows descriptive statistics, including means and Standard Errors for performance on each of the impulsivity tasks in relation to the TFEQ characterization based on the interaction between the TFEQ-D and TFEQ-R subscales. Results are discussed in terms of performance on each of the tasks.

Table 3.4.1: Descriptive Statistics for Performance on Impulsivity Tasks

	HDHR		HDLR		LDHR		LDLR	
	mean	SE	mean	SE	mean	SE	mean	SE
<i>MFFT</i>								
Errors	10	1.71	8.125	1.66	7.61	1.84	9	1.613
Time Total	1718	206	2100	213	1810	236	1448	220
i-score	0.11	0.38	0.52	0.39	0.38	0.4	-1.11	0.39
<i>DDT</i>								
AUC	3017.65	423.14	2681.26	510.32	2970.52	452.35	2076.45	488.6
k-values	0.09	0.024	0.098	0.029	0.035	0.026	0.082	0.028
<i>BART</i>								
Explosions	10.93	1.07	9.93	1.17	11.42	1.18	13.47	1.14
Adjusted Average Pumps	44.69	3.28	42.85	3.62	44.51	3.76	41.49	3.5

#### 3.4.1.b MFFT Performance

The performance on this task was broken down into a series of 2x2 ANOVA's, with the TFEQ-D (high/low) and TFEQ-R (high/low) used as between subjects variables and dependent variables including errors, latency, error rate (i.e. Errors/latency), and finally *i*-scores, analyzed separately. The most significant differences on tests assessing impulsivity were found using the *i*-score calculations, which are reported in more detail at the end of this section. The main effect of Disinhibition was not significant in terms of total time to complete the task ( $F(1, 58)=1.818, ns$ ).

However, there was a marginally significant effect of TFEQ-D classification on MFFT errors committed ( $F(1, 58)=3.75, p=0.058$ ), and there was a significant difference in error rate between high and low TFEQ-D groups ( $F(1, 58)= 4.41, p=0.038$ ), with a higher error rate in the high scorers on the TFEQ-D.

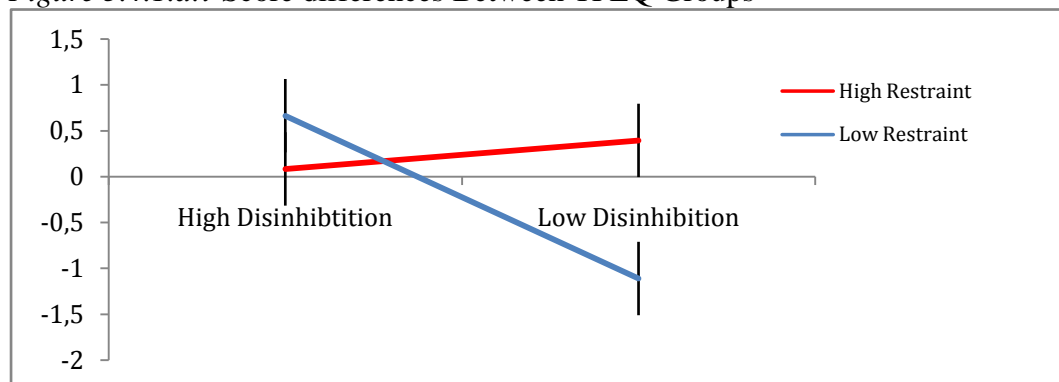
The main effect of Restraint was not significant in terms of total time to complete the task ( $F(1, 58)=0.125, ns$ ), errors ( $F(1, 58)= 1.46, ns$ ) nor error rate ( $F(1, 58)= 1.53, ns$ ).

The interaction between Disinhibition and Restraint approached significance on total time to complete the task ( $F(1, 58)= 3.51, p=0.066$ ) but was not significant for errors

committed ( $F(1, 58) = 1.81, ns$ ). However for error rate there was a significant interaction between the high and low TFEQ-R groups ( $F(1, 58) = 4.08, p = 0.048$ ), which is explained by the HDHR's higher error rate (0.05 errors/sec) compared to the HDLR group (0.003 errors/second). There was no significant interaction between the two low TFEQ-D groups.

Using the *i*-score as a dependent variable, there were significant interactions between the 2 TFEQ subscales ( $F(3, 37) = 3.5, p = 0.021$ ). This finding was largely attributed to the difference in performance between the HDLR group who performed most impulsively (*i*-score = 0.52,  $SE = 0.39, p \leq 0.05$ ) and the LDLR group who performed least impulsively (*i*-score = -1.11,  $SE = 0.39, p \leq 0.05$ ), which is depicted in Figure 3.5.1a. While there were no main effect differences between TFEQ-R groups ( $F(1, 59) = 1.22, ns$ ) the main effect differences on the TFEQ-D subscale approached significance ( $F(1, 59) = 3.18, p = 0.08$ ).

Figure 3.4.1.a: *i*-Score differences Between TFEQ Groups



#### 3.4.1c DDT Performance

As hypothesized, participants with High TFEQ-D scores tended to discount monetary rewards more rapidly than those participants with Low TFEQ-D scores, however, the overall effect was not significant ( $F(1, 56) = 2.08, p = 0.1$ ). Figure 3.4.1b.i and 3.4.1.b.ii illustrate the behaviour response styles in performance on the DDT, first using the AUC method and next using the *k*-value method to illustrate the difference

in the slopes of the hyperbolic curves.

Figure 3.4.1.b: Outcome of Analysis of Variance Characterizing Performance on the DDT, AUC method, between High versus Low TFEQ-D groups

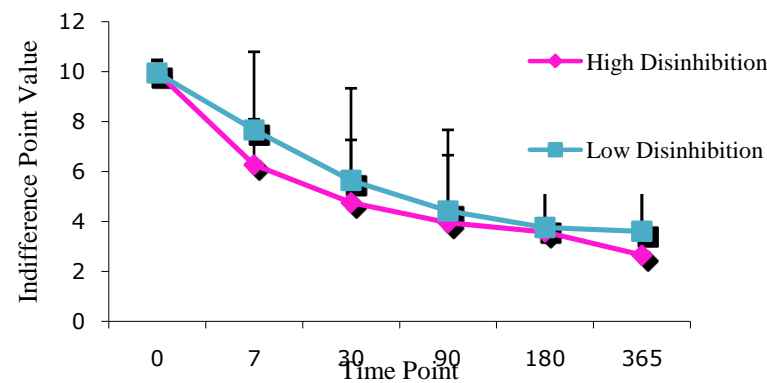
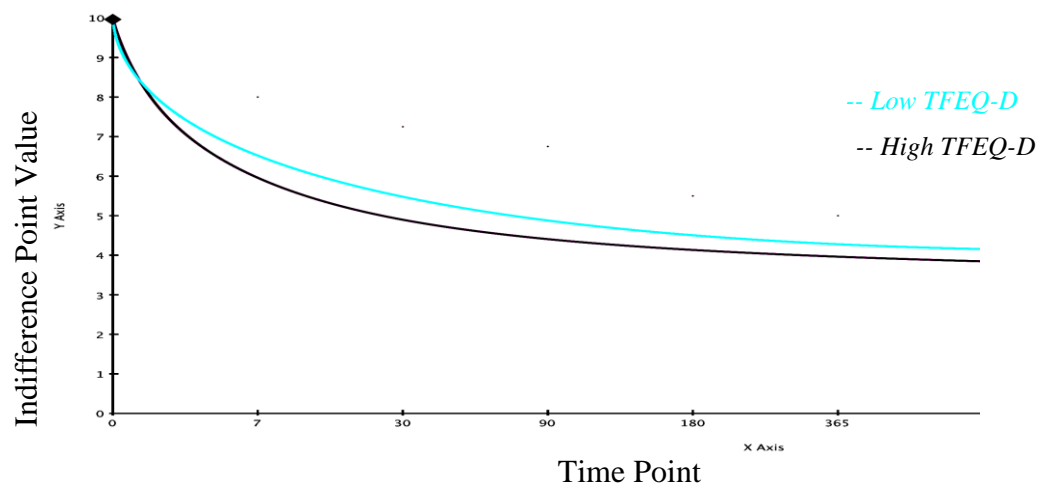


Figure 3.4.1.b.ii: Outcome of Analysis of Variance Characterizing Performance on the DDT, *k*-value method, between High versus Low TFEQ-D groups



#### 3.4.1.d BART Performance

Table 3.4.1.a reports descriptive statistics for several variables to analyze performance on the BART task. In light of the previous chapter, showing a strong positive correlation between the BART and TFEQ-D measure, we endeavored to explore this task in greater detail.

Table 3.4.1a: *Descriptive Statistics for Performance on the BART*

	HDHR		HDLR		LDHR		LDLR	
	Mean	SE	mean	SE	mean	SE	mean	SE
Total Explosions	10.93	4.93	9.93	3.8	11.11	3.14	13.47	5.45
Adjusted Average Pumps	44.69	3.28	42.39	3.61	44.09	3.61	14.49	3.49
Balloons 01-10	40.12	4.16	40.23	4.75	44	4.58	35.4	4.42
Balloons 11-20	49.29	3.36	43.63	3.85	47.66	3.71	42.38	3.58
Balloons 21-30	49.29	3.75	46.83	4.29	52.17	4.14	47.29	3.99
Total Balloon Pumps	1215.12	76.71	1169.39	87.17	1261.86	84.53	1143.93	81.66

Following the same approach as in Experiment 1, the BART measures for Total Explosions, and Total Pumps were included as the main variables. Based on recent analysis of the BART, and the stability of test-retest characteristics, authors suggest the most sensitive measure of reward reactivity is in fact Adjusted Average Pumps, per balloon (White, 2008). For this reason, Adjusted Average Pumps were also analyzed in the similar 2x2 between subjects ANOVA format. Finally, we compared Adjusted Average Pumps at three discrete time intervals, and analyzed this in a mixed ANOVA; with between subjects variables 2(TFEQ-D) x 2 (TFEQ-R) x within subjects variable (adjusted average pumps, at 3 intervals).

Contrary to our predictions, a significant difference was found between TFEQ-D groups in relation to performance on the BART ( $F(1, 58) = 4.3, p = 0.04$ ), although in terms of total Balloon Explosions our results indicate those participants with high TFEQ-D scores were *less* impulsive (mean explosions = 10.08,  $SE = 0.79, p \leq 0.05$ ) than those with low TFEQ-D scores (mean explosions = 12.44,  $SE = 0.82, p \leq 0.05$ ). There were no main effect differences between the TFEQ-R groups on the Explosions Measures. In regard to the 2 (TFEQ-D) x 2 (TFEQ-R) performance on the BART measures, our data reports there were no significant differences between each of the four subgroups of the TFEQ ( $F(1, 58) = 2.71, p = 0.1, ns$ ). Taken together, this data demonstrates the difference in impulsivity performance can be attributed to differences on the TFEQ-D measure, although these results are in complete contrast to



the data of the previous experiment, Experiment 1, whereby the high TFEQ-D scorers were *more* impulsive on the BART measure.

Finally, in order to address a last component of the BART task, two analysis were completed using the Adjusted Average Pumps. For the Total Adjusted Average Pumps, a simple between subjects ANOVA was used to analyse the dependent measure of Adjusted Average Pumps over the course of the thirty balloons. There was no main effect of Disinhibition ( $F(1, 58) = 0.05, ns$ ), or Restraint ( $F(1, 58) = 0.49, ns$ ) nor any interaction between the TFEQ-D and TFEQ-R scales ( $F(2, 55) = 0.002, ns$ ). To explore into greater detail, the Adjusted Average Pumps variable was analyzed at three time points (i.e. On balloons 0-10, 11-20, and 21-30) to explore whether groups of participants became more impulsive based on greater experience with the test. Taking within subjects' variables into account, since the pumps were accrued at three time points the only significant difference was based on the Pumps variable ( $F(2, 110) = 14.14, p \leq 0.001$ ). This finding indicates that across all groups, participants pumped the balloons up more in the last 10 balloons ( $m = 48.89$ ) compared to the first 10 ( $m = 39.94$ ), and this increase in risky behavior was significant.

However, regardless of the populations' increased risk over trials, this had little relevance to TFEQ-subcategory; there was no interaction between pumps x disinhibition ( $F(2, 110) = 0.432, ns$ ), pumps x restraint ( $F(2, 110) = 0.145, ns$ ), or the final interaction comparing pumps x disinhibition x restraint ( $F(2, 110) = 0.928, ns$ ).

### 3.4.2 Food Intake

Table 3.4.2.a,b, report the descriptive statistics regarding differences between the four TFEQ groups in total energy intake, total weight of food consumed, and individual differences between rating the VAS of each of the four snack foods.

Table 3.4.2a: *Total Amount of Food Consumed (g) by TFEQ Group (mean  $\pm$  SE)*

	<i>n</i>	Chocolate Buttons (g)		McVitie's Cookies (g)		Peanuts (g)		Mini Cheddars (g)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
HD+ HR	15	26.29	15.02	19.92	15.68	15.52	15.06	26.33	21.9
HD+ LR	15	23.99	17.8	15.75	13.88	24.34	22.24	23.85	14.8
LD+ HR	15	18.43	16.97	10.19	3.223	11.83	13.36	19.86	17.25
LD+ LR	15	12.06	13.87	13.81	13.18	10.97	9.08	20.57	16.87

Table 3.4.2.b: *Total Amount of Energy Consumed (kcal) by TFEQ Group (mean  $\pm$  SE)*

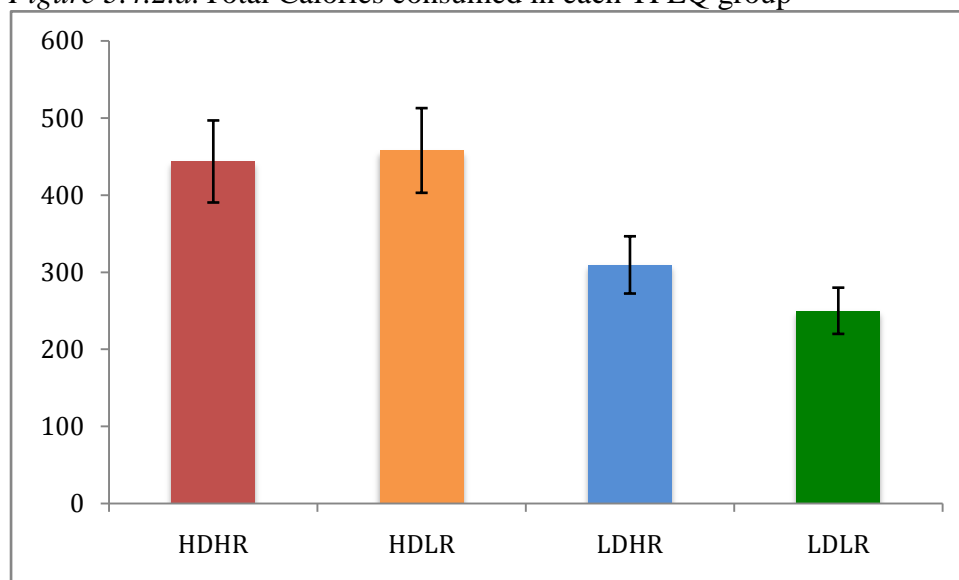
	<i>n</i>	Chocolate Buttons (kcal)		McVitie's Cookies (kcal)		Peanuts (kcal)		Mini Cheddars (kcal)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
HD+ HR	15	132.8	75.9	77.5	60.9	97.02	94.1	136.1	113.3
HD+ LR	15	121.3	89.0	61	54.0	152.1	139	123.3	76.5
LD+ HR	15	93.1	85.7	39.7	24.2	73.9	83.5	102.6	89.2
LD+ LR	15	60.9	70.1	53.7	58.1	68.6	56.8	66.6	51.2

Table 3.4.2.c *VAS Ratings (mm) for Each Snack Food by TFEQ Group*

<b>Food Stimulus</b>	HDHR		HDLR		LDHR		LDLR	
	mean	SE	mean	SE	mean	SE	mean	SE
<i>Chocolate</i>								
Pleasantness	75.68	6.2	82.29	6.88	65.58	6.01	69.15	6.88
Sweetness	64	6.68	79.69	7.4	70.29	6.48	42.08	6.35
Strong	49.88	5.72	56.08	6.35	44.29	5.55	42.08	6.345
Bitter	9.43	3.33	11	3.69	13.47	3.23	10	3.697
<i>Mini Cheddars</i>								
Pleasant	68.56	6.18	78.15	6.86	74	6	72.85	6.87
Sweetness	25.62	6.7	18.62	7.44	32.41	6.5	20.85	7.44
Strong	65.62	5.67	64.46	6.28	61.88	5.5	46.31	6.28
Bitter	15.13	4.82	17.23	5.35	16.76	4.68	10.53	5.35
<i>Low Fat Cookies</i>								
Pleasant	62.78	3.35	63.31	7.09	57.29	6.2	63.46	7.09
Sweetness	65.19	6.33	59.23	7.03	65.52	6.15	55.08	7.03
Strong	52.88	6.22	57.69	6.9	56.18	6.03	28.92	9.6
Bitter	10.62	4.73	18.61	5.25	24.88	4.59	9.53	5.25
<i>Peanuts</i>								
Pleasant	54.31	7.02	45.23	7.78	50.52	6.81	60.62	7.79
Sweetness	25.81	6.24	11.15	6.93	15.71	6.06	22.08	6.92
Strong	73.72	6.18	74.08	6.86	64.18	5.99	67.46	6.86
Bitter	32.18	8.07	29.46	8.95	44.59	7.82	33.38	8.95

As predicted, the High-D group consumed significantly more than the Low-D group in terms of caloric and individual snack consumption ( $F(1, 59) = 11.235, p = 0.001$ ), total intake (g) ( $F(1, 59) = 11.12, p = 0.001$ ), chocolate intake ( $F(1, 59) = 6.07, p = 0.017$ ), cookie intake ( $F(1, 59) = 3.203, p = 0.079$ ), peanut intake ( $F(1, 59) = 4.83, p = 0.032$ ), and mini cheddar intake ( $F(1, 59) = 4.45, p = 0.04$ ). However, there was no significant main effect of restraint classification on any of these measures, and the interaction between Disinhibition and Restraint groups was also non-significant.

*Figure 3.4.2.a: Total Calories consumed in each TFEQ group*



### 3.4.3 TFEQ and Overeating: Predictors of Caloric Consumption in relation to Performance on the Impulsivity Tasks and Self-Reported Eating Behavior

Having confirmed some of the outcomes of Experiment 1, that women scoring high on the TFEQ-D scale also show greater general impulsivity, an important question is to what extent do individual differences in impulsivity predict intake in the snack test.? To address this, a step wise, exploratory multiple regression was used to explore the relationship between calorie consumption, self-report overeating, and the

different measures of impulsivity. Table 3.5.3.a shows regression coefficients of the final model, and Table 3.5.3.b shows the excluded variables in the model.

Table 3.4.3.a: *Regression Co-Efficients of Overeating Behavior*

	<i>B</i>	SE <i>B</i>	Beta
Step 1			
Constant	231.6	62.62	
TFEQ-D	18.95	7.82	0.32**

Note:  $R^2$  for step 1 = 0.32, \*\*  $p \leq 0.01$

The final model indicated that TFEQ-D was the only significant predictor of actual caloric intake, using a multiple regression stepwise method. This confirmed the outcome of the earlier ANOVA analysis. However, the impulsivity measures failed to predict eating even though they differed between TFEQD groups. Final results show that TFEQ-D accounted for 32% of the variability of the model.

Table 3.4.3.b: *Excluded Variables in the Regression Model to account for Caloric Consumption based on Individual Differences*

	<i>B</i>	<i>t</i>	Sig
TFEQ-R	0.054	0.413	0.681, <i>ns</i>
DDT AUC	0.116	0.909	0.368
DDT <i>k</i> -value	0.006	0.042	0.876, <i>ns</i>
BART Explosions	0.116	0.909	0.368, <i>ns</i>
BART Adjusted			
Average Pumps	0.024	0.192	0.849
MFFT Time	-0.131	-0.997	0.323, <i>ns</i>
MFFT Errors	-0.098	-0.762	0.449, <i>ns</i>
MFFT <i>i</i> -score	0.021	0.162	0.87

As Table 3.5.3.b illustrates, all other variables entered into the Food Consumption model were excluded, as all *t*-values were insignificant and therefore do not represent significant predictors. This result was surprising in light of the significant literature that supports the link between the two TFEQ scales (D and R), which is discussed in greater detail in the General Discussion.

### 3.5 Discussion

The overall outcome of Experiment 2 confirmed that high scores on the TFEQ-D were associated with greater inhibition impulsivity as indicated on the MFFT

measure. Our results also verified that actual overeating is indeed predicted by self-reported overeating measures (TFEQ-D scores) in lean healthy females. Contrary to our hypothesis, intake in the snack test was not predicted by the interaction between TFEQ-D and TFEQ-R scores, nor was it predicted by impulsivity performance, suggesting that the relationship between impulsivity with regard to overeating behavior is complex.

An important aim of this study was to compare a performance-based measure of inhibition (MFFT) alongside two other measures of reward reactivity (BART and DDT). Several different outcomes were possible here. Firstly, that a tendency to overeat (i.e. high scores on TFEQ-D) represent a heightened response to rewards, perhaps as indicated by the tendency for women scoring high on this measure to show greater sensitivity to palatability (M. R. Yeomans, Tovey, et al., 2004) and to more rapidly acquire liking through associations between flavours and hedonic rewards (M. R. Yeomans, Tovey, et al., 2004). If so, the prediction would have been that both the DDT and BART measures would show greater impulsivity for those scoring high on the TFEQ-D, but this would not be predicted for the MFFT. Again, the literature lends support to the reward sensitivity part of this hypothesis: scores on TFEQ-D correlate with performance on the DDT (Experiment 1 and Yeomans *et al*(2008)), and BART scores correlated with TFEQ-D scores (Experiment 1). However, although there was a trend for higher responses on the DDT, this was not significant in Experiment 2, and the BART findings from Experiment 1 did not replicate. Moreover, high scorers on the TFEQ-D were significantly more impulsive on the MFFT. Thus the pattern of data do not fit well with a simple model that suggests TFEQ-D equates with increased Reward Reactivity. A second possibility, and once again which could be supported by the literature (C. Nederkoorn, Van Eijs, Y., Jansen, A., 2004a), is that a lack of inhibitory control (i.e. higher scores on the MFFT) would be seen in women who are poor at maintaining restraint, i.e. those that scored high on both TFEQ-D and TFEQ-R, and potentially those women who score high TFEQ-D, but not on TFEQ-R.

One of the most interesting findings to emerge from this investigation is that there were significant differences in performance on the MFFT between the TFEQ groups. Aspects of each groups' MFFT scores fit within our original prediction that high

TFEQ-D scores would be associated with greater impulsivity, and low TFEQ-D would be associated with lesser impulsivity; certainly the LDLR group fits this profile, as their performance on this task was the least impulsive of any subcategory.

The distinction between the other three groups is more complicated; the difference between the HDHR and HDLR group approached significance, with the HDHR performing *less* impulsively than the HDLR. This raises a question with regard to the beneficial properties of self reported Restraint, which is that it could have protective benefits for those individuals with high TFEQ-D classification. The high TFEQ-R score may relate directly to MFFT reflectivity, as it may express an individual's increased attention devoted to selecting *specific* stimuli, i.e. the selection of correct items on the MFFT.

One could also speculate that differences in the TFEQ-D subcategories are related to the concept of a “controlled” eating environment, and these had subsequent influences both in terms of impulsivity performance and eating behavior. Based on obesity related research that highlights obese and overweight individuals' tendency to skip breakfast, one might be able to argue the same case for those in the high TFEQ-D group, and the control breakfast may have actually served to *enhance* the high TFEQ-D group's performance on the impulsivity tasks. The variable of breakfast consumption had not been considered in the design of this study, as our primary aim was to control caloric intake, but nonetheless may have significant bearings on the results of the current investigation.

### 3.5.2 Food Intake and Self Report Measures of Overeating (TFEQ-D)

A multiple regression was used to explore the relationship between TFEQ-D and food consumption, indicating that TFEQ-D was the only variable significantly associated with food intake. Given the size of the current sample (n=64), this confirms that the snack intake test appeared to model some of the behaviour described by responses on the TFEQ-D scale. Typically, regression analysis is appropriate for larger sample sizes typically with at least 100 participants or data points (Field, 2005).

The relative strengths of the TFEQ-D scale for assessing overeating, the magnitude of the main effect findings for the TFEQ-D scale with respect to consumption of *ad lib* snack foods, contrasted with a lack of any interaction with the TFEQ-R scale all indicate that the TFEQ-D subscale was solely responsible for the differences in eating behavior. Despite the findings in this experiment, there is a wealth of empirical support that stresses the use of these scales in tandem (J. Westenhoefer, 1991; J. Westenhoefer, et al., 1994; M. R. Yeomans, Blundell, et al., 2004; M. R. Yeomans, Coughlan, E., 2009; M. R. Yeomans, et al., 2008; M. R. Yeomans, Tovey, et al., 2004); as such, this finding merits serious deliberation.

The predictions of a classic disinhibition study in relation to restraint would have been that those women scoring high on the restraint scale should have eaten more (i.e. have been disinhibited to a greater extent) than those classified as LR. This was clearly not the case. In the current study, differentiating among the high TFEQ-D group (into subcategories of HDHR, and HDLR) did not have any bearing on caloric intake; the HDLR group, ate a similar amount of food ( $m \text{ kcal} = 424.57$ ) compared to the HDHR group ( $m = 433.86$ ). This finding can be interpreted in two ways; that the relative strength of the TFEQ-D score is in actual fact a better predictor of eating behavior, or that something in the current investigation elicited an “overeating response” in the HDHR group. Interpretation is more complex since all participants were in the equivalent to the Experimental group from a classic preload test: they all had a ‘disinhibiting’ preload prior to the taste test.

A further issue of interest, and contrast between Experiment 1 and 2, was the requirement both to fast overnight and consume a standard breakfast in the laboratory prior to testing. The idea that snack intake in the HRHD group was in part due to disinhibition of restraint could thus be interpreted as consistent with Herman & Polivy’s (1980) “Counter Regulatory Response” to the Control Breakfast and fast from the night before. Indeed, the fasting component, combined with a Control Breakfast, may have served as a restrictive or stressful precondition to participation in the current experiment, thereby eliciting overeating (counter regulatory responses) in the HDHR group. The HDHR group represents the High Restraint group on Herman & Polivy’s (1983) Restraint Scale, and this post hoc hypothesis would satisfy those predictions made by the Boundary Model of Dieting.

Whether the Control Breakfast and fast from the night before constitutes a “diet”, is cause for debate. However, the potential role that enforced control of eating prior to the test played in this study obliges further consideration, particularly in light of the difference in impulsivity findings between Experiment 1 and Experiment 2. Furthermore, the positive interplay between breakfast consumption and cognitive performance is an important detail that we had not previously considered. In addition to the possible effects of forced control of eating on behaviour of restrained participants, having a set breakfast may have also impacted cognitive functioning. Within obesity related research, the link between breakfast consumption and lower BMI has been considered in several meta-analyses (e.g. Rampersaud, 2005). The role of a morning meal on cognitive performance is also beginning to show some intriguing findings; in a meta-analysis of 22 studies examining breakfast consumption in relation to academic performance (Rampersaud, 2005), authors concluded that the inclusion of a morning meal including complex carbohydrates improves cognitive function relating to memory, and overall academic performance (Wesnes, 2003). Therefore, it is not unreasonable to consider the possibility that the breakfast meal in this experiment could have had a positive influence on cognitive performance on those participants in the high TFEQ-D groups, who may generally refrain from eating breakfast (in the case of the HDHR group as a way to reduce caloric intake, and for the HDLR group as a reflection of lack of appetite early in the morning). The change in daily routine, and that the experiment required unbending adherence to a set of dietary “rules”, may have served to improve impulsivity performance on the battery of tasks among those HDLR participants, but contributed to impulsivity and overeating for the HDHR participants who are highly aware of their own eating behavior, and reacted against an additional manipulation to eating behavior.

Future studies will need to include a Control group to determine if the Breakfast manipulation has a significant impact in impulsivity performance in lean women. An investigation into the impulsive responding, with a specific emphasis of contrasting controlled versus an unrestricted eating environment would help clarify this matter.

The clearest findings of this study were the high TFEQ-D participants’ increased impulsivity on the MFFT task and food intake in the *ad lib* snack intake test. With



respect to the observed food intake, TFEQ-D scores offered the clearest predictive measure of overeating. The significant difference between high and low TFEQ-D groups on impulsivity measured with the MFFT, but lack of replication using the BART or DDT measures merits considerable deliberation. One suggestion that was considered at any earlier part of this discussion was that the inclusion of the pre fast and controlled breakfast meal contributed to an increase in impulse control between the HDHR groups. Future studies that include comparisons between a controlled condition (such as that used in this experiment) and unrestricted eating environments (such as that used in Experiment 1) to evaluate differences between impulsivity performance will address this issue.

The observations from this study indicate that the TFEQ-D scale is a strong predictive measure of overeating, not only in an experimental analysis, but also with a further regression analysis. Together, these two findings offer support for the utility of the TFEQ-D measure as a measure of *actual* overeating. How the inability to control prepotent responses (i.e. Inhibition impulsivity) is related to this behavior will be explored in greater detail in the following experimental analysis.

### 4.1 Introduction to Experiment 3

The outcome of Experiment 1 and 2 found consistently higher impulsivity scores for women scoring high on the TFEQ-D subscale, but there were some inconsistencies between the two experiments particularly with regard to the BART and the MFFT, and possibly the DDT since this has not been entirely consistent in its replication with our original study (M. R. Yeomans, et al., 2008). These discrepancies warrant further investigation to determine if impulsivity was a consequence of the changes in eating environments between the two investigations, and this was the primary aim of Experiment 3.

In the context of overeating, the outcome of Experiment 2 adds to growing support for the notion that self reported overeating (TFEQ-D scores) is associated with actual overeating in the laboratory in lean females. However, the results from the eating test in Experiment 2 were curious by virtue of a host of literature that has indicated it is not simply TFEQ-D alone that predicts an overeating individual, but rather the combination between the TFEQ-D and TFEQ-R scales used in tandem to characterise an individual's overeating behaviour (J. Westenhoefer, 1991; J. Westenhoefer, et al., 1994; M. R. Yeomans, Tovey, et al., 2004). How the distinction between the four TFEQ groups relates to overeating and impulsivity is an important focus for this Chapter.

To briefly recapitulate results in terms of impulsivity performance, the previous findings to this point have aimed to determine whether impulsivity is consistently associated with a tendency to overeat, and further to address which *subtype* of impulsivity is most clearly related to self reported overeating. In Experiment 1, the TFEQ-D subscale of eating behaviour was the most sensitive measure of self-report over eating in relation to impulsivity; problematically, this study showed strong associations between the TFEQ-D scale and *both* measures of Reward Reactivity and Inhibition, and also we failed to include a performance based measure that clearly addressed the detection of *inhibition* impulsivity.

In Experiment 2, a larger battery of performance based tasks was selected specifically to address the issue of defining impulsivity in terms Reward Reactivity or Inhibition subtypes, and in addition to using the TFEQ scale, a concrete measure of overeating was included, which was forced consumption of a high calorie pleasant tasting preload paired with *ad lib* access to an array of highly pleasant high calorie foods. Regression analysis indicated that TFEQ-D was the only significant predictor of overeating behaviour, and subsequent analysis demonstrated an overall difference in impulsivity between high and low TFEQ-D groups on a measure of inhibition, the MFFT task, which again was independent of any interaction with the TFEQ-R subscale. However, Experiment 2 failed to find any differences between TFEQ-D scores with either the BART or the DDT, the two measures of Reward Reactivity.

The major differences in methodology between Experiments 1 and 2 which could have contributed to the differences in outcomes was (a) the restrictions on eating and required consumption of a set breakfast in Experiment 2 and (b) the inclusion of an intake test. The anticipation of food may have impacted participants' sensitivity to the rewarding components of the impulsivity tasks used in Experiment 2, since to meet ethical requirements they had to be aware that they would consume food at some stage of the study. Therefore, Experiment 3 was designed in order to isolate whether the focus on eating impacted performance on the impulsivity tasks.

In the present investigation, we eliminated the preload and snack component, and instead focused on whether differences in impulsivity emerged in response to a Controlled, versus Unrestricted Eating environment. In order to achieve these different conditions, two breakfast conditions were contrasted; a Control Breakfast Condition where prior eating was controlled (following the procedure from Experiment 2 whereby a fast from 11.00 pm was required in addition to the instructions to come to the lab to consume a breakfast meal, and then refrain from eating for 2-3 hours), versus an Unrestricted Eating condition (where participants were asked to come into the lab between 11-1.00 pm, the same time as those in the Control Breakfast condition, but with no mention of any restriction or any other aspect of eating).

Our primary aim was to assess whether assignment into one of these breakfast conditions modified participants' performance on a battery of impulsivity tasks, and in light of the strong main effect TFEQ-D difference found using the MFFT, to explore another measure of Inhibition impulsivity, by using the Go No Go task. By including this final Inhibition impulsivity assessment, we had constructed a battery of tasks that assessed impulsivity in the most comprehensive manner to date, within the field of Eating Behaviour research.

In brief, the Go No Go task requires participants to attend to a series of visual stimuli (such as a 5-digit sequence of numbers that are presented on a computer screen in black print). The participant is required to respond when a "Go" target appears, and withhold when a "No Go" target appears. In the Go No Go task, Go targets are those numbers that follow the initial 5-digit sequence that are both an identical 5-digit sequence and also the colour black, whereas No Go signals are either different numbers, or change from black print to red print half way through the trial. The Go No Go task has been shown to be a suitable way to measure of the inhibition process (C. Avila, Parcet, M.A., 2001; C. R. Li, Huang, R., Constable, T., Sinha, R., 2006) and inaccurate reactions to the target stimuli is related to impulsivity (Logan, et al., 1984; Logue & King, 1991), with longer stop signal delays representing an inability to inhibit ongoing motoric responses (Logan, 1995; Logan, et al., 1984).

The Go No Go task has been used in previous experimental investigations in the field of eating behaviour. Earlier attempts to examine impulsivity and a tendency to overeat authors explored response inhibition between high and low scorers on the RSS and performance on the Go No Go task (Nasser, et al., 2004; C. Nederkoorn, Van Eijs, Y., Jansen, A., 2004b). Authors hypothesized that a fundamental lack of response inhibition may contribute to future episodes of "disinhibited overeating" in women with high scores on the RSS, and compared performance on impulsivity tasks (self-report and performance based) before and after exposure to food cues. Specifically, impulsivity was operationalized in terms of performance on the Go No Go task, in addition to the BAS/BIS questionnaire. Nederkoorn *et al.*'s (2004) study showed women with high RS restraint scores (which would equate to HRHD in relation to scores on the TFEQ) were more impulsive in terms of the Inhibition process, emphasizing the link between self-reported overeating and impulsivity. As

such, we deemed the Go No Go task an important secondary measure to assess Inhibition impulsivity in our current group participants.

Determining those individual factors that are associated with increased compliance with calorie reduced diets has been a priority within health promotion type research, and some of the findings within this field of research has direct application to understanding the divergent patterns between HDHR group versus HDLR group with regard to overeating and impulsivity. There is a significant amount of research that demonstrates individuals who overeat and are overweight often benefit from restrictive diets (Goodric, 1998; Klem, 1997; Presnell, 2003; E. Stice, Davis, K., Miller, N., Martin, C.N., 2008; E. Stice, Fischer, M., Lowe, M.R., 2004; E. Stice, Presnell, K., Groesz, L., & Shaw, H., 2005), which raises an important issue with regard to HDHR's ability to avoid overconsumption in the presence of palatable food. For example, in order to address the controversy regarding increased dietary restraint and putative increase of bulimic symptoms, Presnell *et al* (2003) investigated a group of healthy weight women interested in losing (BMI < 25). In that experiment, women were assigned to either a Restrictive diet (1200 kcal), versus a weight list condition. Bulimic symptoms were assessed with the Eating Disorder Examination, which provides a DSM-IV classification of bulimic symptoms and were also overweight. Interestingly, and contrary to the predictions made by the Restraint Model, those women in the restrictive condition not only lost weight, but also significantly decreased bulimic pathology (Presnell, 2003). Weight loss programs that emphasize dietary restriction have also had similarly positive results with long term weight maintenance after following a calorie reduced dieting plan (C. P. Herman, Polivy, J., 1980; Klem, 1997), and recently it was reported that rigid habits, like daily weigh-ins, and complete elimination of soda pop promote weight loss and healthy weight maintenance (Boutelle KN, 2009).

However, the fact that while 5% of young adult and adolescent women suffer from bulimia, versus 40-60% of those who report dieting have bulimic symptoms (Lewinsohn, 200; Neumark-Sztainer, 2006), indicates that self reported restrictive eating behaviour does have a link with disordered eating patterns, which follow those predictions set by Restraint Theory. Although Stice *et al* (2003) reported the benefits of dietary restriction in regard to bulimic pathology, in a subsequent investigation (E.

Stice, Davis, K., Miller, N., Martin, C.N., 2008) the same team of researchers found a need to qualify the types of “restrained” behaviour that have the greatest association with future binge type eating; they found that extreme dieting behaviour, such as fasting, actually increase the occurrence of binge episodes in bulimic and binge eating individuals.

The previous experiments’ emphasis on a fast from 11 o’clock pm the night prior to testing, combined with a control breakfast may have had divergent effects on the two subgroups of the high TFEQ-D groups; namely, this manipulation may have threatened the regular dietary regime of the HDHR women, thus the icecream preload further contributed to a violation of dietary restraint, and the anticipation of the additional consumption of *ad lib* snacks may have elicited greater impulsivity on the battery of tests. However, in light of literature that supports the idea that restricted eating regimes have emotional benefits (Klem, 1997; Presenell, 2003; Goodric, 1998) this same manipulation may have actually been beneficial for those women who simply overeat, but do not restrict caloric intake (HDLR), perhaps giving this group a greater sense of control and thus enhancing control in the impulsivity tests. This hypothesis could explain the lack of replication for the BART data.

In the current investigation, it was hypothesized that the Controlled Eating environment will have a diverging influence on participants based on their TFEQ classifications. We predicted that high TFEQ-D participants will be more impulsive than low TFEQ-D participants, but critically we predicted that there would be differences between the HDHR compared to all other TFEQ groups, because of this groups’ enhanced focus on a dieting goal. We predicted the Control Condition to enhance impulse control for the HDLR participants, yet for those HDHR participants, the Control Breakfast will be interpreted as a threat to dietary control, and therefore this group were predicted to perform significantly more impulsively than those in the Unrestricted Eating condition.

We predicted a similar pattern for those low TFEQ-D groups, in essence that the LDHR group will perform more impulsively in the Control Condition than Unrestricted Eating. Finally, we do not predict that there will be any significant differences in impulsive responding between LDLR groups in each condition, as this

group should not theoretically find eating manipulations threatening or discomforting. Moreover, since the fast was not constructed in order to elicit greater hunger and the control breakfast has sufficient calories to be deemed satiating, only those participants with heightened awareness regarding eating stimuli would later respond with changes in impulsive performance.

## **4.2 Method and Materials**

### *4.2.a Participants*

The key focus of this experiment was to contrast impulsivity measures between women scoring high or low on the TFEQ-D and TFEQ-R scales, with a Controlled versus Unrestricted eating conditions. To ensure substantial differences between high and low TFEQ-D scorers, upper and lower tertiales of the TFEQ scale were taken from 780 women volunteers from the same study population who had previously completed the TFEQ scale.

Disinhibition was defined as having a TFEQ-D score as 9 or higher (the upper tertiale), whereas those with a score of 5 and lower (the lower tertiale) were selected for the Low group. A similar approach for TFEQ-R would have been ideal, but in practice the numbers of potential participants in HRLD and LRHD groups would have been too small for such a study to be feasible. Therefore the Restrained scores (TFEQ-R) were determined by using a median split based on the same population (those with 7 or lower were classified as Low Restrained, and those with 8 and higher as High Restrained).

Eighty normal-weight female students were recruited to participate in a study investigating “mood and food preferences” at the University of Sussex Ingestive Behaviour Unit. Twenty women were recruited in each of the TFEQ-D x TFEQ-R subgroups, with ten women from each group tested in the Controlled Eating condition and the other ten the unrestricted condition. Appendix 3a and 3b illustrate the differences in Consent Forms received by these two groups.

Table 4.2.1.a summarizes group BMI and TFEQ score means. There were no significant differences found on the TFEQ-D scores between the two high TFEQ-D groups, nor significant differences found between the two high TFEQ-R groups, but significant differences between the High versus Low TFEQ-D or TFEQ-R subcategories.

Table 4.2.1a: *Participant Characteristics regarding TFEQ scores and BMI*

	HD-HR	HD-LR	LD-HR	LD-LR
BMI	22.5 $\pm$ 3.2	23.3 $\pm$ 3.2	22.8 $\pm$ 3.0	21.9 $\pm$ 2.1
TFEQ-R	13.7 $\pm$ 2.1	3.0 $\pm$ 2.1	11.3 $\pm$ 3.3	3.9 $\pm$ 2.8
TFEQ-D	12.8 $\pm$ 1.9	11 $\pm$ 1.3	4.2 $\pm$ 2.1	3.9 $\pm$ 1.7

#### 4.2.b Self-Report Eating and Impulsivity Testing Measures

The testing measures used in this experiment were the same as those in previous chapters in this thesis, with the addition of an additional test of inhibition of responding (the Go No Go task). For a full description of the reliability, validity, and in the case of impulsivity tests their assignment to measures of Inhibition versus Reward Reactivity, please see the corresponding Chapter reference. The Three Factor Eating Questionnaire (TFEQ) was used to classify eating behaviour (please see 2.2.2.4, and for a greater review on research related to the TFEQ please see 1.2c and 1.3). Impulsivity was assessed with several of the measures already used; Reward Reactivity was assessed using the Balloon Analogue Risk Task (BART) (2.2.3b), and Delay Discounting Task (2.2.3a). Inhibition was assessed using the Barrett Impulsivity Scale-11 (BIS-11) (please see 2.2.2c), and Matching Familiar Figures Test (MFFT) (3.2.3.d) were all used.

#### 4.2.c The Go No Go Task

The Go No Go task is a measure of response inhibition. For the current investigation, a program called the GoStop Impulsivity paradigm (Dougherty, 2005) was used. This task is based on a temporal “race model” of behavioural control, which postulates opponent neural centres regulate expression versus inhibition of motor behaviour (Logan, et al., 1984). The way the task is structured allows for the precise



measurement of an individual's ability to inhibit prepotent motoric behaviour. Critically, the GoStop paradigm presents both go and stop signals in the same stimulus modality (visual), thus enhancing the clarity of interpretation between response times in No-Stop and Stop trials. In previous investigations (Nederkoorn, 2004) the stop signal was communicated by a low buzz tone, as opposed to a visual "stop" stimulus. This change in sensory modality may lead to greater variation for individuals hard of hearing, or who are unable to process two types of modalities (Dougherty, 2005; Marsh, 2002).

The task required participants to attend to visual stimuli (5 digit sequence of numbers) and respond by left clicking a mouse if this is followed by the same 5-digit sequence. There were three trial types: No-Stop, Stop, and Novel trials. A No-Stop trial presented the only "go" or correct response (i.e. 23456... followed by 23456 in black). A proportion of these go trials included trials where a cue told the participant not to respond even though the numbers matched (the critical "Stop" trials). Here the second stimulus matched the initial stimulus in terms of numerical content but the display changed from black to red. Therefore the participant was required to try to withhold their responses on these trials (i.e. 23456 followed by 23456 flashing to red). Finally, at least 50% of the trials were novel trials, consisting of randomly generated non-matching numbers presented in black.

The timing of the appearance of the Stop Signal (ie. Change of matching stimulus from black to red) can vary. In the version of the Go No Go task used here, stop signals could be presented at 25, 50, 100, 150, 250 and 350 milliseconds following the go stimulus onset. Previous research has demonstrated that 350 millisecond exploits the poorest response inhibition styles, as the response initiation process has progressed to the point where a response will occur prior to being averted to the inhibition process (Dougherty, Mathias, Marsh, & Jagar, 2005). The task demands correspondence to the temporal race model of behaviour control wherein opponent neural centres are postulated to regulate expression versus inhibition of motor behaviour (Logan, 1984).

The primary dependent variable to assess impulsiveness is the Stop Latency or the time between Stop Signal onset and response. The GoStop generates a Stop Interval that results in a response inhibition rate of approximately 50 per cent, based on the

setting of an even split between GO and NOGO stimuli. This interval represents a threshold where processes of response inhibition and execution are “tied”. The speed of the inhibitory process is interpreted from the latency between Stop Signal onset and response on this 50% inhibition trial type. Aside from setting the initial Stop Signal onset, the adjustment of the steps for each response (or lack of response) is based on the individual’s performance to the Stop Signal, which can be set to adjust in 25, 50 or 100 msec intervals, depending on experimental protocol. For example, some studies use an adjusting stop signal of 50 msec (Nederkoorn, 2004). In the current investigations, the program adjusted the Stop Latency in 25msec steps following each correct and incorrect response such that the initial stop onset time increased for each successful inhibition (indicating the participants needing *less* time to adjust their behaviour), or decreased (resulting in *more* time to assess the stimulus) for each failure to inhibit a response to a Stop Signal. In addition to the three trial types (Stop, NoStop and Novel), there were temporal demands that participants were required to comply with, resulting in accurate (correct) or inaccurate (false) responses. An on-time response is any response that occurs during a trial where the number is still on the monitor, regardless of colour. A late response was any response that occurred during the inter-trial interval, after the number had disappeared from the monitor, regardless of colour, but before the appearance of the next stimulus. The number of late responses was calculated for each trial type.

The primary advantage of the current Go No Go task is that it adjusts to behaviour in 25 millisecond “steps”, thereby providing the most precise measurement of participants ability to control prepotent responses, compared to other tasks that only have 50 msec steps. A second advantage is that the Go and Stop signals are presented in the same visual modality (visual), although other stop signal paradigms (Nederkoorn, *et al.* 2004; Logan, 1995) without adverse performance effects. Finally, our stop signal task is capable of calculating “missed” trials, and responses that are not made within the 700 msec time allotment. It is not clear in Nederkoorn *et al.* (2004) whether this feature was available on their stop signal task.

In the current investigation, the five digit stimulus was presented for 700 msec, preceded by a 500 msec fixation point, which has been a combination that has discriminated between women with high and low trait impulsivity (Dougherty, *et al.*,

2005; Marsh, 2002). Initially, the stop signal was presented at 250 msec after the presentation of the Go signal (the black number stimulus that turned to red), and then adjusted dynamically depending on the responses of the subject. When the subject failed to inhibit the response, the delay was decreased by 25 msec, thereby making it easier to inhibit the next stop signal. When the subject successfully inhibited the response, the delay was increased by 25 msec. When the subject reached a point where the reflex to initiate and withhold responses were equal, this empirically derived figure was recorded in a tabulated column showing responses to each set of trials. The variable measured in this task is the point at which this empirically derived figure is made, by virtue performance on the blocks of trials. There were 2 blocks of trials, with 64 trials in each block.

#### *4.2.e Procedure*

The general procedural guidelines highlighted in Chapter 3 were also used in the current experiment. Participants were recruited via a general email advertisement (please see Appendix 4.a and 4.b for a sample of the recruitment emails sent). Once a participant had contacted the researcher, she was assigned into either the Controlled Eating condition versus Unrestricted Eating Environment, which was conducted in an A-B-A-B order to ensure conditions were controlled. Participants were then sent a set of instructions that explained whether to fast, and come to the lab for breakfast, or to simply come to the lab at a mutually convenient time (Please see Appendix 4.2 and 4.3 for these information sheets). In both cases, participants rearranged to come back into the lab between 11.00 am- 1.00 pm.

Participants who received instructions for the Control Breakfast condition were instructed to refrain from eating from 11.00 pm the night prior to testing, with exception of water. Once these participants had arrived at the lab between 8.00 am- 9.30 am, they were given a control breakfast (please see section 3.2.3 and 3.2.4 for caloric information). Participants were free to leave the lab, and return at their prearranged time between 11.00 am- 1.00 pm.

Participants who were assigned to the Unrestricted Eating Condition were asked to arrange a mutually convenient time with the experimenter to come into the lab between 11.00 am- 1.00 pm, where they were met and greeted by the experimenter.

Once participants had arrived for the testing component of the experiment, they were asked to sit in a quiet room where they were presented with each of the impulsivity tasks. The DDT was programmed onto a MacIntosh G4 computer, and the BIS-11, BART, MFFT, and Go No Go task were programmed onto a Dell PC, and both computers were located in the testing room. Participants completed the tasks with the BIS-11, BART, DDT, MFFT, and finally ending with the Go No Go task.

When participants had finished all five tasks, they were thanked for their participation, debriefed, and paid £5.00 for their time.

#### *4.3 Design and Data Analysis*

The study contrasted performance of women on a battery of measures of impulsivity depending on whether they had been classified as scoring high or low on the TFEQ-D and TFEQ-R scales and whether their eating behaviour prior to test had been controlled (Controlled Eating condition) or not (Unrestricted Eating Environment condition). Thus, a series of between subjects ANOVA's were carried out on each of the five dependent measure of impulsivity, with a 2 (TFEQ-D, high vs. low) x 2 (TFEQ-R, high vs. low) x 2 (Eating Environment, Controlled versus Unrestricted Eating) Design, with scores on the MFFT, DDT, BART, Go No Go, and BIS-11 as the dependent variables.

#### **4.4 Results**

A series of between subjects ANOVA analysis were conducted, and Table 4.4a reports means and standard deviations for performance on each of the impulsivity tasks in the Control Breakfast versus Unrestricted Eating conditions.

Table 4.4a: *Descriptive Statistics for BIS performance between TFEQ groups and Experimental Condition*

	Control Breakfast				Unrestricted Eating			
	HDHR mean $\pm$ SD n= 10	HDLR mean $\pm$ SD n= 10	LDHR mean $\pm$ SD n= 10	LDLR mean $\pm$ SD n= 10	HDHR mean $\pm$ SD n= 10	HDLR mean $\pm$ SD n= 10	LDHR mean $\pm$ SD n= 10	LDLR mean $\pm$ SD n= 10
<i>BIS-11</i>								
Cognitive	18.6 $\pm$ 3	17.9 $\pm$ 3	19.7 $\pm$ 3.2	16.4 $\pm$ 2.35	19.2 $\pm$ 2.97	18.9 $\pm$ 3.57	19 $\pm$ 3.16	17.3 $\pm$ 1.49
Motoric	23.4 $\pm$ 3	25 $\pm$ 3.5	24.1 $\pm$ 5	22.7 $\pm$ 3	24.2 $\pm$ 2.5	23.3 $\pm$ 1.2	21.4 $\pm$ 3	17.4 $\pm$ 4
Non Planning	24.3 $\pm$ 3.2	24.9 $\pm$ 2.9	26.9 $\pm$ 7	27 $\pm$ 3.3	32.3 $\pm$ 5	29.2 $\pm$ 5	30.7 $\pm$ 5	25.5 $\pm$ 5
Total	67 $\pm$ 4.41	68 $\pm$ 8.26	68 $\pm$ 9	66.76 $\pm$ 4.91	66.4 $\pm$ 7.3	68.2 $\pm$ 8.42	73 $\pm$ 8.5	70.1 $\pm$ 8.06

#### 4.4.1 BIS-11

In previous literature the BIS-11 scale has consistently discriminated between overeating female populations, both in terms of bulimic behaviour (Steiger, et al., 1999), in addition to women with high TFEQ-D scores (Spinella, 2007). Results in the current study indicated a near significant main effect between high and low scorers on the TFEQ-D measure ( $F(1, 79) = 2.75$ ,  $p = 0.09$ ), as participants with high TFEQ-D scores had higher Motoric impulsivity scores ( $m = 17.5$ ,  $SE = 0.5$ ) compared to participants with low TFEQ-D scores ( $m = 17.0$ ,  $SE = 0.3$ ). There was also a significant main effect of TFEQ-R, which occurred on the subscale of Cognitive (or, as it is sometimes referred to as Attentional) impulsivity ( $F(1, 79) = 7.63$ ,  $p = 0.007$ ). Those high TFEQ-R participants had higher mean attentional impulsivity scores ( $m = 19.6$ ) compared to those individuals with low scores on the TFEQ-R ( $m = 16.8$ ).

There was also one significant difference between experimental conditions; on the subscale of Non Planning, those participants who were part of the Control group reported lower Non Planning scores ( $m = 25.6$ ) compared to those who had a regular breakfast ( $m = 28.5$ ), which was significant ( $F(1, 79) = 7.44$ ,  $p = 0.008$ , which may be interpreted as this groups' heightened self-awareness regarding the required fasting component of the experiment.

Interactions between the TFEQ scales with Breakfast condition provided some interesting findings. Although there were no overall significant main effects of TFEQ-

D scale and the BIS-11, when the two Breakfast conditions were compared, those high TFEQ-D scorers who were required to fast and consume the control breakfast had significantly lower self reported Non Planning scores ( $m=24.66$ ) compared to those who followed their regular morning routine ( $m=30.75$ ) ( $F(1, 79)=9.85$ ,  $p=0.002$ ). Comparing these data with the low TFEQ-D group, those participants who had a control breakfast ( $m=26.7$ ) showed virtually no change from those who followed their regular morning routine ( $m=26.3$ ). These data demonstrates that a structured routine, although short term, may be especially beneficial to those individuals who self report higher Disinhibition on the TFEQ scale. There were no significant interactions between TFEQ-R and Breakfast condition. Finally, there were no interactions between the TFEQ-D and TFEQ-R scale ( $F(3, 70)=1.41$ ,  $ns$ ).

#### 4.4.2 Balloon Analogue Risk Task (BART)

Table 4.4.2a: *Descriptive Differences and BART Performance between TFEQ Groups and Breakfast Condition*

	Control Breakfast				Unrestricted Eating Environment			
	HDHR (n=10)	HDLR (n=10)	LDHR (n=10)	LDLR (n=10)	HDHR (n=10)	HDLR (n=10)	LDHR (n=10)	LDLR (n=10)
	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE
Adj. Average	37.78 $\pm$	43.43	50.72	42.18	49.52	42.59	43.25 $\pm$	38.72
Explosions	3.47	$\pm 3.47$	$\pm 3.47$	$\pm 3.47$	+3.66	$\pm 3.17$	3.47	$\pm 3.6$
	8.6 $\pm$	11.5	12.4 $\pm$	10.1 $\pm$	10.2 $\pm$	10.2 $\pm$	10.9 $\pm$	
Explosions	1.2	$\pm 1.2$	<u>1.3</u>	1.3	1.4	1.2	1.3	9.4 $\pm$ 1.4

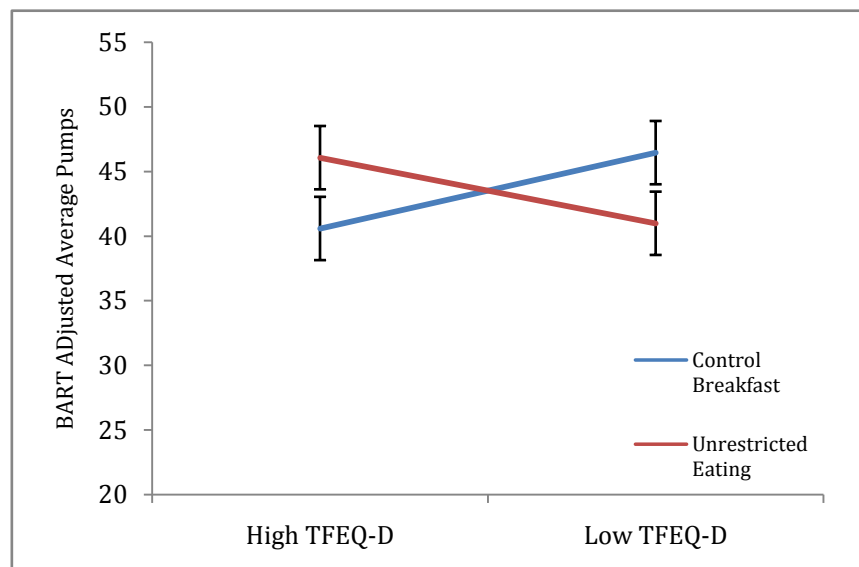
Table 4.4.2b: *Outcome of ANOVA of performance on the BART between the two TFEQ conditions and Breakfast condition*

Independent Variable	BART Total Explosions	Adjusted Average Pumps Per Balloon
Main Effect D	( $F(1,72)=1.36$ , $ns$ )	( $F(1,72)=0.026$ , $ns$ )
Main Effect R	( $F(1,72)=0.63$ , $ns$ )	( $F(1,72)=2.14$ , $p=0.15$ )
Main Effect Breakfast	( $F(1,72)=0.52$ , $ns$ )	( $F(1,72)=0.000$ )
TFEQ-D*breakfast	( $F(1,72)=0.97$ , $ns$ )	( $F(1,72)=4.92$ , $p=0.03$ )
TFEQ-R*Breakfast	( $F(1,72)=0.00$ , $ns$ )	( $F(1,72)=0.744$ , $ns$ )
TFEQ-R*TFEQ-D	( $F(1,72)=3.35$ , $p=0.07$ )	( $F(1,72)=1.41$ , $p=0.24$ )
TFEQ-D*TEQ-R*Breakfast	( $F(1,72)=0.52$ , $ns$ )	( $F(1,72)=2.8$ , $p=0.09$ )

Table 4.4.2a reports descriptive statistics including means and standard errors for each TFEQ subgroup in regard to Adjusted Average Pumps, and Table 4.4.2b reports descriptives for total explosions.

There was a significant interaction between Breakfast Condition and TFEQ-D classification, with participants classified as High TFEQ-D pumping the balloon significantly more in the Control Breakfast condition ( $m=46.06$ ,  $SE=2.42$ ,  $p\leq 0.05$ ) compared to those participants in the Unrestricted Eating condition ( $m=40.58$ ,  $SE=2.47$ ,  $p\leq 0.05$ ). On the other hand, the low TFEQ-D participants performed *less* impulsively in the Control Breakfast condition ( $m=46.45$ ,  $SE=2.45$ ,  $p\leq 0.05$ ) compared to the Unrestricted Eating condition ( $m=40.98$ ,  $SE= 2.45$ ,  $p\leq 0.05$ ), which was significant. Figure 4.4.2.i illustrates this interaction.

*Figure 4.4.2.i:* Interaction between Breakfast Condition and TFEQ group and performance on the BART using the Adjusted Average Pumps measure



In order to explore this interaction further, a three way ANOVA was run, including the analysis of TFEQ-D (high/low) x TFEQ-R (high/low) x Experimental Condition (Breakfast/ Unrestricted Eating). This second analysis, although only approaching significance showed that the two High TFEQ-D groups (HDHR versus HDLR) were significantly more impulsive on the BART task, which was contingent on Breakfast group assignment ( $F(1,72) = 2.8$ ,  $p=0.09$ ).

Contrary to our predictions, in the Control Condition, the HDHR group performed *more* impulsively ( $m= 48.70$ ,  $SE= 3.66$ ) compared to the Unrestricted Eating condition ( $m= 37.80$ ,  $SE= 3.49$ ), whereas, there was very little difference in impulsivity performance between the two conditions for the HDLR group who had almost as many average balloon pumps in the Control Condition ( $m= 43.37$ ,  $SE= 3.49$ ) as in the Unrestricted Eating Condition ( $m= 42.89$ ,  $SE= 3.49$ ). With respect to the low TFEQ-D groups, those LDHR participants performed in a similar fashion to the HDHR participants, as they performed most impulsively in the Control Condition ( $m= 50.72$ ,  $SE= 3.49$ ) compared to the Unrestricted Eating condition ( $m=43.25$ ,  $SE= 3.49$ ). Those participants classified as LDLR had little difference in the Control Condition ( $m= 42.18$ ,  $SE= 3.49$ ) as in the Unrestricted Eating condition ( $m=38.94$ ,  $SE= 3.49$ ).

In terms of BART Balloon Explosions, our current data demonstrates this measure is not as sensitive as the Adjusted Average Pumps measure, in light of the lack of significant differences detected between TFEQ groups. There was one near significant interaction between TFEQ-D and TFEQ-R classification ( $F(1,72)=3.35$ ,  $p=0.07$ ), which indicated that participants with HDHR classification had the fewest explosions ( $m=9.4$ ,  $SE= 1.2$ ) and LDHR had the most explosions ( $m=11.6$ ,  $SE=1.2$ ).

#### 4.4.3 DDT

Table 4.4.3: *Descriptive Statistics describing TFEQ groups performance on the DDT*

	Control Breakfast				Unrestricted Eating			
	HDHR (n=10)	HDLR (n=10)	LDHR (n=10)	LDLR (n=10)	HDHR (n=10)	HDLR (n=10)	LDHR (n=10)	LDLR (n=10)
<i>DDT</i>	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE
	4110 $\pm$ 1396	3138 $\pm$ 1475	2705 $\pm$ 1767	3055 $\pm$ 1459	3271 $\pm$ 1676	2869 $\pm$ 1449	3095 $\pm$ 1500	2912 $\pm$ 1635

Currently, we have yet to replicate an overall significant main effect of TFEQ-D classification in relation to their discounting rates on the DDT with lean females, which we had found in a prior investigation (M. R. Yeomans, et al., 2008).



In the current study, there were no significant main effects of TFEQ-D ( $F(1, 79)=1.36, p=0.247$ ), TFEQ-R ( $F(1, 71)=0.633, ns$ ), nor Breakfast Condition ( $F(1, 79)=0.410, ns$ ).

There were also no significant interactions between the Breakfast condition and TFEQ-D ( $F(1, 79)=0.987, ns$ ) or TFEQ-R ( $F(1, 79)=0.00, ns$ ). Finally, there was no interaction between TFEQ groups (TFEQ-D by TFEQ-R) in terms of performance on the DDT ( $F(1, 79)=1.06, p=0.31$ ). The three-way interaction between TFEQ-D, TFEQ-R, and Breakfast condition was also non-significant ( $F(1, 79)=0.523, ns$ ).

#### 4.4.4 MFFT

Table 4.4.4a: *Descriptive Statistics for MFFT Performance between Each of the TFEQ Groups*

	Control Breakfast				Unrestricted Eating			
	HDHR (n=10) Mean $\pm$ SE	HDLR (n=10) Mean $\pm$ SE	LDHR (n=10) Mean $\pm$ SE	LDLR (n=10) Mean $\pm$ SE	HDHR (n=10) Mean $\pm$ SE	HDLR (n=10) Mean $\pm$ SE	LDHR (n=10) Mean $\pm$ SE	LRLR (n=10) Mean $\pm$ SE
MFFT-Errors	11.75 $\pm$ 2.16	11.67 $\pm$ 2.16	8.1 $\pm$ 2.16	7.33 $\pm$ 2.28	14.1 $\pm$ 2.16	9.9 $\pm$ 2.05	9.5 $\pm$ 2.16	11.5 $\pm$ 2.16
MFFT-Total Time	1395 $\pm$ 206	1288 $\pm$ 188	1420 $\pm$ 206	1640 $\pm$ 217	1302 $\pm$ 206	1258 $\pm$ 206	1730 $\pm$ 206	1635 $\pm$ 206
Error Rate	0.008 $\pm$ 0.003	0.007 $\pm$ 0.003	0.007 $\pm$ 0.003	0.005 $\pm$ 0.003	0.016 $\pm$ 0.003	0.011 $\pm$ 0.003	0.01 $\pm$ 0.003	0.011 $\pm$ 0.003
<i>i</i> -score	0.27 $\pm$ 0.5	0.5 $\pm$ 0.5	-0.3 $\pm$ 0.5	-0.15 $\pm$ 0.5	0.76 $\pm$ 0.5	0.21 $\pm$ 0.5	-0.57 $\pm$ 0.5	-0.75 $\pm$ 0.5

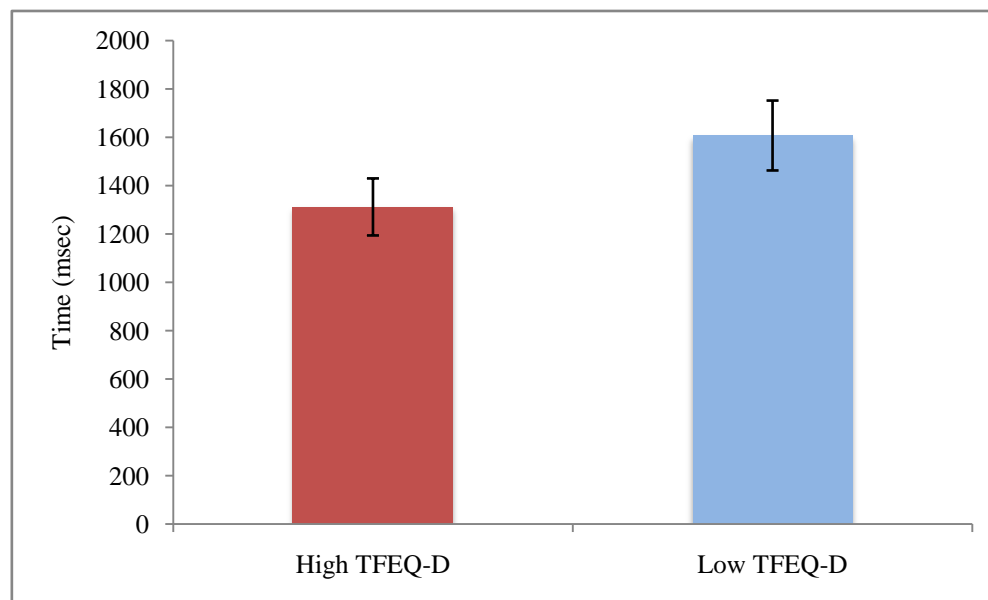
Table 4.4.4b: *Outcome of ANOVA of performance on the MFFT between the two TFEQ conditions and Breakfast condition*

Independent Variable	Errors	Time	Error-rate	<i>i</i> -score
Main Effect TFEQ-D	( $F=3.2, p=0.078$ )	<b>(<math>F=3.93, p=0.05</math>)</b>	( $F=1.24, p=0.27$ )	<b>(<math>F=5.39, p=0.02</math>)</b>
Main Effect TFEQ-R	( $F=0.002, ns$ )	( $F=0.259, ns$ )	( $F=0.44, ns$ )	( $F=0.165, p=.69$ )
Main Effect Breakfast	( $F=0.95, ns$ )	( $F=0.09, ns$ )	( $F=2.06, ns$ )	( $F=0.17, p=.81$ )
TFEQ-D*breakfast	( $F=0.62, ns$ )	( $F=0.52, ns$ )	( $F=0.14, ns$ )	( $F=0.001, p=0.97$ )
TFEQ-R*Breakfast	( $F=0.05, ns$ )	( $F=0.18, ns$ )	( $F=0.92, ns$ )	( $F=0.014, p=0.9$ )
TFEQ-R*TFEQ-D interaction	( $F=0.22, ns$ )	( $F=0.76, ns$ )	( $F=0.13, ns$ )	( $F=0.06, p=0.81$ )
TFEQ-D*TFEQ-R*Breakfast	( $F=1.2, p=0.28$ )	( $F=0.4, ns$ )	( $F=2.4, p=0.12$ )	( $F=1.12, p=0.29$ )

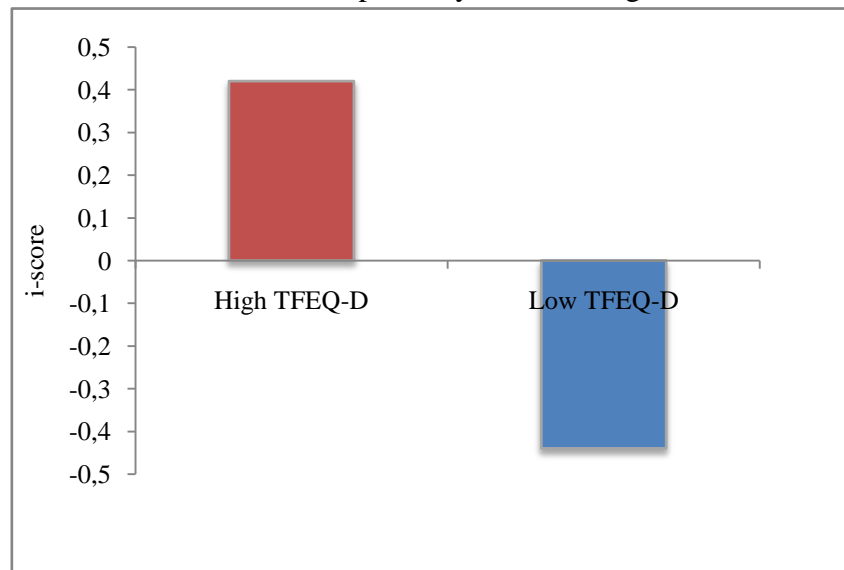
A three way between subjects ANOVA (TFEQ-D (high/low) x TFEQ-R (high/low) x Experimental Condition (Breakfast/ Unrestricted) analysis was conducted to analyze each of the four measures on the MFFT task. Table 4.4.4a reports the Descriptive Statistics for the total Errors, Time, Error Rate, and *i*-score on the MFFT measure. Each statistical finding is reported in Table 4.4.4b.

In the current investigation, there was a significant main effect of TFEQ-D both in terms of total time taken to complete the MFFT ( $F(1, 79) = 3.93, p = 0.05$ ), and *i*-score ( $F(1, 79) = 5.39, p = 0.02$ ). Figure 4.4.4.i illustrates the significant contrast in performance between the High versus Low TFEQ-D groups on the measures of *i*-score and total time taken, with those classified as high on TFEQ-D more impulsive on this task. The main effect of TFEQ-D on the total number of errors made on the MFFT also approached significance ( $F(1, 79) = 3.2, p = 0.08$ ) showing that not only total time taken to complete the task was less for those in the High Disinhibition group, but also they made more errors in light of their increased speed with this task.

Figure 4.4.4.i: Outcome of Analysis of Variance demonstrating significant difference of mean time to complete the MFFT between High vs. Low TFEQ groups



*Figure 4.4.4i: Outcome of Analysis of Variance Demonstrating the Significant Difference in Reflective Impulsivity between High vs. Low TFEQ-D groups*



There were no significant main effects of TFEQ-R on any of the MFFT performance measures. There were also no significant main effects relating to performance between the two Eating conditions.

#### 4.4.5 Go No Go

Table 4.4.4a reports all descriptive statistics regarding means and standard deviations for each TFEQ group and performance on the Go No Go Task . Table 4.4.5a reports all significant statistical main effects and interactions.

*Table 4.4.5.a: Descriptive Statistics for Go No Go Performance and Each TFEQ Groups*

	Control Breakfast				Unrestricted Eating			
	HDHR Mean $\pm$ SE	HDLR Mean $\pm$ SE	LDHR Mean $\pm$ SE	LDLR Mean $\pm$ SE	HDHR Mean $\pm$ SE	HDLR Mean $\pm$ SE	LDHR Mean $\pm$ SE	LDLR Mean $\pm$ SE
	(n=10)	(n=10)	(n=10)	(n=10)	(n=10)	(n=10)	(n=10)	(n=10)
Block 1	181 $\pm$ 41.14	288 $\pm$ 35	225 $\pm$ 38.79	397.2 $\pm$ 38.74	252 $\pm$ 26	350 $\pm$ 36	266 $\pm$ 38.74	300 $\pm$ 38.74
Block 2	265 $\pm$ 42	372 $\pm$ 36	358.3 $\pm$ 39.82	427.8 $\pm$ 39.82	285 $\pm$ 37	370 $\pm$ 37	358.3 $\pm$ 39.82	377 $\pm$ 39.82

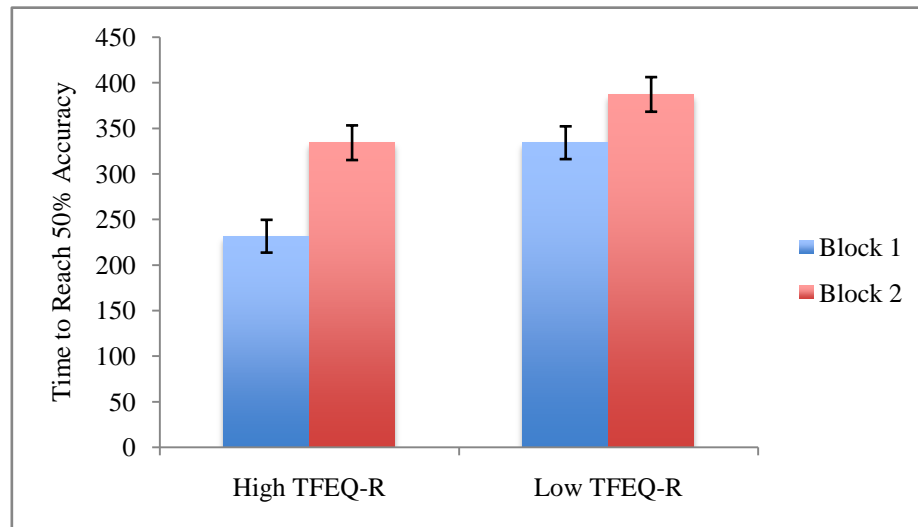
Table 4.4.5b: *Outcome of ANOVA of performance on the Go No Go between the two TFEQ conditions and Anticipation condition*

	Block1	Block 2	Total
Main Effect TFEQ-D	(F(1, 72) =1.16, p=0.28)	(F(1, 72)=2.91, p=0.09)	(F(1, 72)= 2.39, p=0.13)
Main Effect TFEQ-R	<b>(F(1, 72)=14.45, p=0.001)</b>	<b>(F(1, 72)= .33, p=0.005)</b>	<b>(F(1, 72)= 13.58, p=0.000)</b>
Main Effect Breakfast	(F(1, 72)=0.51, <i>ns</i> )	(F(1, 72)= 0.42, <i>ns</i> )	(F(1, 72)= 0.001, <i>ns</i> )
TFEQ-D*breakfast	<b>(F(1, 72)=3.04, p=0.08)</b>	(F(1, 72)= 0.91, <i>ns</i> )	(F(1, 72)= 2.19, p=0.14)
TFEQ-R*Breakfast	(F(1, 72)=1.9, p=0.17)	(F(1, 72)= 0.09, p=0.77)	(F(1, 72)= 0.84, p=0.36)
TFEQ-R*TFEQ-D interaction	(F(1, 72)=0.00, <i>ns</i> )	(F(1, 72)= 0.34, <i>ns</i> )	(F(1, 72)= 0.1, <i>ns</i> )
TFEQ-D*TFEQ-R*Breakfast	(F(1,72)=1.42, p=0.24)	(F(1, 72)= 0.01, <i>ns</i> )	(F(1, 72)= 0.36, <i>ns</i> )

A mixed ANOVA was used to assess the relationship between TFEQ classification, Breakfast condition, and two blocks of Go No Go performance. In order to control for the effect of learning, or fatigue, the two blocks were first analysed as a within subjects variable. As expected, there was a significant difference across the two trials (F(1, 72)3.09, p=0.001), indicating that all participants' performance on the first block of trials was significantly less impulsive (m= 282.7, SE= 13.49, p=0.001) compared to the second (m= 347.12, SE= 13.85). However, there were no subsequent within subjects differences between the two blocks of the Go No Go task with respect to either TFEQ classification or Breakfast condition.

There were several significant differences in performance on the Go No Go task with respect to TFEQ-R classification. Those participants with High TFEQ-R participants had lower mean adjusting time in Block 1 (m= 231.4, SE=19) than those participants with Low TFEQ-R scores (m=334, SE= 18.7) and this was significant (F (1, 79)= 14.45, p=0.000). In Block 2 of the Go No Go, High TFEQ-R participants had lower mean reaction times to the adjusting stop signal (m= 334, SE 18.7) than Low TFEQ-R participants (m= 387, SE= 19.19), and this was also significant (F (1, 79)=8.33, p=0.005), indicating those with High TFEQ-R scores exhibited lesser impulsivity. Figure 4.4.4i illustrates the difference in performance on the Go No Go task between the High versus Low TFEQ-R groups.

*Figure 4.4.4i: Mean Reaction Time to Reach 50% accuracy on the Go No Go Task between High versus Low TFEQ-R groups*



There was one interaction between Eating Condition and TFEQ-D classification that nearly reached significance; those participants with high TFEQ-D scores who ate the Control Breakfast had lower latencies ( $m = 277.10$  msec,  $SE = 24.82$ ) compared to those High TFEQ-D participants in the Unrestricted Eating condition ( $m = 314.40$  ms,  $SE = 23.89$ ), indicating that the Control Breakfast enhanced impulsive control for High TFEQ-D participants. The opposite pattern occurred with Low TFEQ participants, who were more impulsive in the Control Condition ( $m = 353$  msec,  $SE = 25.18$ ) than in the Unrestricted Eating condition ( $m = 316.02$ ,  $SE = 25.18$ ), ( $F(1, 72) = 3.04$ ,  $p = 0.08$ ).

## 4.5 General Discussion

The current investigation explored the effect that short-term dietary control has on impulsivity, and whether the two subgroups of the TFEQ-D scale varied in their performance in regard to a Control Breakfast versus Unrestricted Eating condition. The data from these investigations support our general hypothesis, that women with High TFEQ-D scores are more impulsive than Low TFEQ-D scores. One of the clearest findings from this investigation, was the strength of the MFFT measure in its ability to discriminate impulsive behaviour between the high versus low TFEQ-D groups, regardless of Controlled versus Unrestricted eating environments.

In addition to predicting the main effect differences between High vs. Low TFEQ-D groups on impulsivity performance, we had incorporated directional hypothesis with regard to Control Eating environments and subgroups of the High TFEQ-D classification. We predicted that the Control Breakfast would divide the two subgroups of the High TFEQ-D classification so that the HDHR participants would perform more impulsively in the Control Condition and the HDLR participant would perform more impulsively in the Unrestricted Eating condition. This hypothesis was not supported, as the differences in impulsivity behaviour seemed to be based primarily upon TFEQ-D score, as opposed to a combination of the scales for the present investigation. Moreover, the differences between HDHR and HDLR did not follow the predicted pattern.

Using the BART there was near-significant support for the hypothesis that, without a preload or threat to dietary restraint, participants in the HDHR categories scored more impulsively than did the HDLR group. In the final analysis using Adjusted Average Pumps as a dependent variable, an interesting behavioural pattern was observed; performance of the LDLR group did not differ between Breakfast conditions, whereas HDHR groups were more impulsive in the Control Condition than Unrestricted Eating Condition. These data offer some clear support for tenets of Restraint Theory, which would predict HDHR individuals would disinhibit behaviour after a period of increased cognitive effort to restrict intake.

The second measure of Reward Reactivity, the DDT failed to distinguish between any of the independent variables. There were no significant differences between TFEQ group, nor breakfast condition on the second measure of Reward Reactivity, the DDT.

Our lack of ability to differentiate between eating groups on the DDT could be interpreted in several ways. In the current investigation, we had no main effect differences or interactions when the Area Under the Curve had been used as a dependent variable. There are several reasons for this difference; one of the most basic, but also least plausible, is that in the current study tested a group of 80 participants, whereas previously we had included groups of one hundred participants (please see 2.3.2.a.ii) or 147 participants (M. R. Yeomans, et al., 2008). Thus it may be that the present study lacked the power to detect this effect, and the trend

for greater impulsivity by high relative to low TFEQ-D scores on the DDT here would support that conclusion.

Another explanation for the lack of significant differences between TFEQ groups, or breakfast conditions, may relate to the magnitude of the rewards in the DDT. For example, at present the DDT task used here was set to measure impulsive choice in relation to sums of money ranging from £0.01- 10.00. Although it has been documented that hypothetical versus real rewards (of any magnitude) offer the same platform for which to compare the election of Impulsive Choices (Cardinal, 2006; Cardinal, et al., 2001), the sums in the current investigation may not be large enough to elicit reward reactive behaviour. Data from our first experiment (Yeomans, 2008) had been collected 5 years preceding this experiment, and perhaps the current economic climate and stresses have either made everyone very aware of monetary rewards (therefore, not showing any discounting behaviour), or perhaps the reality that effectively nothing can be bought with sums of money less than £0.50 may have had the same effect, but in the opposite direction. In any case, we have not found any behavioural difference between TFEQ subgroups on this measure of impulsivity, despite a wealth of resources in addiction (Bickel & Marsch, 2001; Billieux, et al., 2006; Dom, et al., 2006; S. H. Mitchell, 2004; Perry & Carroll, 2008; Takahashi, Furukawa, Miyakawa, Maesato, & Higuchi, 2007) and obesity (Weller, et al., 2008) related research that shows Reward Sensitive individuals discount rewards significantly more rapidly.

Another possibility may be that the behavioural differences between TFEQ groups may be too subtle for detection by the DDT. Previous studies using contrasts between healthy individuals versus those with severe physiological or psychological conditions, such as addiction and arguably obesity, have demonstrated clear significant difference between the clinical group in regard to discounting between rewards of greater magnitude based on a temporal delay and the control condition. It could be the case that the change in discounting function with development of an appetitive form of addiction. Since those in the TFEQ groups are not overweight, and their scores are simply analogous to healthy or unhealthy eating patterns, their behaviour on the DDT may be very similar by virtue of other mental abilities and ability

to make economic decisions that prioritize larger future rewards, despite a temporal delay.

In relation to performance on the DDT, in the previous experiment it may have been the inclusion of the *ad lib* preload as opposed to a control breakfast that led to increased impulsivity in the high TFEQ-D group. In the current study, it is clear that controlling breakfast intake had no bearing on performance on the DDT, so in future investigations the role of the *ad lib* preload may need to be a greater focus.

The present study demonstrates the complexity of the relationship between Reward Reactivity and self reported overeating behaviour. Contrary to our earlier predictions, the association between Overeating and Reward Reactivity does not conform to a clear linear pattern. Therefore, impulsivity measures that assess Reward Reactivity may not be best suited for the detection of individual differences related to overeating behaviour.

Compared to our Reward Reactivity Data, measures of Inhibition provided more consistent results showing that High TFEQ-D participants are more impulsive than Low TFEQ-D participants and there were two strong main effect differences with both the TFEQ-D and TFEQ-R subscale on each measure of inhibition, the MFFT and Go Not Go task.

Using the MFFT, there were significant main effects of TFEQ-D classification on total time taken to complete the task, total errors, and finally the *i*-score, indicating that individuals with high TFEQ-D scores were significantly more impulsive than those with low TFEQ-D scores on this measure. This replicates the findings from Experiment 2, and requires some consideration with regard to real life application in terms of food selection and propensity for overeating.

The MFFT requires participants to study a series of stimulus, carefully, before selecting the identical matching picture to the target stimulus. A high *i*-score can indicate that the incentive of finishing the task is more important than finishing the task *correctly*, and also suggesting a sense of urgency belies the motivation to complete the game. Applying this behaviour to the current food environment, rife



with opportunities for eating high caloric high energy dense food, one can see why a tendency to choose any food item (as opposed to carefully selecting the *appropriate* food item) could be related to future weight gain. Moreover, an individual who simply selects a food alternative because it is relatively easy to find, has attractive packaging, or immediately rewarding taste properties, as opposed to considering health consequences or caloric density, has an increased likelihood of developing a weight gain, and perhaps habitual overeating based on the hedonic properties of food.

Individuals who are overweight have self reported that an inability to control episodes of overeating is triggered by a certain “forbidden” food (Greeno, et al., 2000; Hetherington & MacDiarmid, 1993). If these individuals were able to resist the urge for selecting this item, their attempt to control food intake would be greatly enhanced. Therefore, it may be the inability to resist eating the forbidden food item is pending on an individual’s inability to control urgency- as opposed to a myopia for the future benefit of a lean or more healthy body weight.

Finally, our results with the Go No Go task provided some new data with respect to TFEQ-R classification. With respect to Breakfast Condition and TFEQ-R classification there was no significant three-way interaction, as we had predicted. The TFEQ-D subgroup HDHR showed an interesting pattern with regard to Eating Condition; this group was *less* impulsive in the Control condition compared to the Unrestricted Condition, whereas the HDLR group performed similarly in both conditions. In this case, the interaction between high TFEQ-D with high TFEQ-R subscales suggests a Controlled breakfast reduced impulsivity, although this interaction only approached significance.

Contrary to earlier findings, our results show that high scores of Restraint on the TFEQ- R were associated with *greater* ability to inhibit inappropriate responses which contradicts prior findings using this measure (Nederkoorn, 2004); moreover, this was a main effect difference, with no association with the TFEQ-D subscale. Originally, Nederkoorn had found that women with high Restraint, measured by the RS, were more impulsive on the Go No Go measure. She predicted the high RS individuals’ inability to withhold prepotent responses could be related to future inability to control urges for overeating. We had hoped to find a similar finding,

although with participants classified as HDHR, as opposed to high RS. Therefore, that participants with high TFEQ-R scores were better at this measure than those with low TFEQ-R scores was a surprise.

This final issue raises an important concern with regard to classification of eating behaviour and impulsivity performance. Therefore, a second supplementary investigation was conducted using Nederkoorn's (2004) original parameters for the Go No Go task, and participants were classified with both the RS and the TFEQ measures. This is included as a final supplement to this chapter.

In addition to exploring subtypes of impulsivity with respect to TFEQ classification, another priority was to investigate the influence of a Controlled versus Unrestricted Eating environment. Surprisingly, there were no main effect differences between Eating Condition with any of the impulsivity tasks, and only a few significant interactions with TFEQ classification. The benefits of breakfast consumption on impulse control were not made entirely clear in this investigation, and there is significant debate regarding breakfast consumption and general cognitive performance within eating behaviour literature. For example, early studies have shown that there were no differences between conditions regarding performance on the MFFT, or a Continuous Performance Task of sustained attention (Pollitt *et al* 1981(Pollitt, 1998). Subsequent studies (Conners, 1982; Cromer, 1990) have shown similar results, in essence a lack of differentiation on performance on tasks such as the MFFT, Go No Go, and also trait measures of anxiety in regard to breakfast consumption.

The data from this investigation offer preliminary confirmation for the idea that high individuals with high TFEQ-D scores have greater Inhibition Impulsivity.

Most notably, was the difference in performance on MFFT Inhibition tasks between the High versus Low TFEQ-D groups. This data underscores the complexity in the way impulsivity varies with environmental and personal characteristics, particularly with regard to Reward Reactive impulsivity. This study addressed the role of a Control eating environment with regard to Impulsivity and future investigations will be designed to assess how consumption of pleasant tasting food preload relates to subsequent impulsivity in order to fully explore our initial findings from Experiment 2.

## **Comparing between measures of Dietary Restraint and performance on the Go No Go task: is impulsivity related to Ineffective Restrained Eating?**

### **5.1 Introduction to Experiment 4**

The current study aimed to investigate the discrepancy between the outcome of Experiment 3 and Nederkoorn et al.'s (2004) findings regarding Restrained Eating classification and performance on the Go No Go task. This experiment was conducted with the assistance of Clare Holley, who participated in the collection of data as part of an Undergraduate Final Project.

Nederkoorn (2004a) found high Restrained women (defined by the RS) were more impulsive on the same task, which was in stark contrast to our previous findings, whereby women with high TFEQ-R scores were significantly *better* at controlling impulsive responding. This result may be the consequence of the discrepancy between the two methods of classifying Restrained eating behaviour (TFEQ versus the RS), or perhaps a difference in the calibration of the Go No Go task.

Our understanding of psychological factors that belie the motivation to overeat has been greatly assisted by Restraint Theory (Herman & Mack, 1975; Herman & Polivy, 1975). Restrained eating is defined as the intention to cognitively restrict food intake in order to maintain body weight, or promote weight loss; and it has been hypothesized that cognitive control of eating is a psychologically derived determinant of overeating behaviour (A. J. Ruderman, 1986), and bulimia nervosa (C. P. Herman, Polivy, J., 1980). A large number of studies have established that for Restrained Eaters, in essence, those participants with high scores on the Restraint Scale, overeating occurs as a response to a pre-load that disrupts dietary restraint (Heatherton, 1988; Mills & Palandra, 2008; A. J. Ruderman, 1986; A. J. Ruderman, Christensen, H., 1983), which suggests that increasing putative dietary control only leads to a cycle of overeating and (unsuccessful attempts) to restrict caloric intake, ultimately leading to greater weight gain. However, a few studies have failed to support the causal relationship between Restrained Eating scores and overeating behaviour (Dritschel, 1993; A. Jansen, Oosterlan, J., Merckelbach, H., & van der Hout, M., 1988; Lawson, 1995; M. R. Lowe, Kleifield, E.I., 1988; J. Wardle, Beales, S., 1987). Authors who have failed to find the overeating or “counter regulatory

response”, have attributed this lack of reproduction to the use of different measures of eating behaviour used to assess Restraint, such as the TFEQ-R or DEBQ-R, which may provide greater measures of *actual* as opposed to *intended* caloric restriction (Laessle RG, 1989; Larsen, et al., 2007) . An ensuing controversy regarding the viability that Restrained Eating is a unitary construct has been a central focus within the field of eating behaviour (please see the General Introduction, section 1.2b and 1.2 c).

It has been suggested that RS does not capture behaviours associated with weight loss, but rather it offers a way of detecting failed restraint (M. R. Lowe, Foster, G.D., Kerzhnerman, I., Swain, R.M., Wadden, T.A., 2001; M. R. Lowe, Kleifield, E.I., 1988), and the subscale of TFEQ-R is a better measure of behaviours that are associated with weight loss or maintenance of weight loss (Laessle RG, 1989; Williamson, et al., 2006). For this reason, the TFEQ-R and RS classification could be argued to represent completely different eating attitudes, and that the combination between TFEQ-D *with* TFEQ-R scales offers a measure that is comparable to the original RS (Westenhoefer, 1994). Findings from the previous investigation (Experiment 3) do not conform to this position as our results showed that high TFEQ-R participants were better at inhibiting inappropriate responses, but surprisingly, moreover, was no relationship whatever between Go No Go and TFEQ-D scores.

The second explanation for the difference between the two studies, is that the differences in Go No Go parameters used in our previous investigation (Marsh, 2002{Dougherty, 2005 #166}) are sufficiently different from those used in Nederkoorn’s (2004a). Although Go Stop performance has been shown to be stable across manipulated parameter changes (C. R. Li, Huang, R., Constable, T., Sinha, R., 2006), it has also been suggested that the Go No Go captures simple over responding (Aron, 2007). Since the objective of this task is to measure *accurate* responding, as opposed to *over* responding, retesting Nederkoorn’s (2004) design was a priority to establish the link between impulsivity and restraint.

In the current investigation, we replicated Nederkoorn *et al.*’s (2004) investigation, but classified participants’ eating behaviour in terms of RS restraint and also TFEQ-R, TFEQ-D, and TFEQ-R+D subscales. A multiple regression was used to assess

which factors had the greatest association with Go No Go Performance. Also, a bivariate correlation was conducted in order to explore for associations between the RS and TFEQ-D and TFEQ-R subscales of eating behaviour.

## 5.2 Methods and Materials

### 5.2.1 Participants

62 female participants took part in the study, all of which were either students or staff at the University of Sussex. In contrast to our previous study, participants were not recruited on the basis of fitting within high or low TFEQ-D criterion, but instead were recruited by email or responding to adverts on campus. All were naïve to the purpose of the experiment, and were instructed that the study was investigating the relationship between personality traits and cognitive performance. All participants were fully debriefed upon completion of the study, as well as offered the opportunity to find out more via email.

#### 5.2.1a: Participant Characteristics

Table 5.2.1.a *Descriptive Statistics for Self Report Eating Measures and BMI*

	Mean n=62	SD n=62	Minimum n=62	Maximum n=62
BMI	23.2	± 3.2	17	33
TFEQ-D	7.19	± 3	1	15
TFEQ-R	8.6	± 5.4	0	19
RS	12.98	± 5.25	4	26

Participants who responded to the recruitment email for the following investigation were included, provided they did not meet any of the exclusion criteria (such as previous history with eating disorders, and the full exclusion criteria is included in Appendix 5 in the consent form). BMI was not addressed as an exclusion criterion, as such, there were two obese participants in the following investigation. Moreover, TFEQ-D scores were not used to classify participants, therefore the distribution of scores for the current sample included a greater concentration of median scoring females (i.e. TFEQ-D score between 5 and 8 points).

### *5.2.2 Materials*

#### *5.2.2.a Three Factor Eating Questionnaire (Stunkard & Messick, 1985)*

Please see section 2.2.4a for a detailed description of the TFEQ scale

#### *5.2.2.b The Revised Restraint Scale (RS) (Herman & Polivy, 1980)*

The RS (Herman et al. 1978) is a ten-item questionnaire that requires participants to self assess dieting and weight fluctuation. Two factors emerge: CD Concern for Dieting, and WF Weight fluctuation, although a single score is obtained which does not differentiate between these two subscales. An original RSS is included with the scores and classification of CD versus WF items in Appendix 4.a, the remaining items that are not classified as CD or WF refer to information about participants' weight history. The RS is provided in Appendix 5b.

#### *5.2.2.c Go No Go Task Parameters*

In the current investigation, participants attended to five digit number sequences that were presented for 1000 ms on a Dell computer screen. Participants were instructed to click the computer mouse (left click) as soon as they were sure the subsequent 5-digit stimulus was a “Go” stimulus (and not a No Go stimulus, which changed colour to red). The initial stop signal was presented 250 ms after presentation of the Go signal, this delay dynamically adjusted depending on the participants performance, by increasing by 50 ms after an unsuccessful inhibition task, making the future trial easier, or by decreasing by 50 ms after a successful inhibition trial, making the subsequent trial more difficult. The No Go trials comprised 25% of the total trials, and Go trials comprised 25% of the trials. The remaining 50% of the trials were novel trials, during which unmatching 5-digit sequences were presented. 120 trials were presented, with 120 sec break in between trials.

### *5.2.3 Procedure*

Each participant came to the lab for a pre-booked 20-minute test sessions. Upon arrival, the procedure of the experiment was explained and full consent obtained with

participants' clear awareness of their right to withdraw at any time. Please see Appendix 5a for a consent form. The participant was led to a testing cubicle where she received a set of instructions explaining how to complete the Go No Go task. The participant was left to complete the Go No Go task, and once the Go No Go was completed, the experimenter provided a digital version of the TFEQ task, which was also completed by the participant. After both the Go No Go and TFEQ had been finished, the experimenter directed the participant to a second cubicle where she completed the RS, and was finally weighed at the end of the experiment, with scales accurate to +/- 0.3 kg. Participants were offered a chocolate as reward for participating, and were fully debriefed before they left.

### 5.3 Results

Table 5.3.a: *Descriptive Statistics for Participant Characteristics and Performance on the Go No Go Task*

	Mean $\pm$ SE (n= 62)
BMI	23.22 $\pm$ 0.45
RS	12.90 $\pm$ -.68
TFEQ-D	7.21 $\pm$ 0.38
TFEQ-R	8.65 $\pm$ 0.68
TFEQ-D+R	15.83 $\pm$ 0.88
Go No Go	298 $\pm$ 177

Table 5.3.a provides descriptive statistics for the current sample with regard to BMI, RS, TFEQ-D, TFEQ-R, and TFEQ-D+RA. In order to explore the inter relationships between each of the variables, Pearson's bi-variate correlation was conducted and results are reported in Table 5.3.b.

Table 5.3.b: *Intercorrelations between Participant Self Report Measures of Eating Behaviour and Go No Go Performance*

	RS	TFEQ-D	TFEQ-R	TFEQ-R+D	BMI
Go No Go	0.31 **	0.21*	0.09	0.16	0.16
RS	1.00	0.40***	0.57***	0.61***	0.43***
TFEQ-D	0.40***	1.00	0.34**	0.69***	0.33**
TFEQ-R	0.57***	0.34***	1.00	0.92***	0.27*
TFEQ-D+R	0.61***	0.69***	0.92***	1.00	0.32**
BMI	0.43***	0.33***	0.24*	0.32**	1.00

\*p<0.05, \*\*p<0.01

In order to determine which measures of self reported Restraint had the most robust association with Go No Go performance, a stepwise multiple regression was performed. Since previous research (Nederkoorn, 2004) had shown a significant relationship between RS and Go No Go performance, RS was entered as a forced entry variable, and the subsequent other measures (TFEQ-D, TFEQ-R, TFEQ-D+R, and BMI) were entered in as a stepwise analysis.

The regression analysis showed the model was statistically significant ( $F(1, 60) = 6.20, p \leq 0.05$ ). The model accounts for 9.4% of the variable, which falls by 1.6% once adjusted indicating that this model can account for 7.8% of the variance of the general population.

The current model replicated the finding that high RS scores were significantly associated with higher impulsivity on the Go No Go task (Nederkoorn, 2004). Moreover, RS scores were the only significant predictor in the model ( $t = 2.49, p = 0.016$ ), and Table 5.3.c provides all regression statistics.

Table 5.3.c: *Final Regression Model for Self Reported Eating Behaviour and Impulsivity on the Go No Go task*

		<i>B</i>	<i>SE B</i>	<i>Beta</i>
<i>Step 1</i>				
	Constant	184.24	43.17	
	RS	8.93	3.12	0.35 **
<i>Step 2</i>				
	Constant	150.05	116.74	
	RS	10.09	4.05	0.39*
	BMI	0.64	5.53	0.016
	TFEQ-D	6.51	6.19	0.144
	TFEQ-R	-5.011	3.82	-0.195
	TFEQ-D+R	-0.72	0.46	0.72

Note:  $R^2 = 0.35$  for Step 1;  $\Delta R^2 = 0.4$  for step 2

\* $p < 0.05$ , \*\* $p < 0.01$

Notably, there was a negative relationship between TFEQ-R and reaction time on the Go No Go, which could be interpreted as support for our previous finding, although this relationship was not significant.

## 5.4 Discussion:

The current investigation found that the RS was the only significant predictor of performance on the Go No Go task, which supports Nederkoorn's original hypothesis



(2004) that Restrained Eaters are more impulsive on the Go No Go measure.

Although the model was found to be highly significant, it only accounted for a small proportion of variance in the general population, and so while the RS is a significant predictor of Go No Go performance, it has relatively low predictive capabilities.

It is important to consider the underlying cause of the difference between the current investigation and those found in Experiment 3. As noted, the parameters for the Go No Go task were different; the stop signals in Experiment 3 occurred on 33.3% of the trials, compared to Nederkoorn's 25% of the trials. One may argue that the higher occurrence of stop signals (and greater probability of encountering a stop signal) primed the participant to prepare for Stop signals. Another important difference, was that the stop signals were only presented for 700 msec in Experiment 3, whereas Nederkoorn *et al.* (2004) exposed participants to 1000 msec with the target stimuli. It could be argued that this shorter time period makes it easier to inhibit responses, as there is less time to wait for the stop signal. Therefore, the shorter stop signal interludes between presentation of the Go and Stop signals may have elicited greater motoric activity, as opposed to accurate inhibition ability for responding to specific stop signals tasks, indicating that participants with high TFEQ-R scores show greater motoric movement during a stop signal task as opposed to enhanced impulse control.

Theoretically, the TFEQ-D+R measure and the RS would offer a similar way of classifying eating behaviour. Thus, it was surprising to find the replication of Nederkoorn's data, contrasted with the total lack of association between TFEQ-R+D and Go No Go impulsivity. This finding offers support for the notion that the two scales offer unique assessment tools for overeating behaviour (C. P. Herman, et al., 2005; T. Van Strien, et al., 2007).

Differences between the current population, and those participants selected for experimental investigations in this thesis are notably distinct. The Pearson's bivariate correlation showed a significant positive association between the TFEQ-R+D and RS, but critically the association between the TFEQ-R and TFEQ-R+D measure approached nearly a perfect correlation, indicating that the proportion of the TFEQ-R+D scores is weighted largely on the TFEQ-R measure.

The distinction between the current participants and those selected for Experiment 3 may explain the discrepancy between the two investigations. In the current investigation, participants' selection criteria was not anchored by a rigid adherence to upper and lower tertile TFEQ-D scores, and one final explanation for our results is that extreme TFEQ-D scorers may be distinct from the current population.

Pudel and Westenhoefer (1992) suggested a better name for the TFEQ-D scale was "susceptibility to eating problems", in light of the finding that high TFEQ-D scorers are prone to overeat in a variety of circumstances, and perhaps have never "inhibited" eating at all. This suggestion captures how the discrepancy between the two populations in Experiment 4 versus Experiment 3 may yield different results; we suggest that participants with extreme TFEQ-D scores may also have distinct perspectives of restraint type behaviour. Since the combined TFEQ-D+R score was weighted heavily by TFEQ-R scores, our current may not have been sufficiently heterogeneous, thus explaining our inability to replicate those findings in Experiment 3, where the TFEQ-D scores ensured two clearly distinct groups of self reported eaters.

The clearest finding to emerge from this investigation, was the replication of Nederkoorn's original data using the RS and a Go No Go parameters. Considering the reliability of this finding, future investigations will incorporate these Go No Go parameters to assess impulsivity.

## **Chapter 6: Satiation and Impulsivity: Does consumption of a preload and *ad lib* snack beforehand lead to greater Impulsivity in self reported overeaters?**

### **6.1 Introduction to Experiment 5**

The results of the previous Experimental investigations leading to this point vindicate our general hypothesis that measures of individual differences in eating are related to impulsivity. Therefore, the purpose of this investigation was to further characterise these relationships, and critically to investigate the acute sensitivity of impulsivity with regard to appetitive state relating to TFEQ classification and response to a preload and *ad lib* snack consumption paradigm.

The consistency of the relationship between Inhibition impulsivity in relation to self reported overeating (high TFEQ-D) has been an intriguing development within this thesis, considering the wealth of support that suggests that Reward Reactivity is a characteristic of an individual with a risk for binge eating and/or obesity (C. Davis, et al., 2008; S. S. Davis C., Berkson M., 2004; Dawe & Loxton, 2004; Galanti, Gluck, & Geliebter, 2007; Rapaka, Schnur, & Shurtleff, 2008; Schnienle, 2009; Steiger & Bruce, 2007; Steiger, et al., 1999; Volkow, et al., 2008; G. J. Wang, et al., 2004). Thus the prediction at the onset of this thesis was that impulsivity measures that relate to Reward Reactivity would be higher in those participants who self report overeating (previously measured as high TFEQ-D scorers). This hypothesis was supported by findings in our laboratory with regard performance on the DDT measure (M. R. Yeomans, et al., 2008) and also our initial positive correlation between TFEQ-D scores and balloon explosions on the BART (Lejuez, 2002). However, our more recent data from Experiment 2 and Experiment 3 demonstrate that the relationship between measures of Inhibition and TFEQ-D scores are more robust, and problematically we have failed to replicate the relationship between self-reported overeating with performance on either the DDT or BART measures.

In order to address this pattern of results, we are compelled to critique aspects of the previous first and second experiments in order to understand where the disparity of our results originate.

There are two critical differences between the first investigation and subsequent experiments, which draw our attention to the complexity of Reward Reactivity impulsivity. In the first investigation, a general group of participants was used, whereas in subsequent experiments, pre-selecting women in the upper and lower tertiles of the TFEQ-D provided a more rigorous profile for group differences. This made it all the more surprising that we failed to find any consistent distinction between the Low versus High TFEQ-D groups in relation to Reward Reactivity (ie. BART and DDT measures). One possibility for the inconsistent findings with Reward Sensitivity might be that performance on these tasks is acutely sensitive to the appetitive state of the participant, an idea tested initially by manipulating the breakfast condition in Experiment 3, Chapter 4.

Despite our prediction that a Control breakfast would lead to deviating performance between HDHR and HDLR groups on the impulsivity tasks in Experiment 3, the clearest finding to emerge was the stability of the main effect difference between high and low TFEQ-D groups' performance on the MFFT. This third experiment replicated our findings in Experiment 2, reconfirming that women with high TFEQ-D scores were significantly more impulsive on the MFFT measure. However, this was independent of either breakfast condition or TFEQ-R association, and further, we did not find any significant differences with regard to BART performance.

Contrary to our original hypothesis in Experiment 3, the breakfast manipulation did not have a clear impact on Reward Reactivity as we had originally hypothesized. Thus, investigating a second element of Experiment 2, the preload and *ad lib* consumption of snack foods, and how forced consumption of a preload and subsequent access to *ad lib* snacks may lead to differences in Reward Reactivity between the two subgroups of the high TFEQ-D bracket of participants is the priority for this experiment.

Experiment 6 was designed to try and further clarify the disparity between our original positive correlation between TFEQ-D and BART pumps in Experiment 1, and lack of replication of this relationship in Experiment 2. Specifically we are interested in whether consumption of a high calorie snack enhances performance for

certain participants who self report overeating (HDLR), but contributes to more impulsive action for others who self report overeating with self restraint (HDHR).

In Experiment 2, participants received the preload and *ad lib* snack before completing the Impulsivity tasks, and this manipulation could have contributed to between group differences in subsequent impulsivity tasks. Restraint Theory would predict that the mandatory preload would have violated a dietary boundary (C. P. Herman & Mack, 1975; C. P. Herman, et al., 1983; C. P. Herman & Polivy, 1982, 2005; C. P. Herman, Polivy, J., 1980), and this could subsequently lead to disinhibited behaviour, perhaps not only in terms of eating the *ad lib* snack, but also in tasks that require self restraint in terms of impulsivity performance, which is a key factor of the BART measure. Problematically, the Boundary model (C. P. Herman, et al., 1983; Herman CP, 1975; C. P. Herman, Polivy, J., 1980) does not provide an account for individuals who simply overeat, but are not interested in restriction. This inability to account for simple “overeaters” is the result of its single variable structure. Examining the differences between the HDHR and HDLR groups has become a priority within recent research projects, and data from our laboratory demonstrates that there are significant behavioural differences between these two groups, both in terms of how they respond to emotional cues (M. R. Yeomans, Coughlan, E., 2009) and also to physiological aspects of eating such as manipulations to the palatability of food (M. R. Yeomans, Tovey, et al., 2004).

Data confirms that there are important differences between HDLR and HDHR classifications (M. R. Yeomans, Blundell, et al., 2004; M. R. Yeomans, Coughlan, E., 2009). In an experiment investigating the effect of two different tomato sauces (bland versus palatable) in a pasta and sauce meal, HDLR participants consumed significantly more palatable sauce than any other group, whereas the LDHR group did not change intake between the bland versus palatable conditions (M. R. Yeomans, Tovey, et al., 2004). Another important factor, is the emotional cues that contribute to overeating; once again, there seems to be a significant difference in the factors that elicit overeating in the HDHR versus HDLR groups. In a recent investigation (M. R. Yeomans, Coughlan, E., 2009) the effects of classic disinhibitors, mood-states, were manipulated with movie clips to investigate the effect that the induction of a positive, negative, and neutral mood had on consumption of popcorn or raisins. Authors found

a significant dissociative interaction between TFEQ restraint and disinhibition scores and negative versus positive moods: participants with the HDHR classification ate significantly more in response to a negative film clip, whereas those participants with HDLR classification ate significantly more in response to a positive film clip, and participants with low TFEQ-D scores did not alter their intake in response to the film clips.

The previous investigation with film clips and subsequent intake underscores the differences between HDHR and HDLR groups. In terms of Reward, these data show that exposure to one reward (a positive film clip) makes the HDLR group more sensitive to a second reward (pleasant tasting snack food), whereas for the HDHR group the negative mood contributed to greater intake. In the current experiment, we are interested to see whether the consumption of the preload and *ad lib* snack foods subsequently altered performance on the Reward Reactive measures of impulsivity. To date, no one has explored whether acutely challenging someone with a preload has subsequent effect on impulsive behaviour and we predict the HDHR groups and HDLR groups performance will vary on the Reward Reactivity tests depending on the consumption of the preload and *ad lib* snack.

For the current investigation, we hypothesize that the High TFEQ-D groups will continue to show greater impulsivity on the Inhibition measures of impulsivity, particularly on the MFFT measure. For the Go No Go measure, we were limited by a complicated pattern of results found in Chapter 4 and to a degree, Chapter 5 also. As such, we did not make a directional hypothesis. For the Reward Reactivity measures, particularly the BART we predicted that the HDLR groups would be more impulsive in Snack condition, showing a greater appetite and drive for Rewarding experience after *ad lib* snack consumption, but we predicted that the HDHR group would be less impulsive in this condition after having reached satiety with the preload and *ad lib* snack.

## **6.2 Method and Materials**

### *6.2.1 Participants*

The key focus of this experiment was to examine the effects that a high calorie, pleasant tasting preload had on impulsive performance. 80 women were recruited for

the purpose of this experiment, based on their TFEQ profile, such that 20 participants were included in each of the four TFEQ subgroups (HDHR, HDLR, LDHR and LDLR). In previous experiments, substantial differences between high and low TFEQ-D scorers were obtained by using the upper and lower tertiales of the TFEQ scorers, this same procedure was followed for the current experiment with High Disinhibition defined as a score of 9 or higher, and Low Disinhibition defined as a score of 4 or lower. A similar approach for TFEQ-R would have been ideal, but in practice the numbers of potential participants in HRLD and LRHD groups would have been too small for such a study to be feasible. Therefore the Restrained scores (TFEQ-R) were determined by using a median split based on the same population (those with 7 or lower were classified as Low Restrained, and those with 8 and higher as High Restrained). Therefore, twenty women were recruited in each of the TFEQ-D x TFEQ-R subgroups, with ten women from each group tested in the Snack and Preload paradigm and the other ten were simply asked to come to the laboratory without knowledge of any eating component or snack manipulation. Appendix 6a and 5b provide the two distinct consent forms that were sent to participants (6a for the Snack Condition, and 6b for the Control condition) once they had responded to a general enquiry regarding the experiment.

No participant had taken part in previous studies in this thesis to ensure a lack of familiarity with the tasks,

Table 6.2 summarizes participants' characteristics including BMI and TFEQ score means. There were no significant differences found on the TFEQ-D scores between the two high TFEQ-D groups, nor significant differences in restraint found between the two high TFEQ-R groups., but significant differences between the High versus Low TFEQ-D or TFEQ-R subcategories. Included in this summary, are also scores on the National Adult Reading Test (Nelson, 1982), in order to control for the possibility that pre-morbid intelligence may interact with scores on the impulsivity tasks. There were no significant differences between any of the TFEQ subgroups with respect to performance on this measure, and there were no significant differences in BMI between each of the four TFEQ groups.

Table 6.2: Descriptive Statistics of Participants' Characteristics

	Snack				No Food			
	<u>HDHR</u>	<u>HDLR</u>	<u>LDHR</u>	<u>LDLR</u>	<u>HDHR</u>	<u>HDLR</u>	<u>LDHR</u>	<u>LDLR</u>
	mean $\pm$ SE <i>n</i> = 10	mean $\pm$ SE <i>n</i> = 10	mean $\pm$ SE <i>n</i> = 10	mean $\pm$ SE <i>n</i> = 10	mean $\pm$ SE <i>n</i> = 10	mean $\pm$ SE <i>n</i> = 10	mean $\pm$ SE <i>n</i> = 10	mean $\pm$ SE <i>n</i> = 10
TFEQ-D score	10.9 $\pm$ 0.47	11 $\pm$ 0.47	3.4 $\pm$ 0.47	2.9 $\pm$ 0.47	11 $\pm$ 0.47	9.5 $\pm$ 0.47	4 $\pm$ 0.47	3.1 $\pm$ 0.47
TFEQ-R score	12.3 $\pm$ 0.87	3.2 $\pm$ 0.87	15.1 $\pm$ 0.87	3.2 $\pm$ 0.87	11.2 $\pm$ 0.87	4.0 $\pm$ 0.87	13.8 $\pm$ 0.87	3.1 $\pm$ 0.87
NART	12.5 $\pm$ 1.02	11.5 $\pm$ 1.02	14 $\pm$ 1.02	12.72 $\pm$ 0.98	12.9 $\pm$ 1.02	13.2 $\pm$ 1.08	12.63 $\pm$ 0.98	11.8 $\pm$ 1.14
BMI	23.63 $\pm$ 1.01	21.76 $\pm$ 1.01	21.02 $\pm$ 1.01	22.4 $\pm$ 0.96	23.48 $\pm$ 1.01	22.5 $\pm$ 1.01	24.5 $\pm$ 1.07	21.91 $\pm$ 1.07

## 6.2.2 Materials

### 6.2.2.a Food Consumed in the Experiment

For the purpose of this experiment the same food items used in Experiment 2 were also selected for the current investigation. As per the previous design in Chapter 2, participants were required to fast from 11.00 pm the night before and then came to the laboratory for a standard breakfast of Crunchy Nut Cornflakes, milk, and orange juice; please see Chapter 3, section 3.2.2 for caloric information and measurements of the food used.

Those participants in the Preload group were required to consume ice cream and chocolate sauce, and also consume *ad libitum* sweet and savoury snack foods; please see section 3.2.2 for caloric content and weight for each of the ice cream and snack foods, which included Cadbury's Chocolate Buttons™, McVities Mini Cheddars™, McVitie's Go Ahead!™ Cinnamon Apple mini cookies, and Sainsbury's Dry Roasted Peanuts.



#### *6.2.2.b Testing Measures*

##### *6.2.2.b.i National Adult Reading Test (NART) (Nelson, 1982)*

The only additional testing measure for the current investigation was the inclusion of the National Adult Reading Test.

The NART is currently the most commonly used measure to assess premorbid intelligence (R. Crawford, Parker, D.M., MacKinlay, W., 1992). The NART is a single- word adult reading test consisting of 50 items and the majority of the words are short and irregular, which is to say they are not commonly found words. This format was chosen so that participants do not have to analyse a complex visual stimulus (R. Crawford, Parker, D.M., MacKinlay, W., 1992).

Evidence of the NART's construct validity as a measure of intelligence has been provided by factor analytic studies of the Weschler Adult Intelligence Index (WAIS) and the NART (J. R. Crawford, 1989). The NART loaded very highly (0.85) on the first unrotated component of the WAIS. As such, the NART has become a widely used test to estimate premorbid intelligence in research settings (R. Crawford, Parker, D.M., MacKinlay, W., 1992).

The NART is one of the most reliable neuropsychological testing measures in practice (J. R. Crawford, 1989). It has high split half reliability (J. R. Crawford, 1989; Nelson, 1982), inter-rater reliability (Crawford et al., 1989 b; O'Carroll, 1987) and test-reliability (J. R. Crawford, 1989; R. Crawford, Parker, D.M., MacKinlay, W., 1992). Please see Appendix 5c for a copy of the NART used for this investigation. In the current investigation, a digital version of the NART was used. Using Microsoft PowerPoint software, the NART words had been entered onto Dell PC. The participant was permitted 30 seconds to read each word, and was instructed to press the space key after pronouncing each word. Once all 50 words had been completed, a final screen thanking the participant flashed onto the Dell monitor.

##### *TFEQ (Stunkard & Messick, 1985)*

Please see Chapter 2, section 2.2.4.a for a detailed description of the TFEQ.

*BIS* (Barrett, 1995) Please see Chapter 2, section 2.2.2.c for a detailed description of the BIS-11

*BART* (Lejuez, 2002)

Please see Chapter 2, section 2.2.3b for a detailed description of the BART.

*DDT*

Please see Chapter 2, section 2.2.3.a for a detailed description of the DDT.

*MFFT* (Kagan, 1964)

Please see Chapter 3, section 3.2.3.d for a detailed description of the MFFT.

*Go No Go task*

Please see Chapter 4, 4.2.d for the GoStop task (Dougherty, 2002) a version of the Go No Go task. In the current investigation, participants performed in two batteries of tasks. In the current investigation, participants attended to five digit number sequences that were presented for 1000 ms on a Dell computer screen. Participants were instructed to click the computer mouse (left click) as soon as they were sure the subsequent 5-digit stimulus was a “Go” stimulus (and not a No Go stimulus, which changed colour to red). The initial stop signal was presented 250 ms after presentation of the Go signal, this delay dynamically adjusted depending on the participants performance, by increasing by 50 ms after an unsuccessful inhibition task, making the future trial easier, or by decreasing by 50 ms after a successful inhibition trial, making the subsequent trial more difficult. The No Go trials comprised 25% of the total trials, and Go trials comprised 25% of the trials. The remaining 50% of the trials were novel trials, during which unmatching 5-digit sequences were presented. 120 trials were presented, with 120 sec break in between trials.

### 6.2.3 Design and Data Analysis

The study contrasted performance of women on a battery of measures of impulsivity depending on whether they had been classified as scoring high or low on the TFEQ-D and TFEQ-R scales and whether they had received the high calorie preload and snack

rating paradigm (Preload Group) or were not fed (No Food). Thus, a series of between subjects ANOVA's were carried out on each of the five dependent measure of impulsivity, with a 2 (TFEQ-D, high vs. low) x 2 (TFEQ-R, high vs. low) x 2 (Preload vs. No Food) Design, with scores on the MFFT, DDT, BART, Go No Go, as the dependent variables.

#### 6.2.4 Procedure

The focus of this experiment was to assess the preload and ad lib snack access had on impulsivity, as such the eating component of the investigation preceded performance on the battery of tasks for those participants in the Snack condition.

All participants were recruited to the experiment via email (Appendix 5a). The initial email explained the study was aiming to look at University students' cognitive performance, and the email explained that a requirement of the study also included a breakfast meal, which was served three hours before the actual test.

Once participants has contacted the researcher, a mutually convenient time was arranged to come into the lab, and participants were forwarded a second email that explained in greater detail the nature of the experiment. Those participants who were in the Preload condition received an email detailing the fact that they would be required to eat dairy products in the laboratory, whereas those participants who were not in the Snack condition were simply told that they would have to come into the laboratory for a Control Breakfast, as a means to control sensory experiences prior to testing, and to return to the laboratory 3 hours later.

The participant came to the laboratory between 8.30 and 10.00 am, and were first asked to complete a digital version of the NART (Nelson, 1982). Participants read out loud each word that appeared on the screen. The experimenter made notes of errors or correct responses on a checklist. Once this task had been completed, the participant was fed a standard Control breakfast of Crunchy Nut Cornflakes, milk, and orange juice. The participant gave their signed consent (Appendix 5d) form to the experimenter, and left the laboratory for a 3-hour intermission between breakfast and testing.

Upon the participant's return to the laboratory, she was greeted by the experimenter and led into an individual testing cubicle. For those participants who were randomly assigned to the Snack condition, a bowl of ice cream with chocolate sauce had already been placed in the room and was waiting ready to be consumed (please see section 3.2.2 for a detailed description of caloric content and volume of ice cream and chocolate sauce used for each sundae). Once the participant had consumed the entire bowl of ice cream, she was brought a tray of snack foods that included a mix of savoury and sweet items and VAS rating scales. The items were randomly organized in alphabetic order, and the participant was asked to rate each of the items in the alphabetic order presented. The participant was given instructions to consume as much palatable food as desired, and were left alone in the testing room for 15 minutes.

Upon completion of the Preload and Snack component of the test, participants completed the battery of impulsivity tests including the BART, BIS-11, DDT, Go No Go task, and MFFT. These tasks were counterbalanced to avoid any kind of order of effects with regard to impulsivity performance.

## 6.4 Results

### 6.4.1 Intake in the Snack Test

Table 6.4.1.a: *Outcome of ANOVA of performance for snack consumption between the two TFEQ conditions and preload condition*

	Chocolate	Mini Cookies	Mini Cheddars	Peanuts	Total
Main Effect TFEQ-D	<b>F(1, 35)= 10.70, p= 0.002)</b>	<b>(F(1, 35)= 8.93, p=0.05)</b>	<b>(F(1, 35)= 5.34, p=0.03)</b>	(F(1, 35)= 0.006, <i>ns</i> )	<b>(F(1, 35)= 8.60, p=0.006)</b>
Main Effect TFEQ-R	(F(1,35)= 1.97, p=0.17)	(F(1, 35)= 0.008, <i>ns</i> )	(F(1, 35)= 0.032, <i>ns</i> )	(F(1, 35)= 0.006, <i>ns</i> )	(F(1, 35)= 0.26, <i>ns</i> )
TFEQ-D x TFEQ-R interaction	(F(1, 35)= 0.4, <i>ns</i> )	(F(1, 35)= 2.69, p=0.11)	<b>(F(1, 35)=4.67 , p=0.038)</b>	(F(1, 35)= 1.22, p=0.28)	(F(1, 35)= 2.25, p=0.13)

Table 6.4.1.b: *Outcome of ANOVA of performance on the VAS Pleasantness ratings between the two TFEQ conditions and Anticipation condition*

	Chocolate	Mini Cookies	Mini Cheddars	Peanuts
Main Effect TFEQ-D	(F(1, 36)= 0.018 <i>ns</i> )	(F(1, 36)= 0.55, <i>ns</i> )	(F(1, 36)= 0.44, <i>ns</i> )	(F(1, 36)= 0.82, <i>ns</i> )
Main Effect TFEQ-R	(F(1, 36)= 0.027, <i>ns</i> )	(F(1, 36)= 0.192, <i>ns</i> )	(F(1, 36)= 9.93, p=0.003)	(F(1, 36)= 3.3, p=0.08)
TFEQ-D x TFEQ-R interaction	(F(1, 36)= 0.001, <i>ns</i> )	(F(1,36)= 4.55, p=0.04)	(F(1, 36)= 0.61, <i>ns</i> )	(F(1, 36)= 0.17, <i>ns</i> )

Table 6.4.1.a and Table 6.4.1.b report the significant main effect and interactions regarding consumption and rating of the foods.

As predicted, the High TFEQ-D group consumed significantly more total kCal than the Low TFEQ-D group, which replicates previous findings in Experiment 2.

Participants with High TFEQ-D scores ate significantly more than those with low TFEQ-D scores in regard to chocolate (F(1, 35)= 10.70, p= 0.002), mini cookies (F(1, 35)= 8.93, p=0.05), and mini cheddars (F(1, 35)= 5.34, p=0.03). There were no significant differences between groups regarding consumption of Peanuts (F(1, 35)= 0.82, ns).

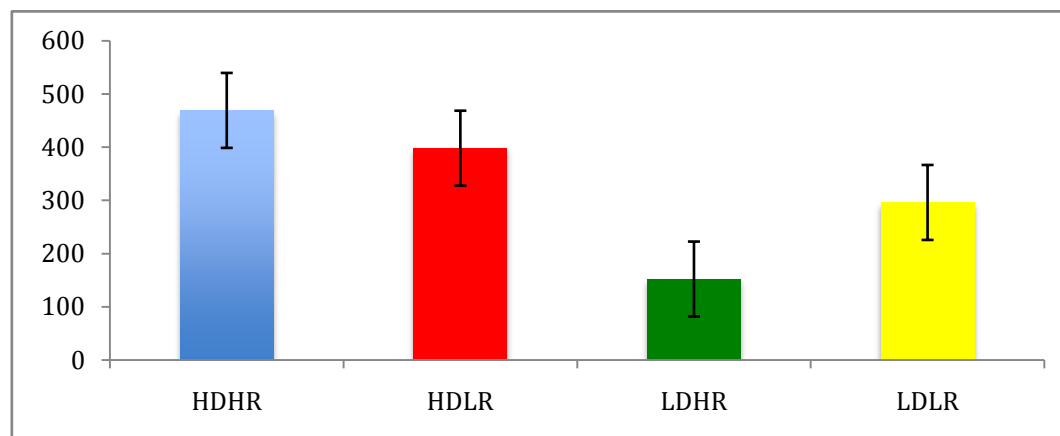
There was no significant main effect of TFEQ-Restraint with any intake measure. It is worth noting, however, the difference in chocolate consumption between high and low TFEQ-R groups approached significance (F(1,35)= 1.97, p=0.17), as participants with low TFEQ-R scores generally ate more chocolate (m= 87.72, SE=16.32) than those with high TFEQ-R scores (m= 55.79, SE=15.88).

There was a significant interaction between TFEQ-R and TFEQ-D groups in terms of consumption of mini cheddars; only the LDHR participants ate fewer than 90 kcal with this snack food. The HDHR group consumed the most (m= 153.2, SE= 26.0), followed by the HDLR group (m= 100.0, SE= 26.1) and finally the LDLR group (m=96.5, SE= 28.0).

The differences in pleasantness ratings showed less variability between the groups; there were no significant differences between TFEQ-D groups regarding pleasantness ratings. There was one interesting difference in mini cheddar ratings between the TFEQ-R groups; supporting the food intake data, those participants with low TFEQ-R scores also rated the pleasantness of the mini cheddars highly ( $m= 81.42$ ,  $SE= 4.58$ ) compared to the high TFEQ-R scorers ( $m= 60.1$ ,  $SE= 4.72$ ), and this was significant ( $F(1, 36)= 9.93$ ,  $p=0.003$ ). There was also a significant difference regarding pleasantness ratings of peanuts; those participants with low TFEQ-R scores rated the peanuts more highly ( $m=65.79$ ,  $SE= 5.56$ ) than those with high TFEQ-R scores ( $m= 51.70$ ,  $SE= 5.42$ ) and this was also significant ( $F(1, 36)= 3.3$ ,  $p=0.08$ ) .

There was a significant interaction between TFEQ-R and TFEQ-D groups regarding pleasantness ratings of the mini cookies ( $F(1,36)= 4.55$ ,  $p=0.04$ ), which is based on the HDLR and LDHR groups' higher pleasantness ratings of cookies than either the LDLR or the HDHR groups. Figure 6.4.1.i illustrates total caloric intake, and significant differences between each of the four TFEQ groups with regard to total caloric consumption in the *ad lib* snack.

Figure 6.4.1.i: Total kCal consumption between each of the TFEQ groups



#### 6.4.2 Performance on Impulsivity Tasks

##### 6.4.2.a Performance on the MFFT

Table 6.4.2.a illustrates significant main effect and interactions occurred between each of the elements of the MFFT, including total errors, total time, and finally the *i*-score, which is calculated based on the standardized scores of the time and error

variables (Salkind, 1980; Salkin & Wright, 1977, please see Chapter 3 section 3.2.3.d for a full brief of this equation).

Table 6.4.2.a: *Outcome of ANOVA of performance on the MFFT between the two TFEQ conditions and preload condition*

	MFFT Time (msec)	MFFT Errors	MFFT i-score
Main Effect Snack	(F(1, 73)= 0.73 , <i>ns</i> )	(F(1, 73)= 0.17 , <i>ns</i> )	(F(1, 73)= 0.54, <i>ns</i> )
Main Effect TFEQ-D	<b>(F(1, 73)= 5.77, p= 0.019)</b>	<b>(F(1, 73)= 6.35 , p=0.014)</b>	<b>(F(1,79)= 8.85, p=0.004)</b>
Main Effect R	(F(1, 73)= 0.15, <i>ns</i> )	(F(1, 73)= 0.08 , <i>ns</i> )	(F(1,79)= 0.013, p=0.908)
TFEQ-R x TFEQ-D interaction	(F(1, 73)= 0.49, <i>ns</i> )	(F(1, 73)= 1.93 , <i>ns</i> )	(F(1,79)= 1.52, p=0.221)
TFEQ-D x Snack Interaction	(F(1, 73)= 0.04 , <i>ns</i> )	<b>(F(1, 73)= 3.73 , p=0.057)</b>	(F(1,79)= 1.6, p=0.221)
TFEQ-R x Snack interaction	(F(1, 73)= 0.74, <i>ns</i> )	(F(1, 73)= 1.29, p= 0.26)	(F(1,79)= 0.09, p=0.7)
TFEQ-D x TFEQ- R x Snack interaction	(F(1, 73)= 0.004 , <i>ns</i> )	(F(1, 73)= 0.002 , <i>ns</i> )	(F(1,79)= 0.02, p=0.893)

Table 6.4.2.a illustrates significant main effect and interactions occurred between each of the elements of the MFFT, including total errors, total time, and finally the *i*-score, which is calculated based on the standardized scores of the time and error variables (Salkind, 1980; Salkin & Wright, 1977, please see Chapter 3 section 3.2.3.d for a full brief of this equation).

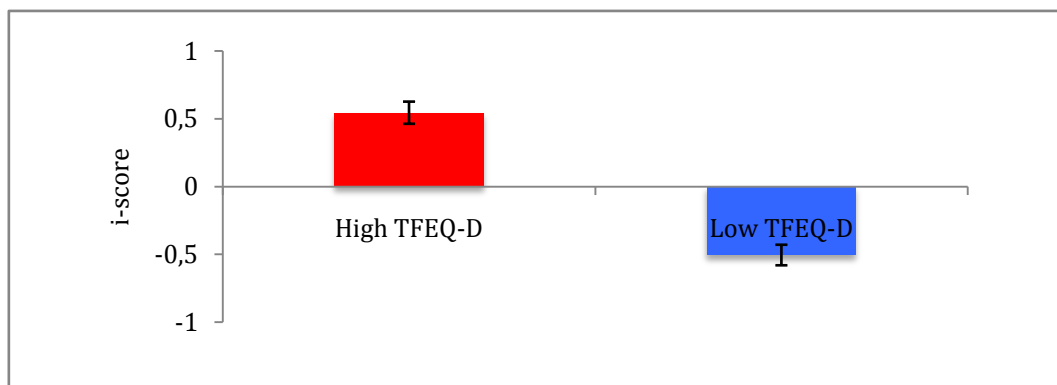
Following the same trends of previous studies, there were no significant main effects of TFEQ-R on any of the MFFT measures. There were also no main effects of the Snack condition.

There were significant main effects of the TFEQ-D groups for all of the components of the MFFT, which replicates the results of our previous investigations (Experiment 2 and 3). Those participants with high TFEQ-D scores completed the test significantly faster than those with low TFEQ-D scores (F(1, 73)= 5.77, p= 0.019) but they also made significantly more errors than did those with low TFEQ-D scores (F(1, 73)= 6.35 , p=0.014). Therefore, it was not surprising that there was a significant main

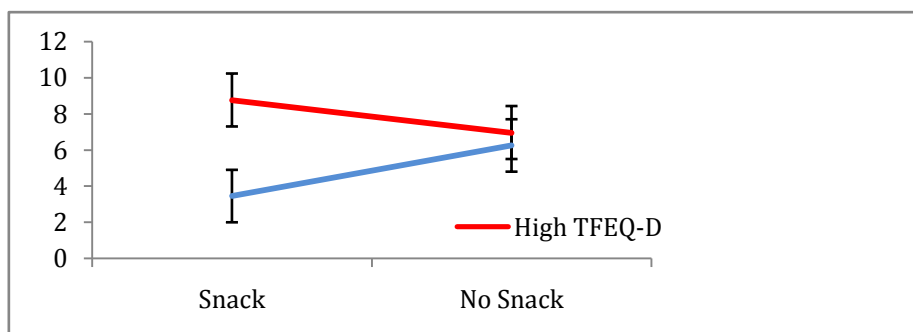
effect of TFEQ-D on the *i*-score, where participants with high TFEQ-D scores had higher *i*-score ratios ( $F(1,79)= 8.85$ ,  $p=0.004$ ). Figure 5.4.2.i illustrates the main effect difference between the high and low TFEQ-D groups' performance on the *i*-score measure of the MFFT.

Figure 6.4.2.ii presents the data from the significant interaction that occurred between TFEQ group and Snack condition. There was a marginally significant interaction between TFEQ-D group and Snack condition ( $F(1, 73)= 3.73$ ,  $p=0.057$ : Figure 5.4.2.i) and this arose because those participants with High TFEQ-D scores who consumed the ice cream preload and snacks made more errors on the MFFT ( $m= 8.75$ ,  $SE= 1.19$ ) than those who did not have the snack ( $m= 6.95$ ,  $SE= 1.19$ ). The opposite pattern followed for those in the low TFEQ-D groups; those with low TFEQ-D scores in the Snack Condition made fewer errors ( $m= 3.45$ ,  $SE= 1.17$ ) than those who were not fed ( $m= 6.25$ ,  $SE= 1.19$ ).

*Figure 6.4.2.i:* Impulsivity differences between High vs. Low TFEQ-D scorers and impulsivity performance on the MFFT, positive *i*-scores are indicative of impulsive behaviour



*Figure 6.4.2.ii:* Interaction between TFEQ-D and Snack condition and Total Errors committed on the MFFT.





#### 6.4.2.b The Go No Go Task

In the Go No Go task, the dependent variable is reaction time to Go stop signals. Slower or longer reactions times are indicative of greater impulsivity. On this measure, there were no main effect of Snack condition, TFEQ-D, or TFEQ-R condition. There were no interactions between TFEQ-D or TFEQ-R classifications, and there were no interactions between experimental condition and TFEQ classification. Table 6.4.2.b.i and Table 6.4.2.b.ii report these findings from the ANOVA statistical analysis.

Table 6.4.2.b.i: *Descriptive Statistics for Performance on the Go No Go between TFEQ groups and Experimental Condition*

Snack				Control Condition			
<u>HDHR</u>	<u>HDLR</u>	<u>LDHR</u>	<u>LDLR</u>	<u>HDHR</u>	<u>HDLR</u>	<u>LDHR</u>	<u>LDLR</u>
mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE
297.5 $\pm 36.25$	277.5 $\pm 36.25$	261.25 $\pm 36.25$	332.9 $\pm 36.25$	283.75 $\pm 36.25$	301.25 $\pm 36.25$	242.5 $\pm 36.25$	293.75 $\pm 36.25$

Table 6.4.2.bii: *Outcome of ANOVA of performance on the Go No Go between the two TFEQ conditions and preload condition*

Main Effect Snack	(F(1,73)= .307, <i>ns</i> )
Main Effect TFEQ-D	(F(1,73)= .0179, <i>ns</i> )
Main Effect R	(F(1,73)= 1.070, <i>p</i> =0.3)
TFEQ-R x TFEQ-D interaction	(F(1,73)= .307, <i>ns</i> )
TFEQ-D x Snack Interaction	(F(1,73)= 0.000, <i>ns</i> )
TFEQ-R x Snack interaction	(F(1,73)= .203, <i>ns</i> )
TFEQ-D x TFEQ- R x Snack interaction	(F(1,73)= 0.144, <i>p</i> =0.706)

#### 6.4.2.c DDT Performance

Table 6.4.2.c: *Descriptive Statistics for Performance on the DDT between TFEQ groups and Experimental Condition*

	Snack				No Food			
	<u>HDHR</u>	<u>HDLR</u>	<u>LDHR</u>	<u>LDLR</u>	<u>HDHR</u>	<u>HDLR</u>	<u>LDHR</u>	<u>LDLR</u>
	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE
	n= 10	n= 10	n= 10	n= 10	n= 10	n= 10	n= 10	n= 10
	1863.55	2225.625 $\pm$ 1	1680.23 $\pm$ 1	1943.17	2009.8	1668.4 $\pm$ 1	1805.96	2043.78 $\pm$ 1
AUC	$\pm$ 182.97	82.97	82.97	$\pm$ 182.97	182.97	82.97	$\pm$ 182.97	82.97

There were no significant main effects of Snack consumption ( $F(1,78)=3.42$ ,  $p=0.07$ ), TFEQ-D ( $F(1,78)=1.47$ ,  $p=0.23$ ), or TFEQ-R ( $F(1,78)=1.56$ ,  $p=0.22$ ) classification on performance on the DDT task measured using the AUC method. Furthermore, there were no significant interactions between any the snack condition with either TFEQ-D classification ( $F(1,78)=2.15$ ,  $p=0.15$ ), or TFEQ-R classification ( $F(1,78)=0.819$ ,  $p=0.37$ ). Finally, there was no three-way interaction with Area Under the Curve as a dependent variable for the analysis of the DDT on this task ( $F(1,78)=0.781$ ,  $p=0.38$ ).

#### 6.4.2.d BART Performance

Table 6.4.2.d: *Outcome of ANOVA of performance on the BART between the two TFEQ conditions and preload condition*

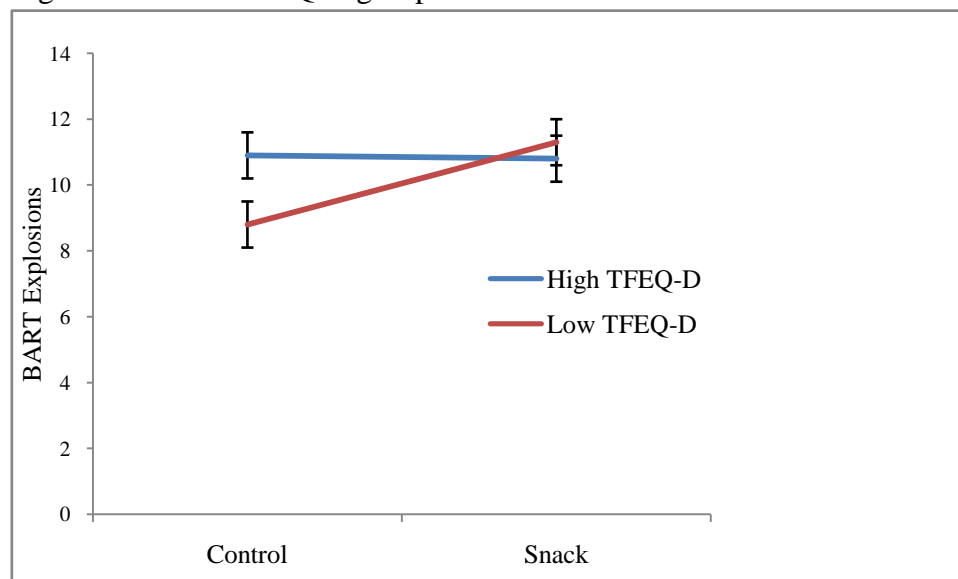
	BART explosions	BART adjusted average pumps
Main Effect Snack	<b>(F(1,78)= 3.92, p=0.05)</b>	(F(1,78)=1.27, $p=0.26$ )
Main Effect TFEQ-D	(F(1,78)= 1.07, $p=.299$ )	(F(1,78)= 0.25, <i>ns</i> )
Main Effect R	(F(1,78)= .606, $p=.438$ )	(F(1, 78)= 0.59, <i>ns</i> )
TFEQ-R x TFEQ-D interaction	(F(1,78)= .477, $p=.492$ )	(F(1, 78)= 0.003, <i>ns</i> )
TFEQ-D x Snack Interaction	<b>(F(1,72)= 3.89, p=0.06)</b>	(F, 1, 72)= 0.19, <i>ns</i> )
TFEQ-R x Snack interaction	(F(1,72)= 0.59, $p=0.445$ )	(F(1, 72)=0.37, <i>ns</i> )
TFEQ-D x TFEQ- R x Snack interaction	<b>(F(1,72)= 5.29, p=0.024)</b>	(F(, 72)= 0.41, <i>ns</i> )

All statistics are reported in Table 6.4.2.d. The BART was the only impulsivity task where there was a significant main effect of snack condition ( $F(1,78)= 3.92$ ,  $p=0.05$ ).

Those participants in the Snack condition had higher mean Total Explosions, (11.1, SE= 0.4) compared to those in the No Snack condition (9.0, SE= 0.4), suggesting that snack consumption resulted in more impulsive behaviour on this task.

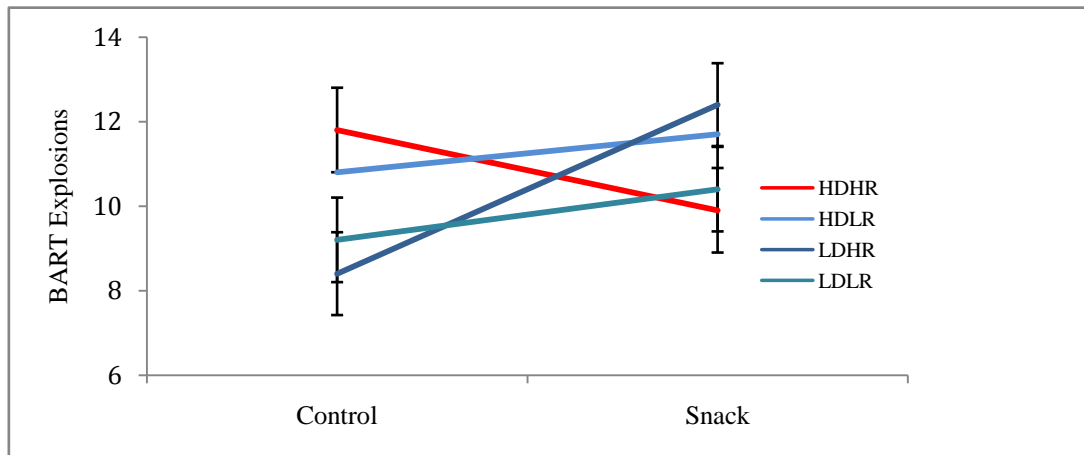
There were no significant main effects of TFEQ-D or TFEQ-R classifications on BART performance. There was however a significant interaction between TFEQ-D and Snack condition for the Total BART explosions ( $F(1,72)= 4.14$ ,  $p=0.046$ ). The Snack condition had the opposite effect on the High vs. Low TFEQ-D groups; those participants with high TFEQ-D scores were *more* impulsive in the snack condition, whereas those participants with low TFEQ-D scores were *less* impulsive in the Snack condition (Figure 6.4.2.di). There was no significant interaction between TFEQ-D groups and Adjusted Average Pumps.

Figure 6.4.2.d.i: Differences in Total Explosions on the BART; comparing between High versus Low TFEQ-D groups and Snack condition



Finally, the three way interaction between TFEQ-D, TFEQ-R, and snack condition was also significant ( $F(1,72)= 5.29$ ,  $p=0.024$ ) (Figure 5.4.2.dii).

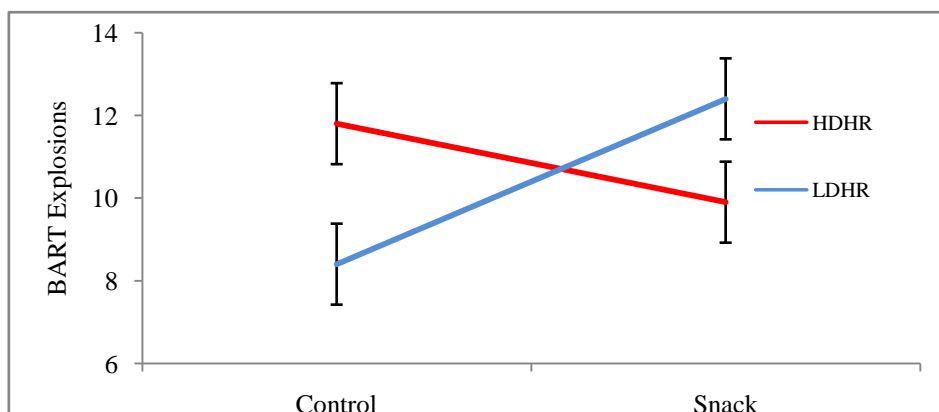
*Figure 6.4.2.dii:* Comparison between BART performance on each of the TFEQ groups and Experimental Conditions



In order to investigate these findings further, a series of independent oneway ANOVAs were run between each of the TFEQ groups. The clearest finding from these data was that the HDHR group performed less impulsively in the Snack condition (mean= 9.9, SE= 0.98) compared to Control Condition (m= 11.8, SE= 0.98), whereas the other three groups all became more impulsive in the Snack condition compared to Control.

One way ANOVA's between each of the groups revealed the interaction between HDHR and LDHR groups and performance in the Snack versus Control Condition was the only significant interaction ( $F(1, 39) = 10.03, p = 0.003$ ) (Figure 5.4.2.div). The interaction between HDHR and HDLR groups and performance on the BART in the two conditions approached significant ( $F(1, 38) = 2.73, p = 0.1$ ), and the interaction between the HDHR and LDLR group was not significant ( $F(1,39) = 2.03, p = 1.6$ ).

*Figure 6.4.2.diii:* Interaction between HDHR and LDHR groups' BART performance in the Snack versus Control Condition



## 6.5 Discussion

The results of the current investigation found a dissociation between Reward Reactive versus Inhibition measures of impulsivity depending on an interaction between restrained eating attitude (TFEQ-R) and self reported overeating (TFEQ-D). The data from the present investigation confirmed the association between high TFEQ-D scorers and higher levels of Inhibition impulsivity, and we were also able to observe a distinct pattern between the HDHR group in response to the Reward Reactivity tasks that helps to explain some of the previous conflicts in Experiment 1 and Experiments 2 and 3.

As with our original preload/*ad lib* snack investigation in Experiment 2, we replicated the finding that high TFEQ-D scorers consumed significantly more food. Despite our original predictions, that the HDHR would over consume the *ad lib* snack relative to the HDLR group in light of the violation to dietary boundaries made by the ice cream preload, we did not find any evidence of counter regulatory eating, as the HDLR group consumed an almost identical amount of snacks. As such, the data presented in this experiment indicate that high TFEQ-D scores are more indicative of overeating behaviour, despite a wealth of information supporting the link between *both* TFEQ-D and TFEQ-R subscales (J. Westenhoefer, 1991; J. Westenhoefer, et al., 1994; M. R. Yeomans, Coughlan, E., 2009; M. R. Yeomans, Tovey, et al., 2004).

One possible explanation for the eating pattern in the HDLR group lies in the recognition of hedonically motivated eating (Lowe & Butryn, 2007). The foods selected for the *ad lib* snack were either high in sugar, fat, or both, and those HDLR participants may have simply engaged in opportunistic feeding. There is growing support for the idea that high TFEQ-D scores are associated with responsiveness to the hedonic aspects of eating (Yeomans MR, 2009; M. R. Yeomans, Tovey, et al., 2004)), which is underscored by the finding that high TFEQ-D scores are associated with consumption of high fat and sweet foods (Contento, Zybert & Williams, 2005). Since we selected participants based on extremes of the TFEQ-D scale, our sample may represent individuals who have a more pronounced tendency to overeat despite self reporting restriction behaviours.

The hypothesis that the HDLR and HDHR groups consumed greater amounts of food in the *ad lib* component by opposing underlying motivation, the HDHR by virtue a threat to dietary boundaries with the preload, and the HDLR as a response to the pleasant taste and experience of consuming high sugar/ fat foods, perhaps needs to be verified with self report mood scales. However, some support for this notion rests with the two groups' opposing behaviour on the BART: the HDHR participants became *more* impulsive in the Snack condition whereas the HDLR group was *less* impulsive in the Snack condition, which verifies the notion that the preload and *ad lib* snack contributed to disinhibiting behaviour in the HDHR group but not the HDLR group.

The BART results showed that consumption of pleasant tasting, rewarding food diminishes Reward Reactivity only among participants who self report *both* the tendency to Restrict with Overeating (HDHR) but contribute to impulsivity in all other participants who either restrict or simply eat for pleasure (the HDLR, LDHR and LDLR groups all increased impulsivity in the Snack condition).

The theory that dieters or individuals who attempt to unsuccessfully restrict caloric intake are more vulnerable to overeating as a response to stress or negative affect has been a theme throughout eating behaviour literature. Herman and Polivy identify this as "Counter Regulatory Eating", Baumeister (1994) has suggested overeating is a response to Ego Threats, and Stroebe (2008) proposed that cognitive load is the chief factor related to the breakdown of cognitive restriction on eating. Several authors have expressed similar theories (Boon, Stroebe, Schut, & Jansen, 1997; Boon, Stroebe, Schut & Ijtema, 2002; Mann & Ward, 200; Lowe & Kral, 2006; Stroebe, 2008); that coping with distress requires cognitive resources, which impair the ability of the restrained eater to focus on their dieting goal, however, the results from this investigation are the first data that we are aware of, to show that Reward Reactivity is reduced after *ad lib* consumption of HED food, and specifically in those individuals who self report dieting *with* overeating (ie. the unsuccessful dieters). The HDHR participants' improvement on the BART upon consumption of HED food could be taken as support for the notion that this group is particularly vulnerable to psychological effects of rewarding food; over time, if the HDHR participants learn to

incorporate HED food as a means to reduce appetite for other pleasant experiences it may lead to maladaptive eating patterns and use of food.

Critically, this study has offered the first plausible explanation for the inconsistency with regard to the relationship between the TFEQ-D scores with BART explosions. In this investigation, we did not find any main effect differences between TFEQ-D or TFEQ-R with BART explosions, but rather the dissociation between the HDHR group with the other three (HDLR, LDHR, LDLR) was contingent on the interaction with a third variable, the Snack Condition. This finding emphasizes the influence that environmental factors have on the Reward Reactive subtype of impulsivity. This finding was inline with our original hypothesis, and shows that HDLR participants continue to be Reward Reactive after an initially rewarding experience, but that the HDHR participants become less Reward Reactive.

The consistency of the relationship between the TFEQ-D measure and the MFFT was made clear in this third investigation, and indicates those individuals who self report overeating are significantly worse at controlling prepotent, inhibitory response. There are aspects of the MFFT that are analogous to the current food environment: the MFFT requires participants to study a series of stimulus, carefully, before selecting the identical matching picture to the target stimulus. A high *i*-score indicates that the incentive to finish the task is more important than finishing the task *correctly*. Poor performance on this measure could help explain why individuals with high TFEQ -D scores are especially vulnerable to weight gain in the current food environment: simply selecting one food alternative because it is relatively easy to find, as opposed to reading caloric or nutrition information, increases the likelihood of weight gain, given the higher concentration of high calorie items in our food environment (A. Drewnowski & Rolls, 2005). More importantly, the tendency of selecting a food item in an urgent manner may interact with the high TFEQ-D scorers tendency to eat for a hedonically based motivations (Lowe & Butryn, 2007), thus perpetuating a style of eating that leads to weight gain.

An important consideration is whether the Reward Reactive versus Inhibition subtypes of impulsivity relate to state and trait differences, and how this contributes to perpetuation of unhealthy eating among high TFEQ-D scorers. It has been suggested

that Inhibition represents a general sense of urgency and inability to control prepotent motoric responding (Dawe & Loxton, 2004; Everitt, et al., 2008; Kertzman, et al., 2006), and given the stability between the high TFEQ-D scores and poor inhibition abilities on the MFFT, we propose that Inhibition is a trait associated with self reported overeating. Reward Reactivity is related to a myopia for future planning, and sensation seeking (Gable SL, 2000; Llewellyn, 2008; Pickering, 2001) and thus it could be argued it is contingent upon environmental inputs, and is therefore a state. In light of the findings in the present study, we propose Reward Reactivity represents a state that functions with appetitive condition, thereby explaining the variety of results we have obtained throughout this thesis.

The current investigation demonstrated that impulsivity tests dissociate between participants based on self-reported eating styles. First, there was confirmation that high TFEQ-D participants are more impulsive on the MFFT measure of impulsivity regardless of the interaction with TFEQ-Restraint, or Snack condition. The consistency of this relationship suggests Inhibition impulsivity is a stable trait associated with the self-reported tendency to overeat. A second important feature was that performance of the BART, a measure of Reward Reactivity, was contingent upon measures of TFEQ-Disinhibition and TFEQ-Restraint, and is also upon on Snack Condition. Most notably, this investigation presented findings that suggest hedonically motivated eating diminished Reward Reactivity in the HDHR group, which unique to all other TFEQ groups, who instead became more Reward Reactive after consuming pleasant tasting food.

In the current investigation, participants were notified about the consumption of snack foods, which may have had subsequent impact on both our food intake data and therefore, impulsivity data. Anticipation for pleasant tasting food plays a decisive role in hedonically motivated eating (E. Stice, Spoor, Bohon, Veldhuizen, & Small, 2008), and critically those individuals who overeat also show significantly higher levels of anticipation to eat rewarding food (Beaver, et al., 2006; E. Stice, et al., 2008). Therefore, a unique idea is to determine whether high TFEQ-D scores are related to greater anticipation for hedonically motivated eating, and further whether an increase in anticipation for rewarding food contributes to impulsivity. The final Chapter of this thesis explores this question.



## **Chapter 7: Anticipatory Food Cues elicit greater implicit wanting and greater impulsivity in participants with high TFEQ-D scores**

### **7.1 Introduction to Experiment 7**

Experiment 6 was the first study to suggest that exposure to a food reward could increase subsequent impulsive responding in general, and that this depended particularly on the self-reported tendency for the individual to be prone to over-eating (indexed by the TFEQ-D scale). The present investigation extended that finding to explore the hypothesis that the increased impulsivity found between the four TFEQ groups arise after the *ingestion* of pleasant tasting food in Experiment 5, Chapter 6, was a consequence of exposure to food cues rather than the actual ingestion of food.

In the previous experimental investigations (Experiment 2, 3, and 5), there has been a consistent pattern whereby women scoring high on the TFEQ-D showed more impulsive responses both in terms of total time taken, total errors, and *i*-score on the MFFT. The effects with the MFFT have been seen regardless of whether eating was controlled prior to testing (Experiment 3) or whether participants were forced to consume a requisite palatable food preload and *ad lib* snack prior to performing on the MFFT relative to the control (i.e. no forced consumption) (Experiment 2 and 4). These findings have led us to hypothesize that MFFT performance and Inhibition impulsivity is a stable trait associated with self reported overeating, however challenging this position is the finding in all of the previous studies that a purer measure of Inhibition (the Go No Go tasks) has revealed no differences between TFEQ-D groups. This discrepancy has led us to hypothesize that participants' awareness of an eating component of the investigation may have altered responses, and the current experiment was designed in order to address this query.

In addition to the inconsistent pattern with the Go No Go task, there has been a very complicated set of data with respect to the BART and DDT measures as well. Despite the considerable support for the association between reward sensitivity and overeating (S. S. Davis C., Berkson M., 2004; Dawe & Loxton, 2004; Franken & Muris, 2005), we have not found a consistent pattern with measures that assess Reward Reactivity and self reported overeating across the four experiments presented in this thesis. In our Fourth Experiment, we found that forced consumption of a palatable food led to a

reduction of Reward Reactivity (measured by the BART) in some of the High TFEQ-D participants (HDHR) but led to increased impulsivity in all other groups (HDLR, LDHR, and LDLR), which suggests that the ingestion of HED palatable food leads to increased Reward Reactivity in the majority of participants, but somehow specifically assists the HDHR group control their Reward Reactive impulses. This could be viewed as support for the idea that the consumption of high-energy dense palatable food reduces reward reactivity in those participants who are sensitive to food rewards, supporting predictions made by Dawe & Loxton (2004) and Davis (2008; 2004; 2007; 2004). However, in another measure of Reward Reactivity, the DDT, we have failed to find any significant differences between groups, a surprisingly finding in light of our previous investigation (M. R. Yeomans, et al., 2008).

An important feature of our previous investigations was that participants were made explicitly aware of the requisite eating. This prior awareness may have assisted aspects of impulse control, particularly in High-Restrained type eaters who may have altered their behavior in response to this information. According to (Trope, 2000) exposure to a tempting stimulus can bolster self control to achieve a long term goal, and the obligatory information given prior to the study includes a description of some of the foods. This theory has been called “counter active control” theory, in order to explain how highly Restrained Eaters (measured by the Herman & Polivy’s RS) are able to consistently resist consuming tempting food items, despite those predictions highlighted by “Counter regulation” theory. In support of the notion that exposure to rewarding substances can actually *enhance* cognitive control, Coelho, Polivy, Herman & Pliner (Coelho, 2008) assessed participants’ dietary restraint in terms of low, medium and high restraint authors found that cue exposure actually bolstered dieting related goals in those participants with very high, or very low dietary restraint.

Comparative studies have shown the importance of appetizing/ palatability properties of food related stimuli and both physiological state and motivational levels (i.e. hunger) activate the neural circuits that underlie food selection and intake (K. Berridge, 1996; Chiara, 2005; Kelley, et al., 2002; Kelley, Schiltz, & Landry, 2005) and human imaging studies have shown that manipulations to hunger/satiety also interact with the pleasure expressed with eating rewarding food such as chocolate (Rolls ET, 2007; Labar KS, 2001).

A major focus for this final investigation was to determine whether anticipation for rewarding food elicits greater impulsivity in those participants who overeat. A critical component of the present investigation was that participants were naïve to the inclusion of palatable food prior to testing, so as not to make them aware and thus bolster dieting goals, which may indirectly influence impulsivity performance.

Already there is some support showing that one aspect of impulsivity, Reward Sensitivity, is linked with hyper responsiveness to food cues. For example, Beaver (2006) illustrated that trait variation in the form of Reward Drive (Behavioral Activation Scale (BAS) affects the extent to which the reward network is engaged by visual food cues, specifically that BAS scores are correlated with activation in the amygdala upon presentation of appetizing versus disgusting foods. Rolls (2007) investigated the difference in hedonic response to chocolate rating between chocolate cravers and noncravers. Interestingly, no differences were found between cravers versus non-cravers in the primary taste cortex (in essence, the cravers did not show any greater activation in this brain region, which would be associated with enhanced pleasure), but rather the *sight* of chocolate produced differences in processing areas, such as the medial orbitofrontal cortex. In light of the role that the OFC plays in expectations (Schoenbaum & Roesch, 2005; Schoenbaum, et al., 2006; Schoenbaum, et al., 2007) and impulsivity (Izquierdo, et al., 2004), this finding suggests that individuals with a pronounced drive for food experience differences in the degree of Executive Planning to obtain the reward, as opposed to simply having a greater preference for that reward.

The observation that exposure to appetizing food cues has the potential to override satiety signals and promote overeating (Cornell, 1989) suggests homeostatic driven models cannot entirely explain the motivation for eating, and especially for pleasant tasting food. Both Rolls (2007) and Beaver's (2006) findings touch on the idea that individual differences indicated by either impulsivity (BAS scales), or self reported eating behavior (craving) lead to enhanced response to food related cues, contributes to our hypothesis that individuals who self report overeating will be more sensitive to a series of appetitive food cues, and will demonstrate this sensitivity in the form of heightened impulsivity.

Recent theories of eating behavior converge on the idea that eating is driven to a large extent by the hedonic rewarding properties of food, rather than a homeostatic measure to reduce hunger (Finlayson, King, Blundell, 2008; Lowe & Butryn, 2007; Yeomans & Gray, 1997). Such reward related mechanisms are thought to contribute in failures of eating regulations, contributing to overeating and thus obesity (Blundell & Finlayson, 2004; Stroebe, 2008). Neurobiological research in animals has shown that pharmacological stimulation of the network that includes the frontal and ventral striatal, amygdala and midbrain regions (Berridge, 1996; Berridge & Robinson, 2003; Chiara, 2005; Kelley, et al., 2005) can override satiety and cause overeating of highly palatable foods. Since visual cues engage this network (Labar KS, 2001; O'Dougherty JP, 2002), too, it has been suggested that cues themselves also acquire motivating and hedonic properties (Cardinal, 2002)

Consistent with this idea is the finding that exposure to food cues (olfactory or visual) increased cravings and actual overeating in Restrained Eaters (which would be akin to the HDHR category on the TFEQ scale) (Federoff, 1997; Rogers, 1989). Moreover, thinking about a favorite food can also lead to overeating in RS individuals (Harvey, 2005). Finally exposure to rewarding food increases cephalic phase response in the form of increased salivation in Restrained versus Unrestrained eaters (Brunstrom, 2004, Tepper, 1992).

An integrative theory that has been used to clarify the difference in reactions to rewarding cues between those individuals who crave rewarding substances versus those who are able to ignore them, is Incentive Salience Theory, which is a model that posits that reward related cues trigger hyperactivity within a network that including the Ventro tegmental area (VTA), nucleus accumbens (NAc), Orbitofrontal Cortex (OFT), amygdala (AMYG), and ventral pallidum (Berridge & Robinson, 2003; Jentsch & Taylor, 1999; Wang, et al., 2004; Wang, et al., 2006). According to Incentive Salience theory, repeated exposure to rewards leads to neuronal adaptations that favour or “sensitize” to that particular reward, focusing behaviour towards attaining that preferred substance, which later may lead to poor decision making and lifestyle choices in order to obtain that reward.

Incentive Salience Theory has direct implication for overeating; stimuli associated with pleasant tasting foods, such as media campaigns, the smell of HED baked goods, or even time of day, are likely to have a higher incentive value for overweight individuals and possesses a greater than normal potency for activating the reward system (Stoeckel, Cox, Cook III, Weller, 2007; Stoeckel, Weller, Cook III, Twieg, Knowlton, Cox, 2008). The overeaters' increased motivation for "high incentive" foods (Stoeckel, 2007) triggers excessive motivation to eat for pleasure as opposed to physiological need (Berthoud, 2007; Mela, 2006). This literature indicates that the dual model of hedonic motivation is contingent upon both the explicit liking of an item, in addition to the implicit craving or wanting of an item, and thus the necessity for a measure capable of assessing both of these factors is a critical factor in examining the motivation of individuals with a tendency to overeat. The Incentive Salience model provides an important manner for distinguishing the two components of reward acquisition, and while there is still a considerable debate regarding the application of the Incentive Salience model to overeating, it is likely that the consumption of rewarding food at least induces a Sensitization like state (Berridge, 2009). For this reason, we believe it provides the most concise explanation for describing individuals' hedonically motivated eating episodes.

Finlayson (2007) emphasized that the contribution of both components of reward (wanting and liking) must be identified before changes in consumption patterns can be fully understood. In the current investigation, it is our priority not only to create a paradigm to enhance anticipation, but to objectively determine whether there is a difference in explicit and implicit ratings for food between self reported overeaters. Finlayson (2008; 2007) stressed the methodological challenges that assessment of implicit wanting, and also explicit liking, present psychologists investigating the motivation for to eat. For example, people often fail to dissociate affective reactions from motivational states (i.e. "It's pleasant, so I want it"), however the biggest limitation with assessing implicit wanting, is that people think it is a process they are consciously aware of, whereas Sensitization theory would stress that wanting reflects a 'active reconstructive reorganization' based on any number of factors that could include mood state, comfort level, and environmental factors. In terms of Liking, many studies in the psychology of appetite rely on Visual Analogue Scales that have explicit numeric values anchored on each end of the scale. Rogers & Blundell (1990)

showed that changing whether a participant was asked how they enjoyed the pleasantness of a food versus the pleasantness of *eating* that food led to significant differences in ratings. Therefore, subtle statements of differences can yield significant differences in affective responses, which challenges the validity of these measures. A final limitation is the inaccuracy of liking/wanting measures that arise when these two ratings are taken in successive order. If the liking or wanting question is perceived as the same question, the individual might adjust their responses to be consistent, thus concealing the differences between liking and wanting.

In order to address all of these concerns, the Liking Wanting Computer Procedure (LWCP) was developed (Finlayson, 2007). The LWCP assessed explicit and implicit aspects of liking and wanting based on digital presentation of a series of food cues based on their Fat/Sugar properties. A major operational priority was that both wanting and liking are integrated and measured at the same time, but critically that they are assessed in distinct ways to eliminate contamination of one conscious judgement by another.

To date, there have been several investigations in Restrained versus Unrestrained Eaters implicit liking for food (Roefs, 2005; Papies, Stroebe, Aarts 2007; 2009; Hoefling & Strack 2008), which offer conflicting results with the stability of Restrained Eaters' increased *liking* for food (Roefs A, 2005; Hoefling, 2008) but it has not been made clear whether implicit wanting would differ between self reported overeaters (high TFEQ-D scorers), and moreover how this would contribute to subsequent impulsivity.

In light of the findings that visual food cues are particularly salient for food cravers (Rolls, 2007) and also that individual differences in trait reward drive were positively correlated with pictures of appetizing food and activity in the reward network within the brain (Berridge, 1996; DiChiara, 2005; Kelley, et al., 2005) we predict the presentation of anticipatory food stimuli will be more costly in terms of inhibitory resources, by virtue the greater amount of activity in frontal regions of the brain observed in those sensitive to food cues (such as self reported overeaters, or chocolate cravers in the Rolls (2007) study) than for those individuals who do not self report overeating. Therefore, we expect to find an increase in impulsivity from the Control

Condition to the Anticipation Condition specifically in those individuals with a self reported tendency to overeat, and we interpreted this as a reflection of this groups' diminished inhibitory control in light of the idea that food cues elicit greater prefrontal activity specifically in those who are vulnerable to overeating.

In addition to the predicted differences between Control and Anticipation conditions, and based on the outcome of the previous experiments in this thesis, greater impulsivity overall was predicted for the MFFT, and possibly for the BART, and Go No Go tasks in the high TFEQ-D groups. Finally, in order to address our consistent lack of finding with a measure to assess Impulsive Choice using the DDT measure, we elected to find another measure that was capable of providing a “real-life” experience of selecting Small Soon rewards in preference for Larger Later ones. One such task is the Two Choice Impulsivity Paradigm (Dougherty, 2005) and provides the participant with the actual experience of temporal delay, which was hypothesized to enhance our discriminative ability between the TFEQ groups. In the previous DDT task, participants were required to value Large Later rewards in entirely hypothetical terms, whereas with the TCIP adaptation, participants' actual behavior in response to short delays versus longer ones was recorded. The TCIP has been used with adult and adolescent populations and has impulsive choices on this measure have been positively related to scores with aggressive responding in the laboratory (Cherek, 1997). We predicted that participants with high TFEQ-D scores will consistently choose Smaller Rewards Sooner, as an expression of their increased motivation to obtain the food reward faster

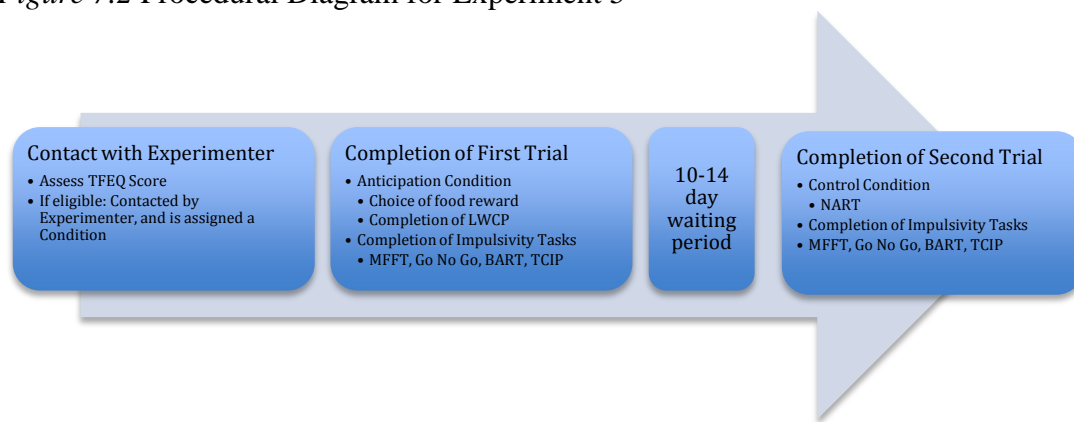
## **7.2 Method and Materials**

### *7.2.a Design*

In the current investigation, participants' impulsivity on a battery of performance based measures was contrasted in a within groups design based on their impulsivity in an Anticipatory Condition versus a Control Condition, and then between-groups contrasts were used to explore the impact of classification as high or low on TFEQ-D and TFEQ-R scales was used to explore how these eating attitudes impacted on impulsive responding elicited by exposure to food cues.

In order to ensure participants' expectations for a food reward was sufficiently different from the control condition, the Anticipation Condition included two components that were presented to participants prior to completing the battery of impulsivity tests. First, participants were asked to select a "food reward" from an array of six palatable snack foods, and next participants were required to complete the LWCP (Finlayson, 2007) which is a computerized program that requires participants to rate how much they like and want specific food items (which are presented digitally).

*Figure 7.2* Procedural Diagram for Experiment 5



### *7.2.b Participants:*

Female university students were invited to participate in an experiment that was aimed to investigate cognitive performance. Inclusion criteria were a BMI between 17- 25, no history of a clinically diagnosed eating disorder or substance use and currently non smoking, not taking any kind of antibiotic or medication besides birth control. Participant information and consent forms are included in Appendix 7a. Critically, participants were excluded based on their TFEQ-D scores as we were interested in participants with TFEQ-D scores in the upper ( $\text{TFEQ-D} \geq 9$ ) and lower tertiales ( $\text{TFEQ-D} \leq 4$ ) of TFEQ-D scorers of a sample of 780 students conducted in our initial investigation (please see Chapter 2 for a detailed description of how the upper and lower tertiales were determined). In line with our previous investigations, we split high/low TFEQ-R scorers based on a median split ( $\text{TFEQ-R score} > /7$ ), as using the same procedure would result in a significantly reduced testing population.



Please see Table 7.1 for participant characteristics, including BMI, NART scores, and TFEQ-R and TFEQ-D scores.

Table 7.2: *Participant Characteristics*

	Anticipation Presentation First				Control Condition First			
	<u>HDHR</u> mean $\pm$ SE <i>n</i> = 5	<u>HDLR</u> mean $\pm$ SE <i>n</i> = 5	<u>LDHR</u> mean $\pm$ SE <i>n</i> = 5	<u>LDLR</u> mean $\pm$ SE <i>n</i> = 5	<u>HDHR</u> mean $\pm$ SE <i>n</i> = 5	<u>HDLR</u> mean $\pm$ SE <i>n</i> = 5	<u>LDHR</u> mean $\pm$ SE <i>n</i> = 5	<u>LDLR</u> mean $\pm$ SE <i>n</i> = 5
TFEQ-D	11.8 $\pm$ 0.8	12.2 $\pm$ 0.8	3.1 $\pm$ 0.9	1.2 $\pm$ 0.8	12.4 $\pm$ 0.8	10.5 $\pm$ 0.9	2.7 $\pm$ 1.2	1.6 $\pm$ 0.8
TFEQ-R	17 $\pm$ 1.1	3 $\pm$ 1.2	13.5 $\pm$ 1	3.4 $\pm$ 0.9	13 $\pm$ 1.1	3 $\pm$ 0.8	13 $\pm$ 1.2	3 $\pm$ 0.8
BMI	20.8 $\pm$ 0.98	22 $\pm$ 0.9	23 $\pm$ 1.1	21 $\pm$ 0.9	24 $\pm$ 0.9	21.7 $\pm$ 1.1	24 $\pm$ 1.2	20.2 $\pm$ 0.9
NART	14.2 $\pm$ 1	15 $\pm$ 1.1	12 $\pm$ 1.7	15.4 $\pm$ 1.1	14 $\pm$ 1.3	15 $\pm$ 1.1	18 $\pm$ 1.1	14.8 $\pm$ 1

## 7.2. Materials

### 7.2.a Anticipatory Food Cues

The food items that participants were asked to select as a Reward for completion of the testing procedure were categorized based on their High/Low Fat properties in addition to Sweet/ Savoury properties. As such, a group of High Fat Savoury (HFSA), Low Fat Savoury (LFSA) and High Fat Sweet (HFSW) and Low Fat Sweet (LFSW) items were included as target rewards. The two HFSA items were 160 g of Mini Cheddars, and a large Croissant with a 30 g piece of Brie. The LFSA item was a 120 g portion of Twiggllets™.

The HFSW items were a large piece of chocolate cake with chocolate icing (350 g), a large bowl of milk chocolate and dark chocolate pieces of chocolate (each piece of chocolate was 20 mm x 20 mm, with a width of 5 mm), and the LFSW item was a large bowl of McVitie's Apple Spice cookies (200 gm of cookies).

The bowls to contain the Mini Cheddars, Crisps, and Mini Cookies were 250 mm in diameter, and 150 mm deep. The bowls were filled so that the same amount of food was perceived to be in the bowl, as opposed to using equal measurements of each of the foods, which could lead to a distorted perception of “less” or “more” of each food item.

*7.2b Liking and Wanting Computer Procedure (LWCP) (G. Finlayson, King, N., Blundell, J., 2008)*

The Liking/Wanting Computer Procedure (LWCP) was designed to assess the participants' explicit liking and wanting of food, followed immediately by a task to assess implicit wanting for the same food target stimuli, which are represented by food pictures and listed in. In the LWCP, the food cue images were selected based along two dimensions, High Fat (HF) versus Low Fat (LF) Content, and Sweet (SW) versus Savory (SA) Foods. The combination between these categories yields 4 groups: HFSA, HFSW, LFSA and LFSW. High resolution (1024 x 768) digital photographs of 20 foods were used (Table 6.2.d).

In this task, participants indicate 'liking' by rating the pleasantness of a series of foods, and next 'wanting' by engaging in a series of forced choice pairings between two foods, and the type of food that is chosen most frequently is empirically determined as the type of food most implicitly "wanted". Implicit wanting is determined by the reaction time needed to chose the preferred food within a pair trial, in addition to a second method called D", which has been shown to have greater accuracy than the simple reaction time (Greenwald, 2008). The algorithm for the second assessment of implicit wanting is computed by taking the reciprocal value of the reaction time (ie. 0- reaction time). Thus, the speed that one stimulus category is chosen (HFSW, LFSW, HFSA or LFSA) provides two quantifiable measures of implicit wanting for each food category in the procedure.

The LWCP programmed is configured for a PC, and in the current experiment the computer screen measured 17" across a flat screen monitor, so each food cue picture was 150 x 100 mm<sup>2</sup> or 120 x 80 mm<sup>2</sup> depending on whether a single item was presented (ie. during the Liking component of the test) or paired (ie. during the Wanting component). The presentation of foods was randomized in the Liking component, and also the pairing of two foods was also randomized for the Wanting component, this was achieved by an automatic programming feature on the LWCP.

Table 7.2.b: *Food cue pictures used in the LWCP*

HFSa	LFSa	HFSW	LFSW
Pork pie	Ham	Doughnut	Jelly (jello)
Chips (French Fries)	Spaghetti in sauce	Blueberry muffin	Rich tea biscuits
Sausages	Potatoes	Cream cake	Fruit salad
TUC (Biscuits)	Bread roll	Cream slice	Marshmallows
Cheddar cheese	Chicken breast	Shortbread	Jelly babies

Stimuli food pictures were presented on a 17 in. Dell PC desktop computer, and the pictures were 150x 100 mm<sup>2</sup> or 120 x 80 mm<sup>2</sup> depending whether a single or paired combination was presented. The experimental presentation of food (in random order for the ‘liking’, and in randomized combination for the forced choice measures of ‘wanting’) was programmed automatically.

#### 7.2.d.i Measurement of Liking on the LWCP

The hedonic impact of each food was determined by the rater’s responses on a 100 mm VAS scale, anchored at each end with responses of ‘not at all’ and ‘extremely’. Participants were required to indicate the pleasantness of each food stimulus on this scale by moving the mouse between the 100 mm boundaries of the VAS. Participants were asked specifically ‘How pleasant would it be to experience a mouthful of this food now?’ and the VAS were placed below each food stimulus. Once the rating had been made, a continue button moved the program to the next stimulus. Critically, the program is capable of eliminating food stimuli not normally eaten by participants from analyses. To achieve this, participants are also asked if they would ‘normally eat’ the type of food stimulus in each picture with a “yes” or “no” response, and two further VAS scales are then used to assess the ‘palatability/pleasantness’ of the food and ‘the degree to which (they) want more’ of each food. In calculating mean ‘liking’ ratings for each food category the responses for food not normally eaten were excluded.

#### 7.2.d.ii Measurement of Wanting in the LWCP

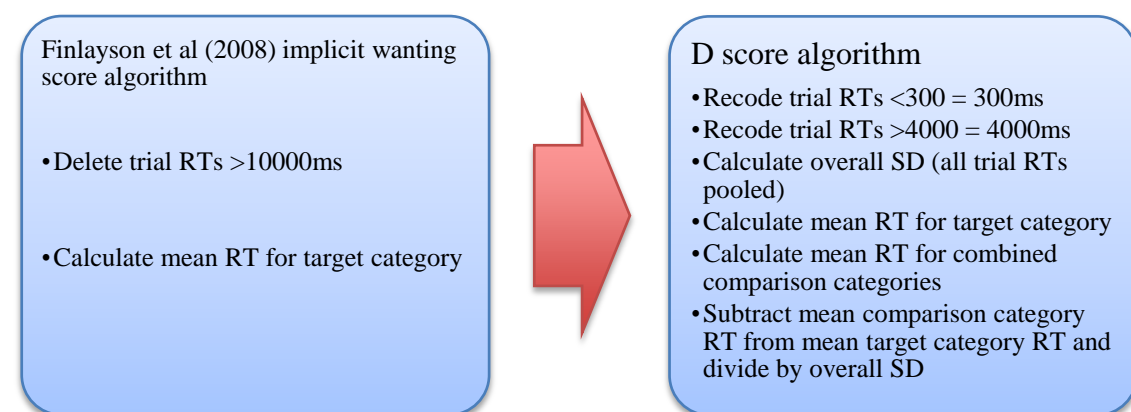
The incentive salience of each food category was assessed by a forced choice methodology, designed and executed using Superlab Pro software package (Cedrus Cor., San Pedro, CA).

In this task, a food stimulus from each of the four food categories (HDSA, HDSW, LFSA, and LFSW) was paired with a stimulus from another category to form one trial in which the subject is given the repeated instructions to choose the food they ‘would most like to eat now’. This instruction specifically avoided using the term ‘want’ in order to semantically guide the participant into understanding the experimental requirements, and experimental operationalization of the term ‘wanting’. Each choice was made via key presses on the computer keyboard, which also triggered the presentation of the next pair of stimuli until all combinations had been presented (N=150). The paradigm assesses wanting by ranking of the type of food that is repeatedly selected by the participant, relative to all other choices. Logging the frequency choices made for each food category derives an operational measure of ‘Wanting’. The higher the frequency of selections made in one category, the greater the participant ‘wants’ this food relative to the other categories.

#### 7.2.diii Comparison of Measurement of Implicit Wanting between two measures: Reaction time versus D

We have used two methods for the calculation of implicit wanting for food in the current investigation. The difference between these two measures is illustrated (Figure 6.2.d.ii), followed by a detailed description of the differences in these procedures.

*Figure 7.2.b: Comparison in Calculation Procedures for Implicit Wanting*



Initially, Finlayson (2007) used a classic method of calculating implicit wanting by calculating the Reaction Time (RT) for each of the four food categories (HFSW, HFSA, LFSW and LFSA) the assumption here is that RT is an expression of the

underlying motivations regarding what one is about to eat. The RT for each category was derived by excluding any choices that took longer than 10000 msec, and then composing an average of all RT's for each of the food categories.

Greenwald *et al.* (2003) identified several shortcomings of the classic RT model, based on their experience with the Implicit Association Test, a task that is similar to the LWCP. First, that the RT model does not account for the fact that repeat exposures to a stimulus increase RT and standard deviations.

Greenwald (2003) explored alternatives for the RT measure by compiling a large group of data from the IAT measure to compare a series of transformations and whether this enhanced detection of implicit judgments compared to the original RT measure. The transformations included mean RT, Median RT, Mean Reciprocal Transformation, Mean Log Transformation, and a final measure that is similar to Cohen's *d* for effect size, but used standard deviations from pooled treatment as opposed to within treatments, this last transformation was called the D transformation. Mean D score correcting for the differences of all trials.

The last transformation, the D transformation significantly enhanced precision by correcting contamination of average response speed and repeated testing.

The D-score is calculated as follows:

1. Calculate overall standard deviation from pooled block trials (all trials)
2. Calculate average RT for each block and calculate between block presentation means
3. Divide differences by overall standard deviation

The D-score is able to correct the differences between treatments so that they can be correlated with the variability in the data. Thus, dividing difference scores by standard deviation adjusts this underlying variability.

The D-score is now an accepted algorithm for calculating and interpreting differences in performance in the IAT.

Finlayson (2008) developed a similar measure for the LWCP, which is calculated as follows:

1. Calculation of overall standard deviations from pooled trials
2. Calculate average RT for each category (HFSW, LFSA, et al)
3. Calculate average RS for relevant comparison categories (HFSW, LFSA, et al)
4. Calculate mean differences between category mean and comparison mean
5. Divide differences by overall standard deviation
6. Calculation of D for each specific food category (HFSA, LFSW, et al)

The D measure is correlated with the original RT measure, but outperforms the RT in terms of its greater correlation with explicit liking and choice frequency measures. In the current investigation, both RT and D measures have been included to assess implicit wanting between participants.

#### *7.2.e Testing measures for Self Report Overeating and Impulsivity*

TFEQ (Stunkard & Messick, 1985)

Please see Chapter 2, section 2.2.4.a for a detailed description of the TFEQ.

MFFT (Kagan, 1964)

Please see Chapter 3, section 3.2.3.d for a detailed description of the MFFT.

Go No Go task

Please see Chapter 4, 4.2.d for the full description of the GoStop task (Dougherty, 2002) and Chapter 5, 5.2.2.c for a description of Go Stop parameters used.

BART (Lejuez, 2002)

Please see Chapter 2, section 2.2.3b for a detailed description of the BART.

Two Choice Impulsivity Paradigm (Dougherty, 2002)

The Two Choice Impulsivity Paradigm (TCIP) is used to operationalize Impulsive Choice, in essence, the preference for Small Soon (SS) rewards in place of waiting for Larger Later (LL) rewards. The TCIP task is a forced-choiced reward directed program, and assesses the tolerance for delay of reward.

In the TCIP, the participant must choose between either a short delay followed by a small reward, or a longer delay followed by a larger reward. The difference with this task compared to our original DDT measure, was that participants were required to wait in real time for the Small Soon versus Large Later reward. In this task, participants make choices between the two alternatives (SS vs. LL) by pressing the mouse to select one of two shapes, which add points to a counter after each trial. In each trial, the two shapes appear together on the screen, the TCIP program randomly generates the orientation of the SS or LL. In the TCIP, when one of the two shapes is chosen, the other shape disappears from the screen and the colour of the chosen shape fades. After the delay of either 5 seconds (Small Soon) or 15 seconds (Large Later), the selected shape resumes its colour, and begins to flash on and off (at a rate of one flash per second), and the participant clicks on the shape the second time to add its respective value to the counter. The experimenter can manipulate the length of the delay prior to finishing the game. Prior to testing, participants complete a training session, where they are able to practice the TCIP on five trials. The purpose is for the participants to experience the reward contingencies prior to actual testing.

In the current investigation, the delay between the SS and LL reward was 5 seconds versus 20 seconds. The SS had a 5-point value and the LL had a 20-point value. Participants completed 60 trials, with a 1-minute break in between each block of 30 trials, in the current trial if a person consistently selected Small Soon rewards the task took approximately 6.83 minutes, whereas if they selected Large Later Rewards the total time to complete the task was 17.43 minutes. This component made the TCIP particularly attractive, as the previous DDT was based entirely on hypothetical rewards and participants did not experience the temporal delay that is suggested to underlie this form of impulsive behavior (Cardinal, 2006; Ho, et al., 1999)

### *7.3 Procedure*

All participants were recruited to the experiment via email (Appendix 6a). The initial email explained the study was aiming to look at University students' cognitive performance, and participants were explained that they would be required to come to the University of Sussex Ingestive Behaviour Unit on two occasions, with at least 10 days between each visit. Participants were also explained that they would be reimbursed £10.00 for their time. Once participants had contacted the researcher, a

mutually convenient time was arranged to come into the laboratory, and participants were forwarded a second email that explained in greater detail the nature of the experiment and also expressed the nature of the experiment was voluntary, and participants were at liberty to discontinue with testing procedures if they felt any discomfort (please see Appendix 7b for the full consent form).

The order in which participants completed the Anticipation and Control Conditions was counterbalanced within groups, and participants were assigned to the two test orders prior to arriving at the laboratory by the experimenter. In the Anticipation condition, participants were greeted at the door, and directed to the testing cubicle. In the testing cubicle, the participant was presented with an array of pleasant tasting food stimuli, and participants were asked to select one of the items they would like to eat at the end of the experiment. It was explained that this food reward was included as compensation for completing a slightly longer testing session. Once participants had selected the Food Reward, the experimenter left the tray in the room, and participants were then asked to complete the Liking and wanting program. The program has explicit instructions regarding completion of the task, but the experimenter gave a brief synopsis of the task. The experimenter left the cubicle, and the participant was left to complete the program in silence. Once the participant had completed the LWCP, and notified the experimenter, the experimenter removed the tray of food stimuli, and set up the battery of Impulsivity tasks. The participant completed each of the BART, Go No Go, TCIP, and MFFT. Once all of these tasks had been completed, the participant notified the experimenter who was in a separate cubicle close by. The experimenter and participant arranged a mutually convenient time for the second testing session (providing at least a ten day break in between sessions), and the participant was given a reward of a small bag of Cadbury Buttons instead of the actual reward selected. This was included for practical reasons, as keeping a supply of the variety of food presented to participants in the initial “Snack Selection” component of the investigation was impractically expensive.

In the Control Condition, the participant was greeted at the laboratory door by the experimenter, and led into a cubicle that was free of food stimuli. The participant was instructed to sit at the desk inside the cubicle, and was required to complete the NART (see Section 6.2.2.bi). It was explained to the participant that the NART is



simply a basic measure of assessing reading level. Participants read each of the words out loud, and the experimenter kept record of errors. Once the NART had been completed the participant was asked to complete the battery of Impulsivity tasks (the BART, Go No Go, TCIP, and MFFT).

Once both conditions had been completed, the participant was weighed, debriefed, thanked, and paid £10.

## **7.4 Results**

All impulsivity test results were calculated based on the F-score ratios of a mixed 3 way ANOVA analysis using impulsivity scores from each of the four impulsivity tests (MFFT, Go No Go, BART, and finally the TCIP). In order to control for the effect of the condition allocation, the Experimental Condition (Anticipation versus Control) was analyzed as a within subjects factor, and classification as high or low TFEQ-D and TFEQ-R scores were analysed as between-subjects factors.

### *7.4.1 Differences in Explicit and Implicit Liking and Wanting between TFEQ groups*

Data from the LWCP were used to calculate mean ratings of explicit liking, explicit wanting, implicit wanting (choice reaction time, in addition to the  $d'$  which calculates the relative frequency of choice so is included as a second measure of implicit wanting). These data are shown in Table 7.4.

Table 7.4.1 : Mean ratings on the LWCP for food categories between TFEQ groups

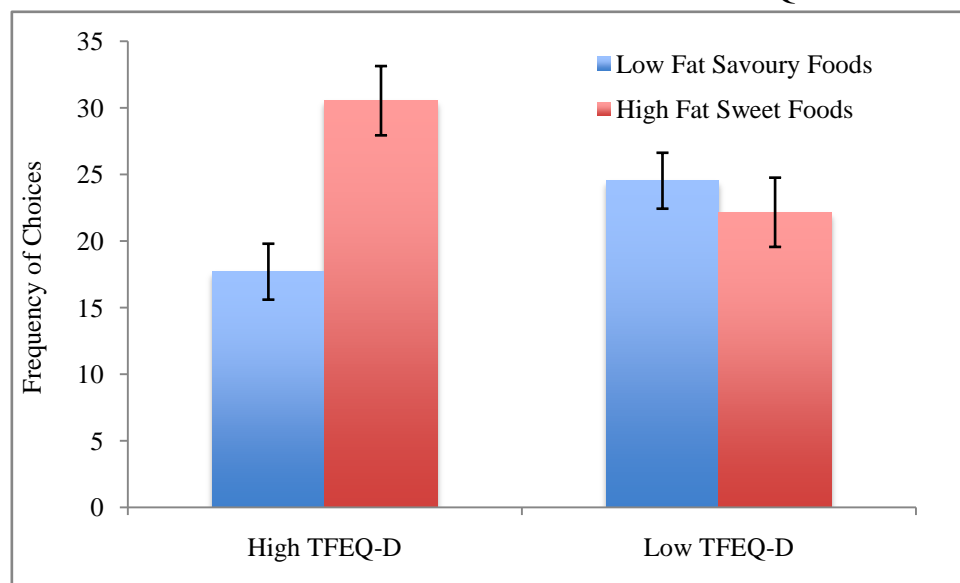
	<b>HDHR</b> n=10 Mean $\pm$ SE	<b>HDLR</b> n=10 Mean $\pm$ SE	<b>LDHR</b> n=10 Mean $\pm$ SE	<b>LDLR</b> n=10 Mean $\pm$ SE
<b>Relative Preference</b>				
Low Fat Sweet	22.18 $\pm$ 2.99	25.67 $\pm$ 3.31	27.56 $\pm$ 3.31	24.27 $\pm$ 3.00
Low Fat Savoury	18.81 $\pm$ 2.88	16.55 $\pm$ 3.82	26.22 $\pm$ 3.18	22.82 $\pm$ 2.88
High Fat Savoury	28.72 $\pm$ 3.51	32.33 $\pm$ 3.88	21.11 $\pm$ 3.88	23.18 $\pm$ 3.51
Low Fat Sweet	26.27 $\pm$ 2.70	21.44 $\pm$ 2.98	21.11 $\pm$ 2.98	25.73 $\pm$ 2.69
<b>Implicit Wanting: Reaction Time of Choice</b>				
			993.90 $\pm$	
Low Fat Sweet	1147 $\pm$ 102	957 $\pm$ 113.85	113.85	1129 $\pm$ 108.01
Low Fat Savoury	1189 $\pm$ 95.22	1066 $\pm$ 105.27	997 $\pm$ 105.27	1131 $\pm$ 99.87
	1086.00 $\pm$		1114.3 $\pm$	1149.3 $\pm$
High Fat Savoury	104.11	883.70 $\pm$ 15.10	115.10	109.19
			931.80 $\pm$	
Low Fat Sweet	1036.20 $\pm$ 92.5	901.01 $\pm$ 102.33	102.33	1077 $\pm$ 97.08
<b>Implicit Wanting: Transformed Reaction Time (d'')</b>				
High Fat Sweet	0.041 $\pm$ 0.14	0.005 $\pm$ 0.16	(0.08) $\pm$ 0.16	(0.01) $\pm$ 0.15
Low Fat Savoury	0.28 $\pm$ 0.16	0.34 $\pm$ 0.17	(0.008) $\pm$ 0.17	(0.01) $\pm$ 0.16
High Fat Savoury	(0.15) $\pm$ 0.17	(0.18) $\pm$ 0.19	0.32 $\pm$ 0.19	0.09 $\pm$ 0.19
Low Fat Sweet	(0.18) $\pm$ 0.12	(0.16) $\pm$ 0.13	(0.24) $\pm$ 0.13	(0.21) $\pm$ 0.13
<b>Explicit Liking: VAS Pleasantness</b>				
High Fat Savoury	41.84 $\pm$ 6.42	53.06 $\pm$ 7.10	42.25 $\pm$ 7.10	39.05 $\pm$ 6.42
Low Fat Savoury	37.84 $\pm$ 5.36	41.44 $\pm$ 5.93	44.06 $\pm$ 5.93	31.32 $\pm$ 5.36
High Fat Sweet	51.89 $\pm$ 6.28	66.67 $\pm$ 6.95	34.86 $\pm$ 6.94	45.71 $\pm$ 6.28
Low Fat Sweet	48.48 $\pm$ 5.09	49.67 $\pm$ 5.63	41.83 $\pm$ 5.63	45.43 $\pm$ 5.09
<b>Explicit Wanting: VAS "Wanting"</b>				
High Fat Savoury	39.47 $\pm$ 6.92	45.25 $\pm$ 7.65	39.31 $\pm$ 7.65	38.5 $\pm$ 6.92
Low Fat Savoury	38.71 $\pm$ 6.15	36.89 $\pm$ 6.79	41.53 $\pm$ 6.79	32.84 $\pm$ 6.15
High Fat Sweet	47.61 $\pm$ 6.28	60.75 $\pm$ 6.94	28.75 $\pm$ 6.94	39.09 $\pm$ 6.28
Low Fat Sweet	45.11 $\pm$ 5.28	44.50 $\pm$ 5.83	40.33 $\pm$ 5.83	39.34 $\pm$ 5.28

## 7.4.1a Relative Preference

As shown in Table 7.4, the Relative Preference of food category was rated uniquely by each TFEQ group. There was a significant difference between high and low TFEQ-D groups with respect to preference for Low Fat Savoury Foods ( $F(1, 39)=5.06, p=0.03$ ) as participants with low TFEQ-D scores had indicated a greater preference for foods in the LFSA condition ( $m=243$ ) compared to those participants with high TFEQ-D scores ( $m=178$ ).

Another significant difference between high versus low TFEQ-D groups can be found in terms of relative preference for High Fat Sweet Foods (HFSW) ( $F(1, 39)= 5.14$ ,  $p=0.03$ ), high TFEQ-D participants had a greater number of relative preference choices for HFSW ( $m=303$ ) compared to low TFEQ-D participants ( $m=223$ ). There were no significant differences in terms of relative choice of food groups between the two TFEQ-R groups, nor was there any interaction between TFEQ-D and TFEQ-R groups, indicating that TFEQ-D is a strong indicator of relative preference in terms of Low Fat Savoury and High Fat Sweet foods.

*Figure 7.4.1a: Outcome of Analysis of Variance (ANOVA) on the frequency of choices measure for HFSW vs. LFSA between the two TFEQ-D classifications*



#### 7.4.1b: Explicit Liking VAS pleasantness ratings

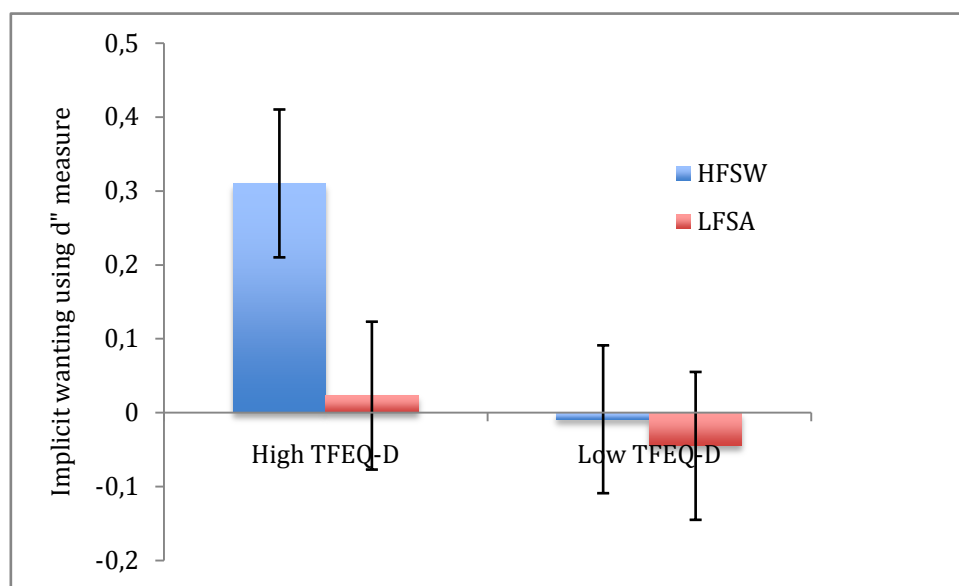
As shown in Table 6.4 explicit liking ratings for High Fat Sweet Foods (HFSW) were higher for those individuals with high TFEQ-D scores ( $m= 585$  mm) than with low TFEQ-D scores ( $m=400$ ) and this was significant ( $F(1, 39)= 8.22$ ,  $p=0.007$ ). The difference between high and low TFEQ-R groups approached significance ( $F(1, 39)= 3.74$ ,  $p=0.06$ ) as participants with high TFEQ-R scores rated High Fat Sweet foods as less pleasant ( $m= 442$  mm) compared to low TFEQ-R participants ( $m=551$  mm).

#### 7.4.1c Implicit Wanting: Choice Reaction Time and $d'$

Mean reaction times calculated to determine the degree a participant implicitly wanted a food showed did not reveal any differences between TFEQ-D, TFEQ-R or

interactions between the two categories. However, using a second measure the  $d''$  we found that high TFEQ-D participants implicitly wanted HFSW foods more than low TFEQ-D participants, and this was significant ( $F(1, 39)= 3.91, p=0.05$ ). We also observed those low TFEQ-D participants implicitly wanted LFSA foods more than high TFEQ-D participants, a pattern that approached significance ( $F(1, 39)= 3.76, p=0.06$ ).

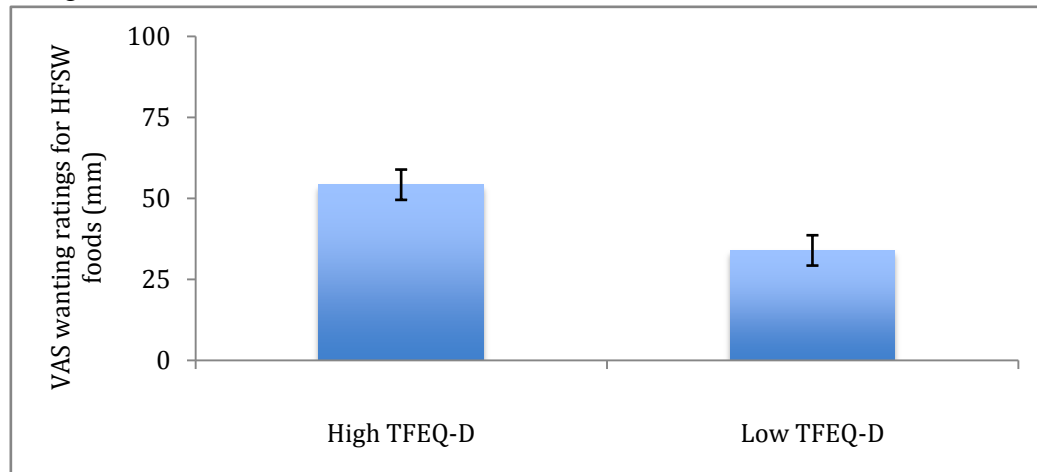
*Figure 7.4.1b: Outcome of Analysis of Variance (ANOVA) on the  $D''$  measure for implicit wanting between the two TFEQ classifications and Anticipation Condition*



#### 7.4.1.d Explicit Wanting using VAS wanting ratings

Mean VAS wanting ratings were calculated, and in line with the greater part of these findings we found high TFEQ-D participants indicated a greater level of explicit wanting for HFSW foods compared to low TFEQ-D participant, and this was significant ( $F(1, 39)= 9.37, p \leq 0.01$ ). In contrast to our other findings with regard to low TFEQ-D participants and preference for LFSA foods, we did not find a significant difference between high and low TFEQ-D groups on this measure. There were no significant differences between TFEQ-R groups, nor were there any differences between the four subcategories of the TFEQ groups.

Figure 7.4.1.c: Outcome of Analysis of Variance (ANOVA) on the VAS-wanting ratings for HFSW foods between the two TFEQ-D classifications



#### 7.4.2 Impulsivity Performance

##### 7.4.2.a MFFT

Table 7.4.2 a: Descriptive statistics (mean and standard error) for performance on the MFFT between the two TFEQ classifications and anticipation condition

	Anticipation Condition				Control Condition			
	<u>HDHR</u>	<u>HDLR</u>	<u>LDHR</u>	<u>LDLR</u>	<u>HDHR</u>	<u>HDLR</u>	<u>LDHR</u>	<u>LDLR</u>
	mean ± SE n= 10	mean ± SE n= 10	mean ± SE n= 10	mean ± SE n= 10	mean ± SE n= 10	mean ± SE n= 10	mean ± SE n= 10	mean ± SE n= 10
time (msec)	1987 ± 544	2504 ± 570	2213 ± 570	1998 ± 570	1951 ± 308	1907 ± 323	2312 ± 323	2160 ± 323
errors	7.27 ± 1.22	9.6 ± 1.3	3.3 ± 1.3	4.7 ± 1.3	7.36 ± 0.9	7 ± 1	2.1 ± 1	5.6 ± 1
i-score	0.33 ± 0.5	0.54 ± 0.5	(0.7) ± 0.5	(0.2) ± 0.5	0.6 ± 0.5	0.6 ± 0.5	(1.2) ± 0.5	(0.07)± 0.5

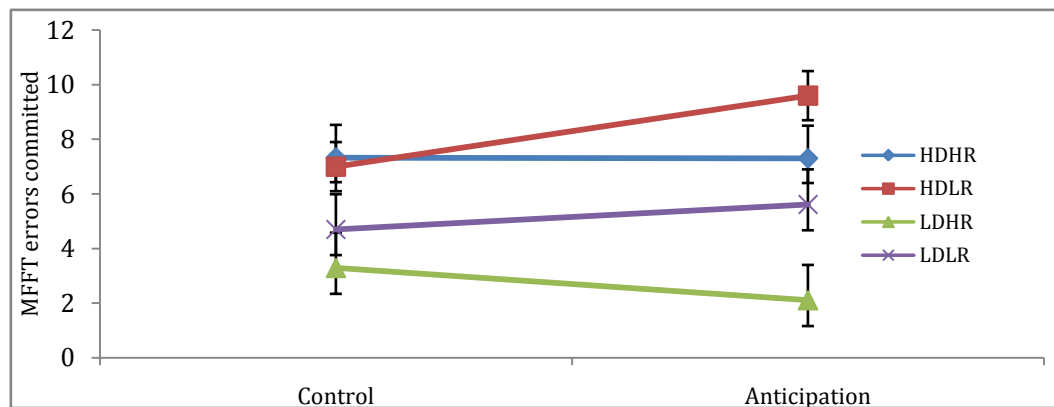
Table 7.4.2.b: *Outcome of Analysis of Variance (ANOVA) on the MFFT between the two TFEQ classifications and Anticipation Condition*

	MFFT Performance		
	time (msec)	errors	<i>i</i> -score
Main Effect TFEQ-D (between subjects variable)	(F(1, 37)= 0.06, <i>ns</i> )	<b>(F(1, 37)= 15.68, <math>p \leq 0.001</math>)</b>	<b>(F(1, 37)= 7.80, <math>p=0.008</math>)</b>
Main Effect TFEQ-R (between subjects variable)	(F(1, 37)= 0.006, <i>ns</i> )	(F(1, 37)= 3.35, $p= 0.075$ )	(F(1, 37)= 1.26, $p=.26$ )
Main Effect Anticipation (within subjects variable)	(F(1, 37)= 0.11, <i>ns</i> )	(F(1, 37)= 1.35, $p= 0.25$ )	<b>(F(1, 37)= 8.31, <math>p=0.007</math>)</b>
TFEQ-D x TFEQ-R interaction (between subjects effects)	(F(1, 37)= 0.35, <i>ns</i> )	(F(1, 37)= 0.61, <i>ns</i> )	(F(1, 37)= 0.852, <i>ns</i> )
TFEQ-D x Anticipation (mixed ANOVA)	(F(1, 37)= 0.6, <i>ns</i> )	(F(1, 37)= 0.84, <i>ns</i> )	(F(1, 37)= 0.38, <i>ns</i> )
TFEQ-R x Anticipation (mixed ANOVA)	(F(1, 37)= 0.19, <i>ns</i> )	(F(1, 37)= 0.06, <i>ns</i> )	(F(1, 37)= 0.14, <i>ns</i> )
TFEQ-D x TFEQ- R x Anticipation (mixed ANOVA)	(F(1, 37)= 0.3, <i>ns</i> )	<b>(F(1, 37)= 3.94, <math>p \leq 0.05</math>)</b>	(F(1, 37)= 0.72, <i>ns</i> )

Table 7.4.2.a provides all means and standard errors for MFFT performance between each of the four TFEQ subgroups (HDHR, HDLR, LDHR, and LDLR). Table 7.4.2.b summarizes the ANOVA results for MFFT total errors, total time, and the *i*-score, which quantifies reflective impulsivity, and is calculated based on the standardized scores of the time and error variables (Salkind, 1980; Salkind & Wright, 1977, please see Chapter 3 section 3.2.3.d for a full brief of this equation).

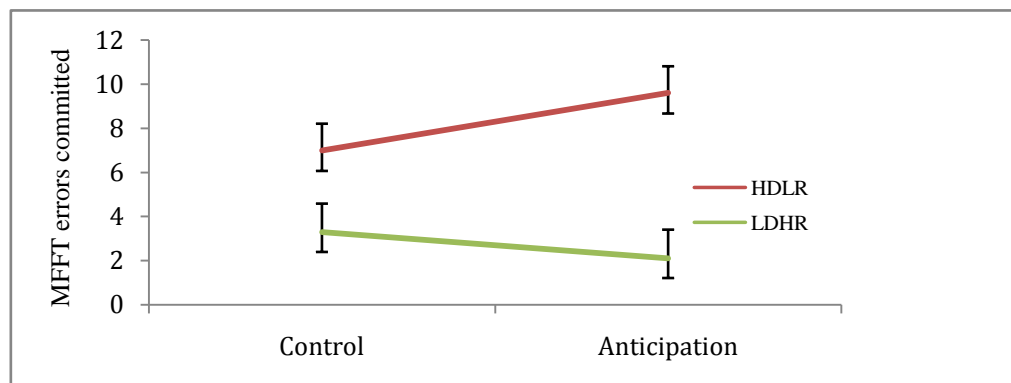
There were several significant findings with the Total Errors variable on the MFFT, there was a significant main effect of TFEQ-D classification: those participants with high TFEQ-D scores made more errors ( $m= 7.8$ ,  $SE= 0.66$ ,  $p \leq 0.05$ ) than those with low TFEQ-D scores ( $m= 3.92$ ,  $SE= 0.67$ ,  $p \leq 0.05$ ). Although there were no significant main effect of TFEQ-R classification, or interactions between either of the TFEQ-D groups with the Anticipation/ Control Condition, there was a significant three-way interaction between TFEQ Disinhibition and Restraint conditions and the Anticipation versus Control Condition (Figure 7.4.2.a).

Figure 7.4.2.a: MFFT errors committed between TFEQ group and Anticipatory vs. Control Condition



To help interpret this complex result, a one way mixed ANOVA was run with TFEQ groups as the between subjects variable, and Condition a within subjects variable in order to determine where the significant group differences in MFFT errors was found. Using this technique, there was a significant main effect of TFEQ-D group ( $F(3, 36) = 6.78, p = 0.001$ ) although there was no effect of condition ( $F(1, 36) = 1.42, ns$ ). Post hoc comparisons using a Bonferoni correction reveal that the difference in MFFT errors committed between the HDHR and LDHR group was significant ( $p = 0.001$ ), in addition to the difference between the LDLR and LDHR was also significant ( $p = 0.08$ ), the largest difference was found between the HDLR and LDHR group ( $p = 0.0001$ ) (Figure 7.4.2b).

Figure 7.4.2.b: MFFT errors committed between HDLR and LDHR group



#### 7.4.2 MFFT i-score

The *i*-score measure was calculated in order to assess the degree of Reflective Impulsivity in each of the four TFEQ groups. There was a significant main effect of TFEQ-D condition, those participants with high TFEQ-D scores showed greater impulsivity ( $m = .52$ ,  $SE = 0.26$ ,  $p \leq 0.05$ ), than those with low TFEQ-D scores ( $m = -0.54$ ,  $SE = 0.25$ ,  $p \leq 0.05$ ). Interestingly, there was also a main effect of Condition, and all participants performed more impulsively in the Anticipation Condition ( $m = -0.009$ ,  $SE = 0.23$ ,  $p \leq 0.05$ ), compared to the Control Condition ( $m = -0.015$ ,  $SE = 0.23$ ,  $p \leq 0.05$ ).

Contrary to predictions, there were no significant interactions between the TFEQ groups and the Anticipation/Control conditions, nor was there a significant three way interaction between the three variables.

#### 7.4.3 Go No Go Performance

Performance on the Go No was analyzed in the same format as the MFFT, with performance on each of the two blocks of trials for the Go No Go analyzed separately. Impulsivity on the Go No Go was defined by the amount of time a participant took to reach a 50% inhibition rate on the presentation of Go, versus No Go trials. This value was determined empirically by the participants' performance on the task, which was adjusted by 25 msec intervals; if a participant inhibited their responses appropriately on the task, the duration of the next presentation of a Go/ No Go stimulus was reduced by 25 msec, increasing the difficulty. In this task, longer stopping times reflect greater impulsivity. Table 7.4.3.a reports mean differences in performance, and Table 7.4.3.b reports significant differences between the TFEQ groups, and performance within the Anticipation and Control Conditions.

Table 7.4.3.a: *Descriptive statistics (mean and standard error) for performance on the Go No Go between the two TFEQ classifications and anticipation condition*

	Anticipation Condition				Control Condition			
	HDHR	HDLR	LDHR	LDLR	HDHR	HDLR	LDHR	LDLR
	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE
	$n = 10$	$n = 10$	$n = 10$	$n = 10$	$n = 10$	$n = 10$	$n = 10$	$n = 10$
Block 1	420 $\pm$ 42	395 $\pm$ 44.7	388 $\pm$ 44.7	359 $\pm$ 44.7	476 $\pm$ 43.4	376 $\pm$ 45.5	310 $\pm$ 45.5	322 $\pm$ 45.5
Block 2	632 $\pm$ 59	590 $\pm$ 62.3	608 $\pm$ 62.3	538 $\pm$ 62.3	618 $\pm$ 45.9	508.9 $\pm$ 48.1	550 $\pm$ 48.1	491.6 $\pm$ 48.1



*Table 7.4.3.b: Outcome of ANOVA of performance on the Go No Go task between the two TFEQ classifications and Anticipation condition*

Go No Go Performance		
	Block 1	Block 2
Main Effect TFEQ-D (between subjects variable)	<b>(F(1, 37)= 5.75, p=0.02)</b>	(F(1, 37)= 0.82, ns)
Main Effect TFEQ-R (between subjects variable)	(F(1, 37)= 1.18, p=0.28)	(F(1, 37)= 2.49, p=0.12)
Main Effect Anticipation (within subjects variable)	<b>(F(1, 37)= 8.67, p=0.006)</b>	(F(1, 37)= 2.43, p=0.13)
TFEQ-D x TFEQ-R interaction (between subjects effects)	(F(1, 37)= 0.66, ns)	(F(1, 37)= 0.9, ns)
TFEQ-D x Anticipation (mixed ANOVA)	(F(1, 37)= 1.55, p=0.22)	(F(1, 37)= 0.005, ns)
TFEQ-R x Anticipation (mixed ANOVA)	(F(1, 37)= 0.03, ns)	(F(1, 37)= 0.176, ns)
TFEQ-D x TFEQ- R x Anticipation (mixed ANOVA)	(F(1, 37)= 0.66, ns)	(F(1, 37)= 0.37, ns)

There was a significant main effect of TFEQ disinhibition classification on performance on the first block of the Go-No-Go task; those participants with high TFEQ-D scores required more time to accurately control prepotent responses ( $m = 419$  msec,  $SE = 21.5$ ,  $p \leq 0.05$ ) compared to those participants with low TFEQ-D scores ( $m = 345$  msec,  $SE = 22.0$ ,  $p \leq 0.05$ ) ( $F(1, 37) = 5.75$ ,  $p = 0.02$ ). There was also a main effect of Anticipation Condition; all participants performed more impulsively in the Anticipation Condition ( $m = 390$  msec,  $SE = 21.3$ ,  $p \leq 0.05$ ) compared to the Control Condition ( $m = 373$  msec,  $SE = 21.0$ ,  $p \leq 0.05$ ).

Contrary to our predictions, and previous data, there was no significant main effect of TFEQ-R, and there were no interactions between the three variables. In the second block of trials, there were no significant main effects or interactions between any of

the independent variables. This may be interpreted as a sign of exhaustion or a ceiling effect of the current Go No Go settings, which is explored at a greater length in the General Discussion (section 7.5).

#### 7.4.4 BART Total Explosions and Adjusted Average Pumps

There were several main effects and interactions using the BART measure. Table 7.4.4.a reports descriptive statistics with respect to BART in terms of performance on the Total Explosions, and Adjusted Average pumps. Table 7.4.4.b reports significant differences in performance between each of the TFEQ groups within the Anticipation and Control Conditions.

*Table 7.4.4.a:* Descriptive statistics (mean and standard error) of performance on the BART task between the two TFEQ classifications and Anticipation condition

	Anticipation Condition				Control Condition			
	<u>HDHR</u>	<u>HDLR</u>	<u>LDHR</u>	<u>LDLR</u>	<u>HDHR</u>	<u>HDLR</u>	<u>LDHR</u>	<u>LDLR</u>
	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE
	<i>n</i> = 10	<i>n</i> = 10	<i>n</i> = 10	<i>n</i> = 10	<i>n</i> = 10	<i>n</i> = 10	<i>n</i> = 10	<i>n</i> = 10
Explosions	7.9 $\pm$ 1.0	9.7 $\pm$ 1	7.6 $\pm$ 1	7.1 $\pm$ 1	9.23 $\pm$ 1	10.7 $\pm$ 1.1	8.4 $\pm$ 1.1	6 $\pm$ 1.1
Adjusted average pumps	39.9 $\pm$ 2.9	41.0 $\pm$ 3.1	32.0 $\pm$ 3.25	32.6 $\pm$ 3.1	36.9 $\pm$ 3	44.1 $\pm$ 3.1	40.0 $\pm$ 3.3	30.6 $\pm$ 3.1

*Table 7.4.3.b:* Outcome of ANOVA of performance on the BART between the two TFEQ conditions and Anticipation condition

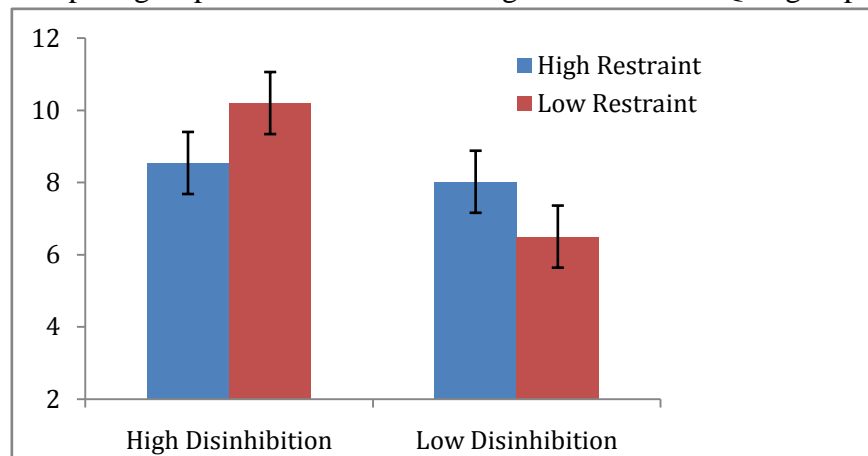
	BART Performance	
	BART explosions	BART adjusted average pumps
Main Effect TFEQ-D (between subjects variable)	<b>(F(1, 37)= 5.49, p= 0.025)</b>	<b>(F(1, 37)= 0.026, p= 0.026)</b>
Main Effect TFEQ-R (between subjects variable)	(F(1, 37)= 0.008, <i>ns</i> )	(F(1, 37)= 0.94, <i>ns</i> )
Main Effect Anticipation (within subjects variable)	<b>(F(1, 37)= 9.08, p=0.005)</b>	(F(1, 37)= 0.77, <i>ns</i> )
TFEQ-D x TFEQ-R interaction (between subjects effects)	<b>(F(1, 37)= 3.08, p= 0.08)</b>	(F(1, 37)= 2.35, <i>p</i> = 0.13)
TFEQ-D x Anticipation (mixed ANOVA)	(F(1, 37)= 1.45, <i>p</i> = 0.25)	(F(1, 37)= 0.75, <i>ns</i> )
TFEQ-R x Anticipation (mixed ANOVA)	(F(1, 37)= 1.05, <i>p</i> =0.23)	(F(1, 37)= 0.22, <i>ns</i> )
TFEQ-D x TFEQ- R x Anticipation (mixed ANOVA)	(F(1, 37)= 0.64, <i>ns</i> )	<b>(F(1, 37)= 8.33, p=0.007)</b>

There was a significant main effect of TFEQ-D condition, those participants with high TFEQ-D scores had more explosions on the BART ( $m = 9.38$ ,  $SE = 0.62$ ,  $p \leq 0.05$ ) than those participants with low TFEQ-D scores ( $m = 7.29$ ,  $SE = 0.64$ ,  $p \leq 0.05$ ). This finding was complimented by a significant main effect of TFEQ-D condition on the Adjusted Average Pumps; again the high TFEQ-D participants acted more impulsively since they pumped up the balloons more (thereby increasing propensity for explosions:  $m = 40.5$ ,  $SE = 1.9$ ,  $p \leq 0.05$ ) compared to those with low TFEQ-D scores ( $m = 33.0$ ,  $SE = 2.0$ ,  $p \leq 0.05$ ).

There was also a significant main effect of Anticipation condition on both the number of balloon explosions and adjusted average pumps: in the Anticipations Condition, interestingly, participants had fewer balloon explosions ( $m = 8$  explosions,  $SE = 0.6$ ,  $p \leq 0.05$ ) compared to the Control Condition ( $m = 8.8$  explosions,  $SE = 0.6$ ). These data are complimented by the Adjusted Average Pumps data, which showed that participants also pumped the balloons more (on average) in the Anticipation Condition ( $m = 36.0$  pumps,  $SE = 1.6$ ,  $p \leq 0.05$ ) compared to the Control Condition ( $m = 38$  pumps,  $SE = 1.5$ ,  $p \leq 0.05$ ) ( $F(1, 37) = 9.08$ ,  $p = 0.005$ ).

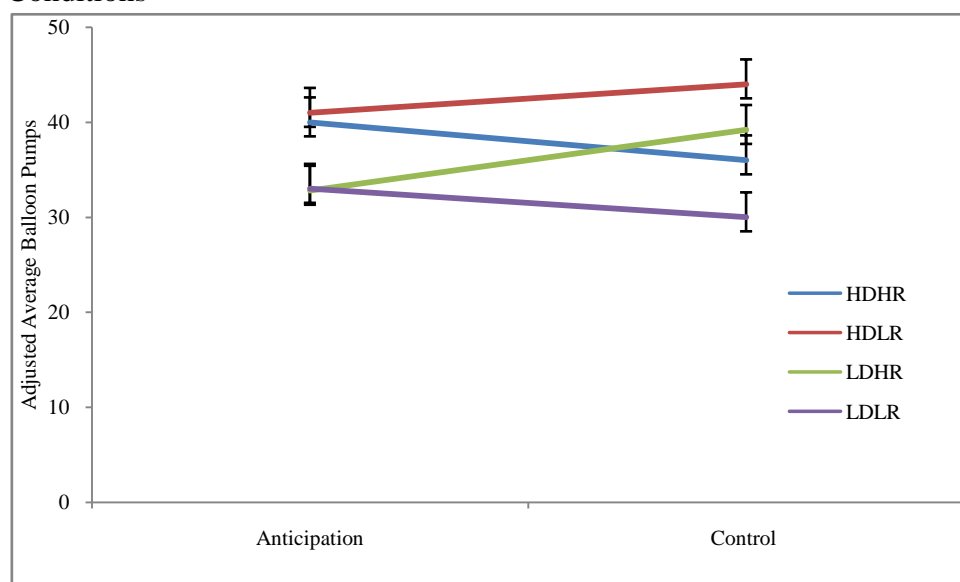
Although there was no significant main effect of TFEQ-R, the interaction between TFEQ-D and TFEQ-R classification approached significance ( $F(1, 37) = 3.08$ ,  $p = 0.08$ ) for the number of explosions. Those participants in the HDHR group scored lower ( $m = 8.54$  explosions,  $SE = 0.86$ ) than did HDLR participants ( $m = 10.2$  explosions,  $SE = 0.9$ ). The effect of a high TFEQ-R classification had the opposite influence on the low TFEQ-D group; the LDHR participants had more balloon explosions ( $m = 8.02$  explosions,  $SE = 0.86$ ) compared to the LDLR group ( $m = 6.57$  explosions,  $SE = 0.9$ ) (Figure 7.4.3.i).

*Figure 7.4.4.a:* Performance on the BART between the Four TFEQ Groups: Comparing Explosions between the High and Low TFEQ-D groups



Finally, the three-way interaction between the TFEQ groups and Condition was not significant for balloon explosions, however, using the Adjusted Average Pumps, a significant three way interaction between TFEQ groups and Anticipatory Condition was found ( $F(1, 37) = 8.33, p = 0.007$ ) (Figure 7.4.4.b).

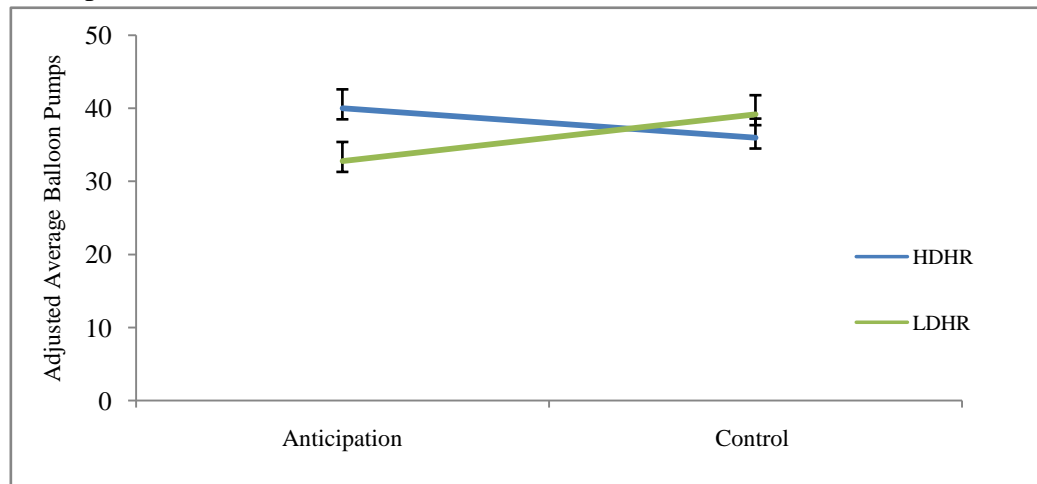
*Figure 7.4.4.b:* Adjusted Average Pumps on the BART measure, comparing performance between TFEQ groups and performance within Anticipation vs. Control Conditions



Post hoc analysis with a Bonferroni correction indicated the only significant interaction occurred between the HDHR group and LDHR group (Figure 7.4.4.b). The

pattern of impulsivity on the BART Adjusted Pumps shows that HDLR group became more impulsive in the Anticipation Condition ( $m= 39.9$ ,  $SE= 2.9$ ,  $p=0.05$ ) relative to control ( $m=36.9$ ,  $SE= 3.0$ ,  $p=0.05$ ) whereas the opposite occurred for the LDHR group who were more impulsive in the Control Condition ( $m=39.9$ ,  $SE= 3.3$ ,  $p= 0.05$ ) than in the Anticipation condition ( $m=32.0$ ,  $SE= 3.3$ ,  $p=0.05$ ) (Figure 7.4.4.c).

*Figure 7.4.4.c: HDHR and LDHR groups and BART performance within Anticipation and Control Condition*



#### 7.4.5 TCIP

The TCIP was selected to measure Impulsive Choice as an alternative to the DDT. Our inability to differentiate between the TFEQ groups using the DDT was replicated with the TCIP adaptation. In the current investigation, there were no significant main effect of TFEQ-D group ( $F(1, 37)= 1.59$ ,  $p= 0.22$ ), TFEQ-R group ( $F(1, 37)= 1.21$ ,  $p=0.28$ ), nor was there a significant difference between Anticipation or Control condition ( $F(1, 37)= 0.25$ , *ns*). There were no significant interactions between TFEQ-D and TFEQ-R groups ( $F(1, 37)= 0.06$ , *ns*), Condition and TFEQ-D group ( $F(1, 37)= 1.46$ ,  $p=0.24$ ), Condition and TFEQ-R group ( $F(1, 37)= 0.046$ , *ns*), and finally there was no significant three-way interaction between TFEQ-D and TFEQ-R classification with Anticipation versus Control Condition ( $F(1, 37)= 2.27$ ,  $p=0.14$ ).

Table 7.4.5.a: *Descriptive statistics for performance on the TCIP (points earned) between two TFEQ classification and anticipation condition*

	Anticipation Condition				Control Condition			
	<u>HDHR</u>	<u>HDLR</u>	<u>LDHR</u>	<u>LDLR</u>	<u>HDHR</u>	<u>HDLR</u>	<u>LDHR</u>	<u>LDLR</u>
	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE	mean $\pm$ SE
	n= 10	n= 10	n= 10	n= 10	n= 10	n= 10	n= 10	n= 10
Total	1105 $\pm$	1074 $\pm$	1252 $\pm$	982.2 $\pm$	1162 $\pm$	877.2 $\pm$	1250 $\pm$	1322 $\pm$
Points	113.9	125.9	133.5	125.9	160.8	177.8	188.6	177.8

Table 7.4.5.b: *Outcome of analysis of variance of performance on the TCIP between the two TFEQ classifications and Anticipation condition.*

	Total Points
Main Effect TFEQ-D (between subjects variable)	(F(1, 37)= 1.59, p= 0.22)
Main Effect TFEQ-R (between subjects variable)	(F(1, 37)= 1.21, p=0.28)
Main Effect Anticipation (within subjects variable)	(F(1, 37)= 0.25, <i>ns</i> )
TFEQ-D x TFEQ-R interaction (between subjects effects)	(F(1, 37)= 0.06, <i>ns</i> )
TFEQ-D x Anticipation (mixed ANOVA)	(F(1, 37)= 1.46, p=0.24)
TFEQ-R x Anticipation (mixed ANOVA)	(F(1, 37)= 0.046, <i>ns</i> )
TFEQ-D x TFEQ- R x Anticipation (mixed ANOVA)	(F(1, 37)= 2.27, p=0.14)

## 7.5 Discussion:

The present investigation offers three key findings that assist the understanding of overeating behavior. First, data from Experiment 6 clarified the influential role appetitive food cues have on those participants who self report overeating (high TFEQ-D scorers). Second, with respect to individual differences associated with high TFEQ-D scores, this final experiment demonstrated that high TFEQ-D scorers have greater implicit wanting for High Fat Sweet foods. Finally, Experiment 6 showed that high TFEQ-D scorers become significantly more impulsive on both the MFFT and BART measures in the presence of appetitive food cues. Taken together, these findings demonstrate how high TFEQ-D scorers' greater sensitivity to environmental

factors, i.e. appetitive food cues, could contribute to a chain of behaviour linked with overeating..

Individuals may be consciously aware of the choice to engage in eating, however they may also be equally unaware of the implicit process that determine appetite. The data in this experiment demonstrated individuals who self-report overeating (high TFEQ-D scorers) were more likely to implicitly *want* high fat sweet foods, and critically were also more impulsive in the presence of anticipatory food cues. It is unlikely participants with high TFEQ-D scores were aware that their implicit desire for HED food was any different from that in a person with a low TFEQ-D score, or more importantly still, that increased impulsivity was contingent upon the presence of appetitive food stimuli. Thus, the data from the previous experiment illustrates that high TFEQ-D scores indicate the increased vulnerability to anticipatory cues for eating.

In the current experiment, high TFEQ-D scorers became significantly more impulsive in the presence of food cues, but critically there was a difference between the two components of the high TFEQ-D groups, the HDHR and HDLR, and their subsequent expression of impulsivity in the presence of appetitive food cues. The HDHR participants were more impulsive on the BART, and HDLR were more impulsive on the MFFT. Differentiating between subtypes of impulsivity and associated measurements of impulsivity has been a central component of this thesis (please see General Introduction section 1.2.3, 1.2.3a, 1.2.3b); the dissociation between the two high TFEQ-D groups along the axis of Reward Reactive versus Inhibition impulsivity, offers further insight into the underlying motivation for selection of High Energy Dense, pleasant tasting foods.

The previous investigation included a novel method of detecting both explicit and implicit motivations for eating, the use of the LWCP afforded precise observation and classification of the factors related to the high TFEQ-D scorers' predilection for High Fat, Sweet food items. One of the clearest dissociations in this investigation was the relative preference, i.e. explicit choices for HFSW between high TFEQ-D groups (please see Table 7.2 for a list of the foods) versus low TFEQ-D participants' preference for LFSA . The types of foods on the HFSW versus LFSA lists, reveal yet

another interesting pattern: LFSA are eaten at specific meal times (for example, pasta and sauce, ham, chicken breast) whereas the HFSW (unsurprisingly) are mainly dessert or snack type items. Not only does this finding capture a difference in food preferences, but and perhaps addresses a broader category of issues related to lifestyle choices between the two groups: high TFEQ-D participants may be more prone to snacking and eating in between meals, versus low TFEQ-D participants who may be better at restricting eating to specific meal times. This observation offers another insight into habits and behaviours that contribute to overeating and weight gain in TFEQ-D participants. These results underscore the position that individuals who self report overeating have a marked preference for HFSW foods which is a pattern, especially for women, that is linked with the development of overweight (Macdiarmid JJ, 1998).

Critically, the high TFEQ-D group had significantly higher Implicit Wanting ratings for HFSW foods, whereas there were no differences in implicit wanting for any food group with the low TFEQ group. This finding suggests conveys the idea that the high TFEQ-D group is in a different motivational state to obtain the HFSW types of foods. Taken together, the liking and wanting data provide a model for understanding differences in eating behavior between high and low TFEQ-D participants' eating behavior; not only does the high TFEQ-D group like HFSW foods, but they *want* it more, critically, the difference in motivational state reported by the high TFEQ-D women is directed towards a group of foods that (arguably) lead to greater hunger (Green SM, 1996), but are clearly more readily available (Farley TA, 2009) than the kinds of foods in the LFSA category, which is to say nothing of their comparative caloric profiles.

To summarize both the implicit and explicit Liking and Wanting data, this experiment has shown high TFEQ-D women chose snack foods that would likely enhance weight gain more often than low TFEQ-D women who chose foods that are associated with meals. Moreover, this preference was accompanied by a significant difference in motivational state (implicit wanting, D<sup>2</sup>), indicates that they are also more likely direct behaviour in order to obtain these kinds of foods. These observations provide concrete support for the use of the TFEQ as it clearly offers a direct assessment of motivations for eating. Whether the TFEQ versus other assessment techniques (such



as the RS or DEBQ) is the most sensitive at assessing implicit wanting for High Fat and palatable foods could be an interesting follow-up to these results.

Psychological mechanisms that underlie overeating behavior has recently become a greater focus within Eating Behaviour research, and psychologists have largely focused on the spontaneous cognitive process triggered by the perception of palatable food (Hoeftling A, 2008; Papies EK, 2009; Roefs A, 2005). Roefs (2005) conducted a test of implicit liking of palatable versus unpalatable food and found that, unsurprisingly, palatable food elicited more positive implicit attitudes in all participants, however there was no significant difference between Restrained versus Unrestrained individuals. (Hoeftling A, 2008) assessed attitudes towards high versus low calorie food (i.e. deep fried/creamy versus steamed/light) and found only a marginally statistically significant tendency for high RS participants to evaluate high Calorie foods as more positively than low calorie. Finally, in their own investigations Papies *et al* (2009) determined that Unrestrained eaters' implicit attitude towards palatable food was more positive than neutral or unpalatable food whereas Restrained eaters showed no significant difference between the three categories, authors suggest this is a reflection of the RS individuals chronic goal of dieting, which ultimately influences food attitudes.

Incentive Salience Theory would predict that *wanting* as opposed to liking would play the most critical role in the overconsumption of rewarding/ palatable foods. Thus, it is not entirely surprising that in the previous investigations ((Hoeftling A, 2008{Papies EK, 2009 #542; Roefs A, 2005})) difference in implicit *liking* were not as pronounced as the differences detected in *implicit wanting* between High versus Low TFEQ-D scorers in the current investigation.

Researchers who have posited anticipation is one of the core issues of overeating (Berthoud, 2007; E. Stice, Spoor, S., Ng, J., Zald, D.H., 2009) support the tenet Incentive Salience theory that predicts that overtime and consistent exposure to the rewarding effects of food, overeaters would *want* HED food more, relative to those who do not overeat. However, it may be the case that this group does not necessarily *like* pleasant tasting food any more than individuals who do not overeat. Evidence to sustain this hypothesis can be found in studies that demonstrate positive correlations

between reported food craving and BMI and objectively measured caloric intake (Michels KB, 2007). Moreover, obese women report stronger craving of high-fat, high sugar foods than lean (A. Drewnowski, Kurth, C., Holden-Wiltse, J., Saari, J., 1996), and obese adults work harder for food and for more food compared to lean participants (Epstein, et al., 2008; Saelens & Epstein, 1996). In light of these findings, Stice (2009) proposed that overeating arises as a consequence of a hyper responsiveness in the anticipatory phase of eating. Our results demonstrate that another method of detecting between-group differences with regard to self reported overeating, is with the implicit wanting measure on the LWCP as those participants who self reported overeating showed a clear preference for the types of food (High Fat Sweet) that are specifically associated with the development of overweight.

In addition to expressing a clear preference for HFSW foods, high TFEQ-D participants acted more impulsively following exposure to Anticipatory food cues. Impulsivity has been suggested as an important factor by previous researchers (R. Guerrieri, 2007; R. Guerrieri, et al., 2007a, 2007b; M. R. Lowe, et al., 2009; Nasser, et al., 2004; C. Nederkoorn, Braet, et al., 2006; C. Nederkoorn & Jansen, 2002; C. Nederkoorn, Jansen, et al., 2006; C. Nederkoorn, Van Eijs, Y., Jansen, A., 2004a, 2004b; E. Stice, et al., 2008), as it theoretically increases the risk for responding to a variety of appetitive stimuli (R. Guerrieri, et al., 2007a, 2007b). In the current study, a pattern of results was found to verify this idea, but critically we have refined the previous theory that impulsivity in general is associated with over responding to food, as our results show rewarding food cues elicit greater Inhibition impulsivity in self reported overeaters.

In light of the previous experiments that have demonstrated the robust association between high TFEQ-D scores and increased impulsivity, and in order to develop a final novel within the current investigation, the remainder of this Discussion aims to describe how greater impulsivity in the presence of appetitive food cues could contribute to the perpetuation of overeating. The best demonstrations of how attractive food cues elicit impulsivity was found with the MFFT and BART measures, as high TFEQ-D scorers demonstrated significantly greater impulsivity using these measures. The most engaging finding was the dissociation between HDHR and HDLR groups in response to the BART and MFFT measures, and how this difference

in eating motives relates to impulsive behaviour, and overeating, is explored in the following section.

In the presence of appetitive food cues, the HDHR group became more impulsive on a measure of Reward Reactivity (the BART), where as the HDLR group became more impulsive on a measure Inhibition impulsivity (the MFFT). This complex set of data may offer a set of novel observations with regard to psychological determinants of overeating behaviour.

In the MFFT, the high TFEQ-D participants exhibited greater inhibition impulsivity compared to low TFEQ-D participants, but critically the HDLR group showed a significant increase in errors committed on the task when in the Anticipatory condition, compared to all other groups. In this task, the interaction between condition and TFEQ classification showed that HDHR group had the same amount of errors within conditions, compared to the HDLR group who made more errors in the Anticipation condition. This finding provides a direct example of the ways that anticipatory food cues elicit disinhibited behavior in self reported overeaters, and could help to describe this groups' tendency for making poorer decisions (i.e. more errors) in the presence of appetitive cues.

Incentive Salience theory predicts individuals who are more sensitive to reward will be at greater vulnerability to cues of that primary reward, in essence stimuli associated with a primary reward acquire motivational potency, and thus triggers hyperactivity in the reward system (Berridge, 2004). Perhaps this is a direct demonstration of the “disinhibition” process associated with poor decisions made in order to obtain rewards, characterized clearly in addictive behavior type research. For those HDLR participants, the presence of appetitive food cues may elicit a desire for eating that diminishes their ability to consider components of that rewarding item (nutrient content, caloric content, and consequences of overeating). This is one of the first investigations to provide a clear demonstration those participants who overeat, but do not restrict behavior, become *more* impulsive in the presence of appetitive cues, thus supporting the notion that the specific HDLR classification is representative of a greater vulnerability to the effects of appetitive food cues.

In addition to the MFFT Inhibition impulsivity measure, the BART provided a second dissociation between impulsive behavior between the HDHR and HDLR groups. Critically, with the BART we found a three-way interaction such that the HDHR and LDHR groups were no more impulsive in the Anticipation Condition, but this was in significant contrast to the HDHR group who became more impulsive in the presence of Anticipatory food cues. One explanation for this pattern of results is that the participants in with High Restraint scores (HDHR and LDHR) groups responded in accordance with Trope's (2000) "counteractive model", which suggests that the presence of food cues can actually bolster restrained behavior. The BART offered those participants who are especially sensitive to food stimuli (HD group) an alternative way to engage in Reward seeking behavior. This argument would also explain the lack of change in impulsivity for the HDLR group, who would only be attracted to food cues without the imposed cognitive restriction, and would therefore not seek alternative channels for rewards beyond the food they were promised, and fully intent on eating, in the first component of the experiment.

The remaining two assessments of impulsivity, the TCIP and the Go No Go task were determined to be less accurate ways of detecting impulsivity between groups characterized by self reported eating behavior. This experiment provided the first evidence that the Go no Go task discriminates between individuals based on a self reported tendency to overeat. We found that high TFEQ-D had longer stop latencies than low TFEQ-D participants, although there was no interaction with Anticipation condition. In addition, there were no significant differences between participants on the TCIP task, indicating that this measure of impulsive choice was not sensitive to detecting differences between participants based on TFEQ scores.

The previous study provided a unique set of data that supports the TFEQ classification method of eating behavior both as a way to characterize behaviors associated with overeating and impulsive behaviour. Despite any lack of difference in BMI or premorbid intelligence, those participants with the HD classification were more sensitive to anticipatory food cues, and this was clear in terms of Inhibition impulsivity using the MFFT measure, those with HDLR classification became *more* impulsive on the MFFT compared to all other groups. This finding verifies the

importance of Inhibition impulsivity for those participants who self report overeating (high TFEQ-D scores).

The finding that HDLR participants are particularly vulnerable to inhibition impulsivity in the presence of Anticipatory food cues has additional pertinence to understanding how self report overeating is associated with greater sensitivity to environmental cues for eating, because images of food are used widely in modern society (i.e. food advertising, packaging, vending machines, and a new addition of flat screen televisions in fast food restaurants to capture high definition pictures of food images). Visual sensory modality has been cited as a particularly potent factor in relation to food cravings (Kemps E, 2009; Simmons WK, 2006)), and this data demonstrates that food cues and anticipation also lead to increased inhibition impulsivity, particularly in individuals who self report overeating.

One of the greatest challenges posed to obesity related research is determining what, precisely, facilitates the choice among overweight individuals for high calorie energy dense food as opposed to lower calorie foods. The collation of the results of this study show that not only do self report overeaters *want* (i.e. report a difference in motivational state) with regard to HFSW foods, but also that in the presence of appetitive cues, they make more impulsive decisions both in terms of inhibition tasks (MFFT) in addition to reward reactive measures (BART). Highlighting the idea that appetitive cues enhance impulsivity specifically in those individuals who self report overeating describes one of facets involved in overeating.

The results of the previous study provide a window into two of the implicit process involved in overeating behaviour; greater implicit wanting for High Fat Sweet foods, paired with increased impulsivity in the presence of appetitive cues. Clarifying the channels related to the behavioural chains of overeating has become a major challenge to psychologists and psychobiological scientists, to say nothing of those individuals who attempt to control or limit caloric intake. The previous investigation showed one way that these implicit factors are linked.

## Chapter 8

### General Discussion

#### *8.1 Summary of results*

At the onset of this thesis, evidence had been presented demonstrating a clear link between greater impulsivity in overweight individuals. Higher rates of impulsivity in obese (Chalmers, Bowyer, & Olenick, 1990), binge eating (Ryden, 2003), and weight cycling individuals (A. Jansen, et al., 2009) could be interpreted as support for this theory. Therefore, upon commencing these investigations, there was at least implicit support for the hypothesis that impulsivity is a stable characteristic of those individuals who overeat, but critically, are not yet overweight.

The General Introduction of this Thesis outlined two major shortcomings of the line of impulsivity/obesity research insofar as that the basis of this association is made upon comparisons between overweight or clinical populations with lean, healthy controls. This type of design cannot address whether impulsivity precursors overeating behaviour, or whether increased impulsivity is a consequence of habitual consumption of pleasant tasting, i.e. rewarding food. Secondly, the specific aim of determining whether impulsivity was associated with a specific behaviour i.e. overeating, had not been addressed. So, although the link between overeating and impulsivity may have been implied, this had yet to be explored empirically, or refined to a point where a stable set of “impulsive” characteristics could be discussed with respect to the motivation for overeating.

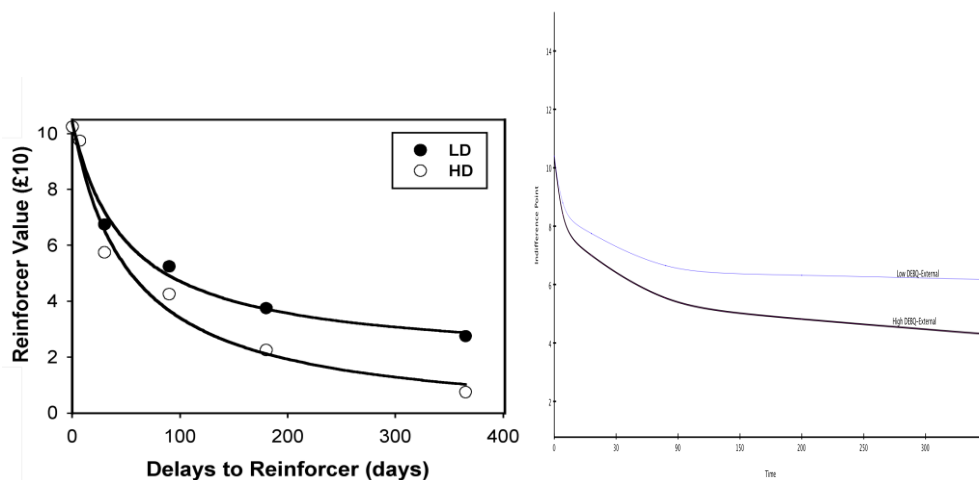
Perhaps the two limitations of impulsivity/ eating behaviour research mentioned above reflected a greater misunderstanding about the relationship between an individual difference, such as inhibition impulsivity, and how it relates to self-reported overeating. Within this thesis, we were able to classify impulsivity in terms of two distinct subsets, and achieve a more precise understanding of how impulsivity specifically relates to self-reported eating styles. Throughout the course of the six experimental investigations presented here, the significant association between high TFEQ-D scorers and greater Inhibition Impulsivity was demonstrated. Most interestingly, the final study not only replicated the association between higher levels of Inhibition Impulsivity using the MFFT and TFEQ-D scores, but also showed a

subgroup, the HDLR participants became significantly *more* impulsive in the presence of appetitive food cues.

### 8.1.2: Comparing Results Between Experiment 1 and Experiment 2

It was initially predicted that high TFEQ-D scorers would more impulsive in terms of Reward Reactivity. Experiment 1 revealed a series of patterns that seemed to confirm this hypothesis, for example the positive relationship between the TFEQ-D and the BART, significantly greater discounting rates on the DDT using the AUC method, and a near significant pattern of discounting using the  $k$ -value method corroborated this view. The finding that TFEQ-D and BART scores shared a strong positive significant relationship was an exciting development. Moreover, the data from the first experiment of this thesis complemented those initial findings by Yeomans *et al*(2008) showing that high TFEQ-D scorers discounted monetary rewards more quickly. Critically, the  $k$ -value slope patterns between Experiment 1, and Yeomans (2008) were similar, as Figure 8.1 illustrates.

Figure 8.1: Comparing  $k$ -value Analysis Between Yeomans(2008) and Experiment 1



Collating the final outcomes of our first two investigations (Experiment 1 and Experiment 2) revealed an important discrepancy between the results of our first correlation study and second experiment. A tidy linear relationship between high TFEQ-D scores and increased Reward Reactivity was not replicated. The latter hypothesis was a tempting conclusion to draw, before scrutinizing the relationship between impulsivity and overeating with more rigid exclusion criteria, like those used

in Experiment 2. The changes incorporated in Experiment 2 (such as participant selection based on upper and lower TFEQ-D tertiles, and also forced consumption of a high calorie preload) did *not* contribute to greater impulsivity on the BART, moreover, the association between high TFEQ-D scores and greater discounting on the DDT was not replicated. Finally, a significant difference in terms of Inhibition Impulsivity, using the MFFT, was found in high TFEQ-D scorers. All of these factors challenged the original hypothesis that high TFEQ-D scorers would be best characterized by increased levels of Reward Reactivity. The difference between Experiment 1 and Experiment 2 indicated key factors, such as the ingestion of palatable food, and classification of participants based on Westenhoefer's (1991, 1992, 1994) dual classification system, played a critical role in understanding the relationship between self reported eating profiles with actual overeating, and critically, impulsivity.

The four subsequent investigations in this Thesis were designed to explore the conflicting results between our initial correlation study (Experiment 1) with the findings of our first experimental investigation (Experiment 2). Therefore, this Thesis included two exploratory investigations (Experiment 1 and Experiment 5) whereby self-report measures of overeating behaviour were explored with measures of Impulsivity. Experiment 2 and Experiment 4 investigated the extent that ingestion of palatable food contributed to impulsivity, and whether differences between individuals classified based on their TFEQ-D and TFEQ-R profiles could be found. Experiment 3 assessed the role that a Controlled versus Unrestricted eating environment has on subsequent impulsivity. Finally, Experiment 6 tested whether appetitive food cues, and anticipation for eating, elicited greater impulsivity in self-reported overeaters. Collectively, these investigations provided a methodical strategy to gain a greater understanding of impulsivity and overeating.

#### 8.1.3: TFEQ-D scores express preference for High Fat Sweet Foods (HFSW)

One of the clearest findings in this thesis was that high TFEQ-D scorers ate significantly more palatable food than their low TFEQ-D scoring counterparts. Although this finding underscored the utility of the TFEQ-Disinhibition scale, it provided a second dilemma. Counter regulatory or disinhibited eating predicted in the



HDHR participants did not emerge as predicted, and as this thesis has demonstrated, it is the use of *two* subsets of eating behaviour scales (Disinhibition *and* Restriction) that provides the most reliable classification system. There was no statistical difference between the amounts of food consumed by the HDHR or HDLR groups: the two high TFEQ-D groups, theorized to consume palatable food for distinct and unique eating motivations, showed nearly identical consumptive patterns. Considerable support demonstrates that the dual classification method suggested by Westenhoefer (1991; 1994) provides the most precise- and critically- accurate (Timko, 2007, Stunkard, 1997) method of characterizing eating behaviour, so, the lack of differentiation between the two high TFEQ-D groups with respect to actual food intake was perplexing.

It is apparent that the use of the term ‘Disinhibition’ is confusing in the context of describing the motivation to overeat; *Disinhibition* is a problematic name because it suggests that prior inhibition occurred, and evidence suggests that those individuals with high Disinhibition scores correspond with over responsiveness to food and greater food intake (Bryant, et al., 2008), as opposed to inhibiting eating in any way. Pudel & Westenhoefer (1992) attempted to alleviate some of the confusion with this subscale by renaming it “susceptibility to eating problems”, however, the use of the word “*problem*” perhaps evokes a negative connotation, and associates the scale (mistakenly) with binge spectrum disorders. In Westenhoefer’s (1994) replication of Herman & Mack’s (1975) milk shake preload/*ad lib* ice cream study, high TFEQ-D scorers consumed more than low TFEQ-D scorers, but critically, HDHR participants counter regulated behaviour by consuming more ice cream after the milk shake preload than the no-milkshake control, whereas the HDLR group did not.

Incorporating a prior Control Condition would have addressed whether the HDHR groups was counter regulating eating behaviour. Had we used a Control Condition that simply included intake of the snack foods, and then compared snack intake with a forced preload condition, the pattern of results likely would have conformed to those hypothesis of Westenhoefer (1991, 1994, 1999). This noted, it should be recognized that our findings do loosely conform to those of Westenhoefer (1994) as a significant difference was found between High versus Low TFEQ-D groups.

A final component of this thesis included a detailed assessment of eating motivation using the Liking Wanting Computer Procedure (G. Finlayson, King, N., Blundell, J., 2007). Experiment 6 incorporated this tool, and the pattern of results revealed a critical set of findings: relative to low TFEQ-D participants, high TFEQ-D scorers had significantly greater implicit wanting, relative preference, explicit wanting, and explicit liking for High Fat Sweet Foods. Moreover, there was no interaction between TFEQ-D and TFEQ-R subscales with regard to both implicit and explicit eating motivations for HFSW type foods.

The data from this thesis indicates that upper tertiale TFEQ-D scores represent a set of eating behaviour and food preferences that contribute to overeating palatable foods. These results suggest that the upper/lower tertiale method of classifying participants, which was employed for the majority of the studies in this thesis, provide a clear distinction between high and low TFEQ-D groups. Using median splits to determine high versus low TFEQ-D groups may not provide a sufficient distinction. The classification of High versus Low TFEQ-D scores based on a median split has been criticized in the past (Gorman, 1995), as it suggests a dichotomy of what should be measured as a continuous variable. Using a regression analysis would have greatly reduced the power for our studies, so employing the tertiale method conforms to suggestions that using participants with scores on the extreme high and low parts of the scale provide a clearer method for assessing group differences.

The classification of participants based on extremes on the TFEQ scales has been explored within an American population (Timko, 2007), and Westenhoefer (1999) suggested the use of upper and quintiles of the TFEQ subscales. Based on the previous experimental investigations (Experiment 2, 3, 5 and 6) using an upper extreme of 9, and lower extreme of 4 provided sufficient variation between the population, and could be considered as a selection criteria for future investigations. Moreover, the utter lack of association between TFEQ-D scores and the Binge Eating Scale found in Experiment 1 suggests the utility of the TFEQ-D scale as a measure for detecting overeating behaviour, without an association with binge eating *per se*.

In light of high TFEQ-D participants increased intake of calories (and also a greater relative trend for the consumption of chocolate in Experiment 2 and Experiment 5),

complemented by qualitative food ratings indicating a higher preference for HFSW foods, the data from this thesis provides a strong case for the idea that high TFEQ-D scorers are at a greater risk for the development of overweight in light of self reported eating behaviour, increased intake in the presence of high calorie food, and finally the greater motivation they experience for eating HFSW foods.

#### 8.1.4: High TFEQ-D scores are Indicative of Higher Inhibition Impulsivity

One of the strengths of this thesis was the emphasis placed on the classification of Reward Reactivity versus Inhibition impulsivity, and subsequent classification of impulsivity assessments based on these guidelines. This strategy provided a clear way to discriminate between testing formats and styles, and based on a specific need for an Inhibition Impulsivity assessment, we were able to identify the MFFT.

Recently, the distinction of inhibition impulsivity has become a priority for other researchers within the field of Eating Behaviour. Guerrieri (2009) published an intriguing finding: the induction of *inhibition* impulsivity led to an increase in food consumption. Specifically, when participants were matched in terms of self-reported eating motivations but received either an inhibition or regular impulsivity induction manipulation, it was only those with the inhibition manipulation who ate more food. In light of these findings, authors suggest “inhibition” is a cause for overeating.

Experiment 6 brought new insight into the mechanisms that underlie eating motivation for high versus low TFEQ-D scorers. In this unique investigation, we did find differentiation between HDHR and HDLR groups; although high TFEQ-D scorers were generally more impulsive, in the presence of appetitive food cues, HDLR participants became *more* impulsive on the MFFT (higher errors committed) whereas the HDHR participants became more impulsive on the BART. Unlike the data from the Food Consumption component of this thesis (i.e. Experiment 2 and Experiment 5), the impulsivity data suggests that the four TFEQ groups have distinct reactions to appetitive cues. Critically, there were significant differences in terms of impulsivity performance between the HDHR and HDLR groups, which has a range of consequences for future investigations. Curbing overeating behaviour in HDHR individuals may be contingent upon finding another task that proves to be equally

stimulating and evoke the same sensation of reward or pleasure (but does not include ingestion of food), and HDLR individuals may benefit from incorporating relaxation techniques or ways to suppress the prepotent response that emphasize focusing on the food properties and consequences of overeating.

It has recently been established that relaxation techniques significantly enhance obese women's ability to resist binge type eating (Manzoni, 2009). Authors suggest that relaxation techniques (via cognitive therapy or digital training) improve psychological resources, i.e. greater relaxing and perceived self-efficacy, positively affect a secondary appraisal process (involved in stressful situations), which then enhances functional coping, and this functional coping decreases the need for food as a way of dealing with stress and negative emotions.

McClelland (2004) suggested that cravings could be reduced with concurrent visual spatial tasks. Visuospatial tasks, such as tapping one's forehead with one's index finger across their forehead from temple to temple with approximately a one cm gap between each tap seem to assist individuals in controlling food cravings. For example, women who were asked to form images of their favourite foods while performing a visuospatial task had significantly lower cravings than those women who did not participate in this "concurrent task". Authors suggest this concurrent task acts to divert attention from food, thus reducing cravings.

In light of the findings presented in this Thesis, we would suggest it is not only cravings per se, but a greater vulnerability to impulsive responding that plays a critical role in maintenance of behaviours linked with overeating. Thus, tools to focus attention and perhaps enhance relaxation could help to counteract the initial attraction to palatable food. Whether an individual with greater responsiveness to palatable food cues, who also becomes more impulsive in the presence of food cues, would be able to control urges and incorporate these types of "visuo spatial" tasks, or relaxation techniques outside of a laboratory environment is worth consideration. A unique way to develop the findings of this thesis would be to train those individuals who report overeating to incorporate a strategy such as a divergent concurrent task, as a means to reduce the episodes of overeating. Although the visuospatial task suggested by McClelland (2004) may have application in the laboratory with food related imagery,

an important step will be to test if this kind of concurrent visual strategy helps to reduce impulsive responding with regard to pleasant, desired food that is not merely imagined but present and available, as in the current food environment.

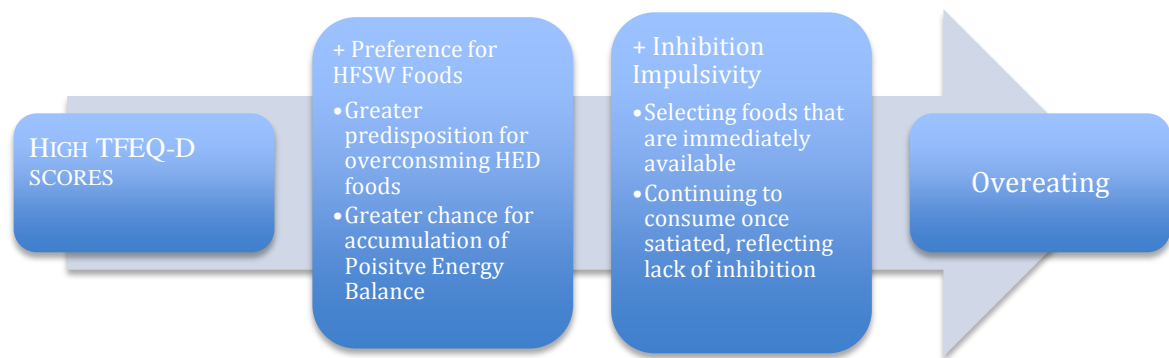
#### 8.1.5: Reward Reactivity and Self Reported Overeating

At the initial stage of this Thesis, it was hypothesized that Reward Reactivity would be the subtype of impulsivity most significantly associated with self reported overeating. Subsequent investigations did not replicate these findings, and describing this dilemma is the last remaining component to address within this thesis.

How did we find an association between high TFEQ-D scorers and BART performance, and DDT monetary discounting in two separate studies? Critically, measures of Reward Reactivity were not reliably discriminative between individual prone to overeating in the majority of the investigations presented here. In order to explore the inability to replicate Yeomans *et al.* (2008), the original data from Yeomans *et al.* (2008), and employed the same TFEQ-D exclusion criteria with this sample. In this analysis, we did not find any significant difference between *k*-value slopes. This finding supports the notion that median TFEQ-D scorers may be more Reward Reactive, but that Inhibition Impulsivity is a more stable characteristic with regard to high TFEQ-D scorers.

The collection of these data reflects the idea that both subtypes of impulsivity are implicated in overeating behaviour. Our data showed that the HDHR subtype are vulnerable to both Reward Reactivity and Inhibition impulsivity in the presence of appetitive food cues, suggesting individuals with this TFEQ profile are especially vulnerable to the consequences of the current food environment abundant with palatable food. The stability of the relationship between high TFEQ-D scorers and higher Inhibition was replicated in several unique contexts, suggesting higher Inhibition is a key factor related to overeating behaviour. Figure 8.2 illustrates a potential mechanism for the way that impulsivity specifically relates to the two subtypes of self reported overeaters.

*Figure 8.2: Working Conceptual Model Presenting the Relationship Between High TFEQ-D Scores and overeating behaviour*



## 8.2 Further Experiments

There are several other logical experiments that could expand the findings presented in this thesis.

### 8.2.1 Does Violating Dietary Boundaries Lead to Greater Impulsivity?

The study proposed here is largely an extension of those findings from Experiment 2 and Experiment 5. In this adaptation, I propose conducting a within subjects design whereby participants are selected based on TFEQ-D and TFEQ-R scores, and complete the same battery of impulsivity tasks (MFFT, Go No Go, BART, and DDT), after completing a mock taste test for a series of palatable, pleasant tasting foods (i.e. those foods used in Experiment 2 and Experiment 5: Cadbury's chocolate buttons, McVitie's Chocolate Chip Mini Cookies, McVitie's Mini Cheddars, and Dry Roasted Peanuts). This development would provide two key insights; first, it would provide a platform to observe HDHR participants' impulsive behaviour when they are attempting to restrict intake, and also allow for observation of differences in impulsivity between HDHR and HDLR participants in a context that would predict increased impulse control for the HDLR participants, who would not have devoted as many resources to controlling eating behaviour, thereby contributing to an increase in control over impulsive responding.

Two weeks subsequent to this initial session in the laboratory, participants would be required to come back to the lab, but would be presented with the ice cream preload and *ad lib* snacks used in the previous investigations. Impulsivity tests would be completed after the mock taste test.

The proposal illustrated here would elucidate whether the HDHR group was consuming *ad lib* snacks in the counter regulatory pattern predicted by research in the field of Eating Behaviour (Herman, Polivy, 1975, 1980; Westenhoefer, et al., 1994). Moreover, this would provide a final investigation into the way that violation of dietary boundaries contributes to impulsivity in self reported overeaters.

#### 8.2.2 Can Inhibition Impulsivity Training Sessions Lead to a Reduction of Food Consumption in Women Who Overeat?

As described throughout this thesis, Inhibition Impulsivity is a characteristic of individuals with high TFEQ-D scores. Recently, Guerrieri (2009) found that inducing inhibition impulsivity led to an increase in food consumption. In this investigation, Inhibition was induced via explicit instructions to perform inaccurately on a Go No Go task. If impulsivity can be manipulated in this way leading to an increase in food consumption, a novel question is to determine if impulsivity training could enhance appetitive control.

One potential extension of this thesis, and the culminating evidence implicating inhibition as a risk factor for development of overweight (Guerrieri, Nederkoorn, C., Schrooten, M., Martijn, C., Jansen, A., 2009; McClelland, 2006; Kemps, 2004; Manzone, 2009)) } } would be to determine if impulsivity training sessions could lead to a reduction in caloric intake. One method for improving inhibition impulsivity, would be to incorporate the MFFT, and engage in training sessions for participants to focus on the target, and subsequently chose the correct matching template.

The proposal outlined would require participants to come to the lab on two occasions, first in an *ad-lib* snack context, and second after training. This would provide the most precise baseline information with regard to caloric intake, and would determine if the impulsivity training is an effective way to inhibit overeating behaviour. One

final addition to this proposal, would be the inclusion of overweight or obese women, who are more likely to benefit from a technique to enhance appetite control.



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## Appendices

### *Appendix 1a: Standard Food and Drink Research Data Base Questionnaire*

The Following questions allow us to identify your suitability to take part in our research. Different studies suit different people, so please answer the questions as accurately as possible. Your answers are confidential, and will be kept on file for future studies, until you leave Sussex or ask us to remove you from our database.

Please answer these questions by *circling* the answer (True) or (False) that best describes your behaviour:

1. When I see a sizzling steak or see a juicy piece of meat, I find it difficult to keep from eating, even if I have just finished a meal. True/ False
2. I usually eat too much at social occasions, like parties and picnics. True/ False
3. I am usually so hungry that I eat more than three times a day True/ False
4. When I have eaten my quota of calories, I am usually good about not eating any more. True/ False
5. Dieting is so hard for me because I just get too hungry. True/ False
6. I deliberately take small helpings as a means of weight control True/ False
7. Sometimes things just taste so good that I keep on eating even when I am no longer hungry True/ False
8. Since I am often hungry, I sometimes wish that I while I am eating, an expert would tell me that I have had enough or that I can have something more to eat True/ False
9. When I feel anxious, I find myself eating. True/ False
10. Life is too short to worry about dieting. True/ False
11. Since my weight goes up and down, I have fone on reducing diets more than once. True/ False
12. I often feel so hungry that I just have to eat something True/ False
13. When I amwith someone who is overeating, I usually overeat too. True/ False
14. I have a pretty good idea of the number of calories in common foods. True/ False
15. Sometimes when I start eating, I just can't seem to stop True/ False
16. It is difficult for me to leave something on my plate True/ False

17. At certain times of the day, I get hungry because I have got used to eat then True/ False
18. While on a diet, if I eat food that is not allowed I consceientiously eat less for a period of time to make up for it. True/ False
19. Being with someone who is eating often makes me hungry enough to eat also True/ False
20. When I feel blue, I often overeat True/ False
21. I enjoy eating too much to spoil it by counting calories or watching my weight True/ False
22. When I see a real delicacy, I often get so hngry that I have to eat right away True/ False
23. I often stop eating when I am not really full as a conscious means of limiting the amount that I eat. True/ False
24. I get so hungry that my stomach often seems like a bottomless pit True/ False
25. My weight has hardly changed in the last ten years True/ False
26. I am always hungry so it hard for me to stop eating before I finish the food n my plate. True/ False
27. When I feel lonely, I console myself by eating True/ False
28. I consciously hold back at meals in order to not gain weight True/ False
29. I sometimes get very hungry late in the evening or at night True/ False
30. I eat anything I want, any time I want. True/ False
31. Without even thinking about it, I take a long time to eat True/ False
32. I count calories as a conscious means of controlling my weight True/ False
33. I do not eat some foods because they make me fat. True/ False
34. I am always hungry enough to eat at any time True/ False
35. I pay a great deal of attention to changes in my figure True/ False
36. While on a diet, if I eat food that is not allowed, I often then splurge and eat other high calorie foods True/ False
37. If I eat a little bit more one day, I make up for it the next day True/ False
38. I eat diet foods, even if they do not taste very food True/ False
39. A diet would be too boring a way for me to loose weight True/ False

40. I pay attention to my figure, but I still enjoy a variety of foods True/ False
41. I would rather skip a meal than stop eating in the middle of one True/ False
42. I alternate between times when I diet strictly and times when I don't pay attention to what and how much I eat. True/ False
43. I prefer light foods that are not fattening True/ False
44. Sometimes I skip meals to avoid gaining weight True/ False
45. I try to stick to a plan when I lose weight True/ False
46. If I eat a little bit more during one meal, I make up for it at the next meal True/ False
47. Without a diet plan I wouldn't know how to control my weight True/ False
48. Quick success is more important for me during a diet True/ False

Please answer the questions by putting a *circle* around the answer that best describes your behaviour:

49. How conscious are you dieting in a conscious effort to control your weight?  
Rarely                      Sometimes                      Usually                      Always
50. Would a weight fluctuation of 5lbs affect the way you live your life?  
Rarely                      Sometimes                      Usually                      Always
51. How often do you feel hungry?  
Only at meal times                      Sometimes between meals                      Often between meals                      Always
52. Do your feeling sof guilt about overeating help you to control your food intake?  
Never                      Rarely                      Sometimes                      Always
53. How difficult would it be for your to stop eating halfway through dinner and not eat for the next four hours?  
Easy                      Slightly difficult                      Moderately difficult                      Very Difficult
54. How conscious are you of what you eat?  
Not at all                      Slightly                      Moderately                      Extremely
55. How frequently do you avoid stocking up on tempting food?  
Almost never                      Seldom                      Usually                      Almost Always
56. How likely are you to shop for low calorie foods?  
Unlikely                      Slightly likely                      Moderately likely                      Very likely
57. Do you eat sensibly infront of others and splurge alone?  
Never                      Rarely                      Sometimes                      At least once a week

58. How likely are you to consciously eat slowly in order to cut down on how much you eat?  
Unlikely                      Slightly likely                      Moderately likely                      Very likely

59. How frequently do you skip dessert because you are no longer hungry?  
Almost never                      Seldom                      At least once a week                      Almost every day

60. How likely are you to consciously eat less than you want?  
Unlikely                      Slightly likely                      Moderately likely                      Very likely

61. Do you go on eating binges though you are not hungry?  
Never                      Rarely                      Sometimes                      At least once a week

62. Do you deliberately restrict your intake during meals even though you would like to eat more?  
Rarely                      Sometimes                      Usually                      Always

63. On a scale of 0-5, where 0 means no restraint in eating (eating whatever you want, whenever you want) and 5 means total restraint (consciously limiting food intake and never 'giving in') what number would you give yourself?

- 0. Eat whatever you want, whenever you want it
- 1. Usually eat whatever you want, whenever you want it
- 2. Often eat whatever you want, whenever you want it
- 3. Often limit food intake, but often 'give in'
- 4. Usually limit food intake, and rarely 'give in'
- 5. Constantly limit food intake, never 'give in'

64. To what extent does this statement describe your eating behaviour? "I start dieting in the morning, but because of any number of things that happen during the day, by evening I have given up and eat whatever I want, promising myself to start dieting again tomorrow" (Please circle one response only)

- 0. Not like me.
- 1. A little like me.
- 2. A Pretty good description of me.
- 3. Describes me perfectly



*Appendix 1.b: Consent form for Experiment 1*

**The purpose of this experiment**

To investigate factors underlying the relationship between some characteristics and choice behaviour.

**What you will be required to do**

The test is very simple. You will first be required to complete a simple computer based task and complete some questionnaires. The whole test may take 45 minutes.

**Precautions**

**The study is very straightforward and anyone is welcome to participate**

**Rewards**

We are able to pay participants £5.00 for their time

If you have any questions or concerns please contact the Principal Investigator

Volunteer Consent Form

I have read and had explained to me the above information. The nature and purpose of the psychological testing has been explained to me. I am aware that I have the right to withdraw from the experiment at any time

I fully understand the nature and purpose of the study and give my consent to participate.

Name: \_\_\_\_\_

Signed: \_\_\_\_\_

Date: \_\_\_\_/\_\_\_\_/\_\_\_\_

*Appendix 1.c: Behavioural Activation/ Behavioural Inhibition Scale*

Each item of this questionnaire is a statement that a person may either agree with or disagree with. For each item, indicate how much you agree or disagree with what the item says. Please respond to all the items, do not leave any blank. Choose only one response to each statement. Please be as accurate and honest as you can be. Respond to each item as if it were the only item. That is, don't worry about being "consistent" in your responses. Choose from the following four response options:

- 1= very true for me
- 2= somewhat true for me
- 3= somewhat false for me
- 4= very false for me

1. A person's family is the most important thing in life
2. Even if something bad is about to happen to me, I rarely experience fear or nervousness
3. I go out of my way to get things I want
4. When I'm doing well at something I love to keep at it
5. I'm always willing to try something new if I think it will be fun
6. How I dress is important to me
7. When I get something I want, I feel excited and energized
8. Criticism or scolding hurts me quite a bit
9. When I want something I usually go all-out to get it
10. I will often do things for no other reason than they might be fun
11. It's hard for me to find the time to do things such as get a haircut
12. If I see a chance to get something I want I move on it right away
13. I feel pretty worried or upset when I think or know somebody is angry with me
14. When I see an opportunity for something I like I get excited right away
15. I often act on the spur of the moment
16. If I think something unpleasant is going to happen I usually get pretty "worked up"
17. I often wonder why people act the way they do
18. When good things happen to me, it affects me strongly
19. I feel worried when I think I have done poorly at something important
20. I crave excitement and new sensations
21. When I go after something I use a "no hold barred" approach
22. I have very few fears compared to my friends
23. It would excite me to win a contest
24. I worry about making mistakes

#### Appendix 1d: Sensitivity to Punishment/ Sensitivity to Reward Questionnaire

*Appendix 1e: The Barrett Impulsivity Index-11*

Please type the number which corresponds to the choice  
that best describes you. Try to describe the way you **USUALLY**  
act and feel, not just how you are feeling right now.

**1 = rarely/never    2 = occasionally    3 = often    4 = 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 easily bored when solving thought 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 orientated.	1	2	3	4

*Appendix 1f: The Dutch Eating Behaviour Questionnaire*

Please indicate the number which corresponds to the choice  
that best describes you.

1 = never    2 = occasionally    3 = often    4 = almost always    5 = always

Do you deliberately eat less in order not to become heavier?

Do you have the desire to eat when you are irritated

Do you have a desire to eat when you are bored or restless?

How often do you try not to eat between meals because you are watching your weight?

You cannot resist eating delicious food

How often do you refuse food or drink offered because you are concerned about your weight?

Do you have a desire to eat when you are cross?

Do you have a desire to eat when you are approaching something unpleasant to happen?

Do you get the desire to eat when you are anxious , worried, or tense?

Do you have a desire to eat when you have nothing to do?

Do you take into account in your weight with what you eat?

Do you deliberately eat foods that are slimming

When preparing a meal are you inclined to eat something?

If you walk past a snack-bar or café, do you usually buy something delicious?

Do you have a desire to eat when somebody lets you down?

If you see or smell something delicious do you have a desire to eat it?

How often in the evenings do you try not to eat because you are watching your weight?

If food tastes good to you, do you eat more than usual?

Do you have a desire to eat when you are depressed or discouraged?

Do you have a desire to eat when you are disappointed?

If food smells and looks good, do you eat more than usual?

Do you have a desire to eat when you are emotionally upset?

If you walk past the baker do you have the desire to buy something delicious?

Do you watch exactly what you eat?

Do you have a desire to eat when you are irritated?

If you see others eating, do you have a desire to eat?

Do you have a desire to eat when things are going against you or when things have gone wrong?

Do you eat more than usual, when you see others eating?

Do you have a desire to eat when you have nothing to do?

Do you have a desire to eat when you are frightened?

Do you try to eat less at mealtimes than you would like to eat?

When you have put on weight, do you eat less than you usually do?

If you have something delicious to eat, do you eat it straight away?

When you have eaten too much, do you eat less than usual the following day?

Do you have a desire to eat when you are feeling lonely?

*Appendix 1g: Eating Habits Checklist*

**EATING HABITS CHECKLIST**

NAME: DATE: \_\_\_\_\_

*Instructions:* Below are groups of numbered statements. Read all the statements in each group and put a ✓ mark next to the one that best describes the way you feel. These questions are about the problems you have controlling your eating behavior.

#1

1. I don't feel self-conscious about my weight or body size when I'm with others.
2. I feel concerned about how I look to others, but it normally does not make me feel disappointed with myself.
3. I do get self-conscious about my appearance and weight which makes me feel disappointed in myself.
4. I feel very self-conscious about my weight and frequently, I feel intense shame and disgust for myself. I try to avoid social contacts because of my self-consciousness.

#2

1. I don't have any difficulty eating slowly in the proper manner.
2. Although I seem to "gobble down" foods, I don't end up feeling stuffed because of eating too much.
3. At times, I tend to eat quickly and then, I feel uncomfortably full afterward.
4. I have the habit of bolting down my food, without really chewing it. When this happens I usually feel uncomfortably stuffed because I've eaten too much.

#3

1. I feel capable to control my eating urges when I want to.
2. I feel like I have failed to control my eating more than the average person.
3. I feel utterly helpless when it comes to feeling in control of my eating urges.
4. Because I feel so helpless about controlling my eating I have become very desperate about trying to get in control.

#4

1. I don't have the habit of eating when I'm bored.
2. I sometimes eat when I'm bored, but often I'm able to "get busy" and get my mind off food.
3. I have a regular habit of eating when I'm bored, but occasionally, I can use some other activity to get my mind off eating.
4. I have a strong habit of eating when I'm bored. Nothing seems to help me break the habit.

#5

1. I'm usually physically hungry when I eat something.
2. Occasionally, I eat something on impulse even though I really am not hungry.
3. I have the regular habit of eating foods, that I might not really enjoy, to satisfy a hungry feeling even though physically, I don't need the food.
4. Even though I'm not physically hungry, I get a hungry feeling in my mouth that only

seems to be satisfied when I eat a food, like a sandwich, that fills my mouth. Sometimes, when I eat the food to satisfy my mouth hunger, I then spit the food out so I won't gain weight.

#6

1. I don't feel any guilt or self-hate after I overeat.
2. After I overeat, occasionally I feel guilt or self-hate.
3. Almost all the time I experience strong guilt or self-hate after I overeat.

#7

1. I don't lose total control of my eating when dieting even after periods when I overeat.
2. Sometimes when I eat a "forbidden food" on a diet, I feel like I "blew it" and eat even more.
3. Frequently, I have the habit of saying to myself, "I've blown it now, why not go all the way" when I overeat on a diet. When that happens I eat even more.
4. I have a regular habit of starting strict diets for myself, but I break the diets by going on an eating binge. My life seems to be either a "feast" or "famine".

#8

1. I rarely eat so much food that I feel uncomfortably stuffed afterward.
2. Usually about once a month, I eat such a quantity of food, I end up feeling very stuffed.
3. I have regular periods during the month when I eat large amounts of food, either at mealtime or at snacks.
4. I eat so much food that I regularly feel quite uncomfortable after eating and sometimes a bit nauseous.

#9

1. My level of calorie intake does not go up very high or go down very low on a regular basis.
2. Sometimes after I overeat, I will try to reduce my caloric intake to almost nothing to compensate for the excess calories I've eaten.
3. I have a regular habit of overeating during the night. It seems that my routine is not to be hungry in the morning but overeat in the evening.
4. In my adult years, I have had week-long periods where I practically starve myself. This follows periods when I overeat. It seems I have a life of either "feast or famine".

#10

1. I usually am able to stop eating when I want to. I know when "enough is enough".
2. Every so often, I experience a compulsion to eat which I can't seem to control.
3. Frequently, I experience strong urges to eat which I seem unable to control, but at other times I can control my eating urges.
4. I feel incapable of controlling urges to eat. I have a fear of not being able to stop eating voluntarily.

#11

1. I don't have any problem stopping eating when I feel full.
2. I usually can stop eating when I feel full but occasionally overeat leaving me feeling uncomfortably stuffed.
3. I have a problem stopping eating once I start and usually I feel uncomfortably stuffed after I eat a meal.
4. Because I have a problem not being able to stop eating when I want, I sometimes have to induce vomiting, use laxatives or diuretics to relieve my stuffed feeling.

#12

1. I seem to eat just as much when I'm with others (family, social gatherings) as when I'm by myself.
2. Sometimes, when I'm with other persons, I don't eat as much as I want to eat because I'm self-conscious about my eating.
3. Frequently, I eat only a small amount of food when others are present, because I'm very embarrassed about my eating.
4. I feel so ashamed about overeating that I pick times to overeat when I know no one will see me. I feel like a "closet eater".

#13

1. I eat three meals a day with only an occasional between meal snack.
2. I eat 3 meals a day, but I also normally snack between meals.
3. When I am snacking heavily, I get in the habit of skipping regular meals.
4. There are regular periods when I seem to be continually eating, with no planned meals.

#14

1. I don't think much about trying to control unwanted eating urges.
2. At least some of the time, I feel my thoughts are preoccupied with trying to control my eating urges.
3. I feel that frequently I spend much time thinking about how much I ate or about trying not to eat anymore.
4. It seems to me that most of my waking hours are preoccupied by thoughts about eating *or* not eating. I feel like I'm constantly struggling not to eat.

#15

1. I don't think about food a great deal.
2. I have strong cravings for food but they last only for brief periods of time.
3. I have days when I can't seem to think about anything else but food
4. Most of my days seem to be preoccupied with thoughts about food. I feel like I live to eat.

#16

1. I usually know whether or not I'm physically hungry. I take the right portion of food to satisfy me.
2. Occasionally, I feel uncertain about knowing whether or not I'm physically hungry. At these times it's hard to know how much food I should take to satisfy me.
3. Even though I might know how many calories I should eat, I don't have any idea what is a "normal" amount of food for me.



**Information for Subjects**

Name: \_\_\_\_\_  
Signature: \_\_\_\_\_

**The Purpose of the Experiment**

To investigate the relationship between appetite and evaluation of snack foods.

**What you will be required to do**

You will report to the laboratory on one day between 08:30 and 10:00 having drunk only water from 11 pm the night before; a saliva sample will be taken to check compliance with this restriction. The lab is in Pevensey 2, room 4B16

You will come to the lab, where we will serve you a standardized cereal breakfast (Crunchy Nut Cornflakes, or Special K based on your preference).

**You will return to the lab 3 hours after eating breakfast** in order to complete a battery of tests, which are similar to basic computer games on the PC's in the Ingestive Behaviour Unit. *You will be required to evaluate a chocolate icecream*, and several novel snacks based on their taste properties.

**\*\* please, if you are lactose intolerant, do not participate in this study.**

To complete each test day you will be asked to evaluate some snack foods and fill out two questionnaires about your eating habits.

The experiment will take no longer than 1.45 hours.

**You should not take part if you:**

- Have diabetes
- Smoke more than 5 cigarettes per day
- Are currently taking prescription medication, excluding the contraceptive pill
- *Prior history of a clinical eating disorder*
- *Are allergic or have an aversion to any of the foods or food ingredients listed below*

Sugar, food flavourings, food colourings, cereal-based products (wheat, oats), dairy products, fruit, nuts, crisps, chocolate.

If you have any queries or concerns, please contact the Principal Investigator: Dr Martin R Yeomans, Department of Psychology, University of Sussex, BN1 9QH. Tel: 01273 678617, email [martin@sussex.ac.uk](mailto:martin@sussex.ac.uk)

**Remember, you may withdraw from the study at any time**

## Appendix 3a: Consent Form for Controlled Breakfast Condition

### Information for Subjects

Name: \_\_\_\_\_

Signature: \_\_\_\_\_

#### *The Purpose of the Experiment*

To investigate the relationship between appetite and evaluation of snack foods.

#### *What you will be required to do*

You will report to the laboratory on one day between 08:00 and 10:00 having drunk only water from 11 pm the night before; a saliva sample will be taken to check compliance with this restriction. The lab is in Pevensy 2, room 4B16

You will come to the lab, where we will serve you a standardized cereal breakfast (Crunchy Nut Cornflakes, or Special K based on your preference).

You will return to the lab 3 hours after eating breakfast in order to complete a battery of tests, which are similar to basic computer games on the PC's in the Ingestive Behaviour Unit.

To complete each test day you will be asked to evaluate some snack foods and fill out two questionnaires about your eating habits.

The experiment will take no longer than 1 hour.

You should not take part if you:

- Have diabetes
- HAVE PARTICIPATED IN THE PREVIOUS SNACK & COMPUTER GAME STUDY
- Smoke more than 5 cigarettes per day
- Are dyslexic
- Are currently taking prescription medication, excluding the contraceptive pill
- Prior history of a clinical eating disorder
- Are allergic or have an aversion to any of the foods or food ingredients listed below

Sugar, food flavourings, food colourings, cereal-based products (wheat, oats), dairy products, fruit, nuts, crisps, chocolate.

If you have any queries or concerns, please contact the Principal Investigator: Dr Martin R Yeomans, Department of Psychology, University of Sussex, BN1 9QH. Tel: 01273 678617, email [martin@sussex.ac.uk](mailto:martin@sussex.ac.uk)

Remember, you may withdraw from the study at any time

**Information for Subjects**

**Name:** \_\_\_\_\_

**Signature:** \_\_\_\_\_

**The Purpose of the Experiment**

To investigate the relationship between performance on cognitive computer games.

**What you will be required to do**

You will report to the laboratory on one day between 11.00 am- 1.30 pm in order to complete a battery of tests, which are similar to basic computer games, on the PC's in the Ingestive Behaviour Unit.

The experiment will take no longer than 1 hour. You will be paid £5.00.

**You should not take part if you:**

- Have diabetes
- HAVE PARTICIPATED IN THE PREVIOUS SNACK & COMPUTER GAME STUDY
- Smoke more than 5 cigarettes per day
- Are currently taking prescription medication, excluding the contraceptive pill
- *Prior history of a clinical eating disorder*
- *Are allergic or have an aversion to any of the foods or food ingredients listed below*

Sugar, food flavourings, food colourings, cereal-based products (wheat, oats), dairy products, fruit, nuts, crisps, chocolate.

If you have any queries or concerns, please contact the Principal Investigator: Dr Martin R Yeomans, Department of Psychology, University of Sussex, BN1 9QH. Tel: 01273 678617, email [martin@sussex.ac.uk](mailto:martin@sussex.ac.uk)

**Remember, you may withdraw from the study at any time**

*Appendix 4a: Consent form for Experiment 5*

**The purpose of this experiment**

To investigate factors underlying the relationship between some characteristics and choice behaviour.

**What you will be required to do**

The test is very simple. You will first be required to complete a simple computer based task and complete some questionnaires. The whole test may take 45 minutes.

**Precautions**

**The study is very straightforward and anyone is welcome to participate**

**Rewards**

We are able to enter participants in a draw to win £25.00, and we will provide a snack at the end of the test.

If you have any questions or concerns please contact the Principal Investigator

**Volunteer Consent Form**

I have read and had explained to me the above information. The nature and purpose of the psychological testing has been explained to me. I am aware that I have the right to withdraw from the experiment at any time

I fully understand the nature and purpose of the study and give my consent to participate.

Name: \_\_\_\_\_

Signed: \_\_\_\_\_

Date: \_\_\_\_/\_\_\_\_/\_\_\_\_

*Appendix 4b: The Revised Restraint Scale*

1. How often are you dieting?  
Never; Rarely; Sometimes; Often; Always (Scored 0-4) **CD**
2. What is the maximum amount of weight (in kilos) you have ever lost within 1 month?  
0-2.; 2.5-5.0; 5-7.5; 7.5-10; 10+ (Scored 0-4) **WF**
3. What is the maximum amount of weight gain (in kilos) within a week?  
0-0.5; 0.5-1; 1-1.5; 1.5-2.5; 2.5+ (Scored 0-4) **WF**
4. In a typical week, how much does your weight fluctuate?  
0-0.5; 0.5-1; 1-1.5; 1.5-2.5; 2.5+ (Scored 0-4) **WF**
5. Would a weight fluctuation of 2.5 kilos affect the way you live your life?  
Not at all; Slightly; Moderately; Very Much (Scored 0-5) **CD**
6. Do you eat sensibly in front of others and then splurge alone?  
Never; Rarely; Sometimes; Often; Always (Scored 0-4) **CD**
7. Do you give too much time and thought to food?  
Never; Rarely; Sometimes; Often; Always (Scored 0-3) **CD**
8. Do you have feelings of guilt after overeating?  
Never; Rarely; Sometimes; Often; Always (Scored 0-3) **CD**
9. How conscious are you of what you are eating?  
Not at all; Slightly; Moderately; Extremely (Scored 0-3) **CD**
10. How many kilos over your desired weight were you at your maximum weight?  
0.0-0.5; 0.5-3; 3-5; 5-10; 10+ (Scored 0-4)

### **The Purpose of the Experiment**

To investigate the relationship between appetite and evaluation of snack foods.

### **What you will be required to do**

You will report to the laboratory on one day between 08:00 and 10:00 having drunk only water from 11 pm the night before; a saliva sample will be taken to check compliance with this restriction. The lab is in Pevensey 2, room 4B16

You will come to the lab, where we will serve you a standardized cereal breakfast (Crunchy Nut Cornflakes, or Special K based on your preference).

**You will return to the lab 3 hours after eating breakfast** in order to complete a battery of taste tests, and five short computer games, which will take 1 hour.

You will be reimbursed £5.00 for your time.

### **You should not take part if you:**

- Have diabetes
- HAVE PARTICIPATED IN THE PREVIOUS SNACK & COMPUTER GAME STUDY
- Smoke more than 5 cigarettes per day
- Are dyslexic
- Are currently taking prescription medication, excluding the contraceptive pill
- Lactose intolerant
- *Prior history of a clinical eating disorder*
- *Are allergic or have an aversion to any of the foods or food ingredients listed below*

Sugar, food flavourings, food colourings, cereal-based products (wheat, oats), dairy products, fruit, nuts, crisps, chocolate.

If you have any queries or concerns, please contact me, Margaret Leitch at:  
[m.leitch@sussex.ac.uk](mailto:m.leitch@sussex.ac.uk)

**Remember, you may withdraw from the study at any time**

**The Purpose of the Experiment**

To investigate the relationship between mood and performance on a series of cognitive tasks.

**What you will be required to do**

You will report to the laboratory on one day between 08:00 and 10:00 having drunk only water from 11 pm the night before; a saliva sample will be taken to check compliance with this restriction. The lab is in Pevensey 2, room 4B16

You will come to the lab, where we will serve you a standardized cereal breakfast (Crunchy Nut Cornflakes, or Special K based on your preference).

**You will return to the lab 3 hours after eating breakfast** in order to complete a battery of tests, which are similar to basic computer games on the PC's in the Ingestive Behaviour Unit.

The experiment will take no longer than 1 hour, and you will be reimbursed £5.00 for your time.

**You should not take part if you:**

- Have diabetes
- HAVE PARTICIPATED IN THE PREVIOUS SNACK & COMPUTER GAME STUDY
- Smoke more than 5 cigarettes per day
- Are dyslexic
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*Appendix 6c: National Adult Reading Test*

Chord	Superfluous
Ache	Simile
Depot	Banal
Aisle	Quadruped
Bouquet	Cellist
Psalm	Façade
Capon	Zealot
Deny	Drachm
Nausea	Aeon
Debt	Placebo
Courteous	Abstemious
Rarefy	Detente
Equivocal	Idyll
Naïve	Puerperal
Catacomb	Aver
Gaoled	Gauche
Thyme	Topiary
Heir	Leviathan
Radix	Beatify
Assignate	Prelate
Hiatus	Sidereal
Subtle	Demesne
Procreate	Syncope
Gist	Labile
Gouge	Campanile



### **The Purpose of the Experiment**

To investigate the relationship between mood and performance on a series of cognitive tasks.

### **What you will be required to do**

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