An Investigation of the Neurocognitive Profile of Binge Eating Disorder

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

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Although current interventions for BED are moderately effective, long-term binge abstinence and weight control are a challenge. Adding neurocognitive targets to intervention has the potential to improve treatment for BED, but the neurocognition of binge eating and binge eating disorder (BED) is currently poorly understood. Very preliminary evidence suggests that executive functions (EF), which are comprised of diverse, overlapping frontal lobe processes that enable an individual to engage in self-initiated, healthy, and adaptive behavior may be weak in individuals with BED. Weaknesses in specific processes that may be associated with binge eating are inhibitory control (inhibiting a prepotent response towards a stimuli), cognitive flexibility (the ability to flexibly generate strategies), decision-making (prioritizing immediate versus delayed reward), and working memory (the ability to keep goal-relevant information online). However, at this time, evidence is mixed as to whether individuals with BED show deficits in these areas, potentially due to significant methodological weaknesses in the studies that comprise the current literature. The current study compared several dimensions of EF in a sample of overweight women with (n=31) and without (n=43) full and sub-threshold BED, with the aim of conducting a thorough investigation of the neurocognitive profile of binge eating. A neuropsychological battery (including tests of inhibitory control, cognitive flexibility, delayed discounting, and working memory), a palatable-foods implicit attitudes task, and a self-report measure of food reactivity were administered to all participants before entry into either a behavioral weight loss program

or cognitive-behavioral treatment for BED. Results indicate that after controlling for IQ and age, individuals with BED displayed poorer performance on tasks of executive planning and inhibitory control, and also displayed higher prioritization of immediate versus delayed rewards compared to the control group. The pattern of results remained unchanged when depression was added as a covariate. Full and sub-threshold BED groups did not differ in performance on any executive functioning tasks. Additionally, the combination of less positive implicit attitudes towards highly palatable food and poor inhibitory control was associated with higher frequency of binge episodes in the BED sample. Results suggest a distinct neurocognitive profile associated with binge eating, independent of weight status and frequency and size of binge episodes. Implications include testing of treatment components that target such executive functioning deficits, and future research should examine what deficits predict or moderate outcome in psychological treatments.

CHAPTER 1: INTRODUCTION

Binge eating disorder (BED) is characterized by recurrent binge episodes accompanied by a sense of loss of control (LOC) over eating. BED causes significant psychological distress, is associated with poor long-term outcomes, and is highly comorbid with obesity (Hsu et al., 2002; Wilfley, Pike, Dohm, Striegel-Moore, & Fairburn, 2001). Individuals with BED also have high rates of psychiatric comorbidity, reduced quality of life, and suffer medical complications related to excess body weight (Johnson, Spitzer, & Williams, 2001; Wilfley, Wilson, & Agras, 2003). Recent research has suggested that LOC, rather than binge size (i.e., objectively or subjectively large) or frequency, is the characteristic of a binge episode most associated with psychopathology, distress, and poor outcomes (Latner, Hildebrandt, Rosewall, Chisholm, & Hayashi, 2007; Striegel‐Moore et al., 2000). While some psychological treatments, including Cognitive-Behavioral Therapy and Interpersonal Psychotherapy have achieved modest success in achieving binge-abstinence in the short-term, interventions for BED have not proven especially successful at eliminating binging or achieving weight control in the long-term (Iacovino, Gredysa, Altman, & Wilfley, 2012). The relative lack of efficacy of available treatments could partially be attributable to a poor understanding of the neurocognitive underpinnings of LOC eating. Identification of neurocognitive weaknesses in this population has the potential to better classify risk factors, suggest markers for severity and prognosis, and provide direction for developing more effective interventions.

1.1 Executive Function and Binge Eating

Executive functions (EF) encompass a diverse, overlapping group of higher-level cognitive control processes that enable an individual to perform autonomous, self-organized, and goal-directed behavior. Executive function is what facilitates an individual's ability to "stop to plan and analyze rather than to act" (Singer & Bashir, 1999). Executive dysfunction includes deficits in planning, heightened impulsivity, cognitive rigidity, and problems with shifting attention. Thus, deficits in executive functioning have significant implications for an individual's ability to carry out self-initiated, goal-directed behavior, such as healthy, regulated eating patterns. Preliminary evidence suggests that disordered eating behavior (such as binge eating), and excess weight are associated with relative deficits in several of these executive function dimensions (Fagundo et al., 2012; John Gunstad et al., 2007; Tchanturia et al., 2004). While binge eating and obesity are often comorbid, data from animal research suggests that the development of binge eating is independent of that of obesity. Factors that are specifically associated with the development of binge eating are a history of caloric restriction, and differential responses to past stressors, hunger, and available highly palatable food (Galioto et al., 2012; Hayaki, 2009; Smith, Hay, Campbell, & Trollor, 2011; Svaldi, Naumann, Trentowska, & Schmitz, 2014). In humans, such differences in response to stressors, highly palatable food, and other factors in the environment could be explained by existing differences in executive function.

For example, an inability to balance a desire for immediate comfort with future consequences, and deliberately plan, choose, and execute an adaptive strategy in the context of binge eating cues (e.g. negative emotion, food cues, interpersonal conflict)

potentially represent weaknesses in EF, which may contribute to the development and maintenance of binge eating. Binge eating clearly results in negative consequences, including psychological distress, increased negative affect, and weight gain, but is maintained regardless (Hilbert & Tuschen-Caffier, 2007).

Several related processes that comprise executive functioning could potentially influence binge eating behavior. Cognitive inflexibility (a weakness in shifting mental sets) can lead to an over-focus on eating as a coping strategy in the presence of an uncomfortable internal or external binge cue (e.g., negative mood, food cues). Inhibitory control problems may contribute to the start of a binge in response to a trigger, and the marked drive to continue eating (LOC) until uncomfortably full. Binge episodes often end in physical discomfort and emotional distress, suggesting a prioritization of immediate (i.e., short-term comfort or numbing out of emotions) versus delayed reward in decision-making. Relatedly, difficulties with planning could explain an inability to develop and engage in adaptive behaviors (e.g., a regular eating schedule) that could prevent many instances of binge eating.

However, many executive functioning constructs are multi-dimensional in nature and overlap in their hypothesized influence on eating behavior. Cognitive flexibility, working memory, and inhibitory control are critical components of successful planning and decision-making. In order to parse out the association of binge eating with specific dimensions of executive function (to the extent that this is possible), use of a comprehensive battery with several tasks measuring well-defined constructs is necessary.

Taken together, there are several neuropsychological constructs that deserve investigation within an overweight BED sample. Despite having implications for

treatment development and prognosis, few studies have investigated these neurocognitive variables in a BED sample, as most research thus far has focused on anorexia nervosa (AN) and bulimia nervosa (BN). With the recent addition of BED to the DSM-5, more research is necessary to begin to understand the executive functioning underpinnings of this disorder. Ten studies investigating the neurocognitive profile of BED exist at this time. These studies have displayed some preliminary evidence for relative neurocognitive weaknesses in adults with BED; however, due to differing methodology (e.g. use of just one measure of EF, unreliable screening of binge eating), results have been mixed (see Table 1). The following review, organized by executive functioning construct, details findings from studies that have examined neurocognitive underpinnings of BED.

1.2 Review of Neurocognition of BED

1.2.1 Cognitive Flexibility

Cognitive flexibility refers to an individual's ability to shift cognitive set (i.e., set-shifting). Set-shifting is necessary for generating strategies or behavior patterns that may be most beneficial in specific situations or when there are goals for behavior change. Cognitive inflexibility may lead to habitual behaviors (e.g. binge eating), even when detrimental to a goal (weight control, abstinence from binge eating). For example, individuals with BED may perseverate on the behavior of binge eating as a way to regulate emotion (i.e., to reduce or avoid negative affect) and thus have problems shifting cognitive set to generate and choose a more adaptive strategy than binge eating. Problems with set-shifting during a binge episode may also explain why binge eaters are unable to stop eating even once uncomfortably full. Thus, set-shifting deficits may be a key neurocognitive characteristic in the development and maintenance of LOC eating.

Thus far, evidence for cognitive inflexibility in individuals with BED is mixed. Two studies (Duchesne et al., 2010; Svaldi, Brand, & Tuschen-Caffier, 2010) reported that overweight individuals with BED performed worse on set-shifting tasks compared to overweight individuals without BED, as measured by the Trail Making B and Wisconsin Card Sort (WCST), respectively. Conversely, two studies (Kelly, Bulik, & Mazzeo, 2013; Manasse et al., in press) reported no differences in set-shifting (measured by the WCST and the Penn Conditional Exclusion Task) between a binge eating and non-binge eating sample. However, the Kelly et. al (2013) study used a self-report scale to measure binge eating, which has questionable reliability. This study also utilized a normal weight, college-age sub-threshold binge-eating sample, which may have precluded finding differences between the two groups. Additionally, differences between groups were analyzed using t-scores which are less sensitive to differences than raw scores. Of note, perseverative errors on the WCST was significantly associated with number of binge episodes in this study, indicating that set-shifting warrants further examination as a marker of illness severity (Kelly et al., 2013). The second study that reported no significant differences in cognitive flexibility between binge eating and non-binge-eating groups also used a sub-threshold group, perhaps clouding any differences that may exist. Thus, overall, there is mixed evidence to suggest cognitive flexibility may be relatively impaired in individuals with BED and is an area worth further investigation.

1.2.2. Inhibitory control

Both internal (emotional, cognitive) and external (interpersonal, environmental) cues (Vanderlinden, Dalle Grave, Vandereycken, & Noorduin, 2001) trigger urges to binge eat. Fisher et al. (2003) suggested that high levels of 'urgency' impulsivity (lack of

inhibitory control and the tendency to act rashly in the context of negative affect) is associated with binge eating (Fischer, Smith, & Anderson, 2003). Thus, inhibitory control deficits may serve as a risk factor for binge eating and BED. Additionally, poor inhibitory control could contribute to the experience of LOC, in that individuals with BED have extreme difficulty with discontinuing a binge episode once initiated, even when they wish not to be eating. While obese individuals without BED show inhibitory control deficits compared to normal weight individuals, it is possible that these deficits exist on a continuum, with overweight individuals with BED having a more severe inhibitory control problem than overweight individuals without BED. Mood disorders and impulsive behaviors, such as compulsive gambling, are more common in individuals who engage in binge eating than those who do not (Wiederman & Pryor, 1996), which could point to a more severe behavioral impulse control problem in BED. The high comorbidity of attention-deficit disorder (Cortese, Bernardina, & Mouren, 2007), which is associated with deficits in inhibitory control (Lijffijt, Kenemans, Verbaten, & van Engeland, 2005), also suggests that individuals with BED could have a dysregulated control system. Preliminary evidence from fMRI studies support this notion in that individuals with BED show differential patterns of brain activation in response to food images in the ventromedial prefrontal cortex, inferior frontal gyrus, and insula (Filbey, Myers, & Dewitt, 2012), all of which have been implicated in self-regulation and impulse control.

Additionally, a body of evidence suggests that a pattern extreme restriction of caloric intake throughout the day is related to reduced inhibitory control for individuals with BN, leading to binge eating and purging behaviors. However, it is unclear if restraint itself creates inhibitory deficits, or if the restraint is incidental in this context. Restraint

tends to be less of a central feature of BED than BN, as individuals with BED tend to eat a similar number of calories as obese individuals without BED, outside of binge episodes. However, relationships between reported restraint and inhibitory control should still be examined.

Five studies (Duchesne et al., 2010; Manasse et al., in press; Mobbs, Iglesias, Golay, & Van der Linden, 2011; Svaldi, Naumann, et al., 2014; Wu et al., 2013) thus far have examined response inhibition or inhibitory control in individuals with BED. Two studies have utilized computerized tasks of inhibitory control, i.e., a Go/No-Go Task and a Stop-signal Task, both of which reported significantly poorer inhibitory control in BED groups as compared to controls.

In Mobbs et. al (2011), individuals with BED displayed slower inhibitory response to food-related stimuli compared to obese individuals without BED. Duchesne et al (2010) additionally reported significant differences between BED and non-BED individuals, as in time to complete the Stroop task. In another study (Manasse, et.al, under review), overweight individuals with LOC eating committed more errors on the Stroop task compared to individuals without LOC eating.

Thus far, research supporting inhibitory control deficits in BED is mixed; it appears that food-specific inhibitory control may be particularly relevant to binge eating. Further investigation of this construct, particularly the use of multiple instruments to tap into multiple facets of impulsivity and using neutral and food-based stimuli, is warranted.

1.2.3. Decision-making: Delayed discounting and Poor Risk Evaluation

Decision-making is a multi-faceted construct, comprised of several processes under the umbrella of executive function. Poor decision-making consists of taking

unnecessary risks and prioritizing short-term over long term. Many studies have used neuropsychological tasks (e.g., Iowa Gambling Task; IGT) that tap into several different processes to measure decision-making as a whole. Despite binge episodes often ultimately resulting in increased, rather than decreased, negative affect, individuals with BED likely maintain binge eating behavior due to an immediate negative reinforcement effect of the behavior (Hayaki, 2009). Along with potential inhibitory control deficits and cognitive inflexibility, overvaluation of immediate reward may predispose an individual to make decisions without taking long-term consequences into account (or discounting later reward in favor of smaller, short-term reward). Conditions of uncertainty or risk of later punishment may exacerbate tendency to choose short-term reward in these individuals. Thus, measurement of delayed discounting (preference for immediate, smaller rewards over later, greater rewards) and risk-taking (preference for high-benefit, but high-risk choices over moderate-benefit, but low-risk choices) is warranted in a BED population as important processes that may disrupt adaptive decision-making. Three studies to this point have examined delayed discounting in a binge eating sample, with one reporting differences between groups (Manwaring, Green, Myerson, Strube, & Wilfley, 2011), but two reporting no differences between groups (Galioto et al., 2012; Manasse et al., in press).

Perhaps partially due to use of instruments that do not specifically tap into these constructs, evidence is mixed thus far as to whether individuals with BED show poorer decision-making ability under conditions of risk or uncertainty than individuals without BED. Svaldi et. al's (2010) findings indicated that overweight BED individuals performed worse than overweight controls on the Game of Dice Task, which measures

decision-making under the context of risk (choosing the outcome from rolling two die, with each die representing safe or risky choices). However, two studies (Danner, Ouwehand, van Haastert, Hornsveld, & de Ridder, 2012; Davis, Patte, Curtis, & Reid, 2010) reported no differences in decision-making ability between individuals with BED and overweight individuals without BED (though, in both studies, overweight BED and non-BED performed worse than normal weight controls), as measured by the IGT. Interestingly, however, there was a significant negative correlation between IGT performance and number of binge episodes in the Danner (2012) study. Thus, decision-making ability may possibly be associated with binge eating severity (i.e., frequency of binges). Although initially reporting differences in IGT performance, in Davis (2010), no significant differences existed between any groups once education level was added as a covariate. However, in this study, non-BED overweight individuals had significantly higher BMIs than overweight BED individuals, creating a confound of weight status, given that weight status is robustly associated with neurocognitive performance (Smith et al., 2011). It should also be noted that both the IGT and Game of Dice Task have a learning component (e.g., learning that Decks A & B are "risky" decks), which may cloud measurement of decision-making per se. Given this mixed evidence and methodological flaws in existing studies, this construct is worth further examination in a BED sample. Direct measurement of facets of decision-making, specifically delayed discounting and risk evaluation, is warranted to clarify the relationship between binge eating and decision-making.

1.2.4. Executive Planning

Planning is an important tenant of executive function, in in that deficits could lead to an inability to have optimal strategy selection and use (e.g., utilizing a strategy other than binge eating in an attempt to reduce negative affect, or when faced with a trigger food). Thus, deficits in these areas could help maintain binge eating behavior in that the ability to develop, organize, and execute adaptive behaviors could be compromised. For example, a regular pattern of eating (e.g., eating every 3-4 hours with regular meals and snacks) is a known protective factor against binge eating; however, an inability to plan out meals ahead of time (e.g., get what is needed at the grocery store, make meals to go for work) could lead to dysregulated patterns that can put an individual at risk for binge eating. However, executive planning ability is difficult to measure discretely, given its multidimensionality. Successful planning requires several executive functioning abilities, such as inhibitory control, mental organization, attention, working memory, and abstract thinking.

Planning in a BED sample has only been examined in two studies, both of which reported relative deficits in planning in the BED group compared to controls, Duchesne (2010) used two tasks which measured planning (the Zoo Map Test and the Action Program Test), and Manasse (in press) utilized the Delis Kaplan Executive Functioning System (DKEFS) Tower Task to measure planning. No other studies have explored executive planning BED, indicating an area that warrants further examination.

1.2.5 Working Memory

Working memory refers to an individual's ability to keep goal-relevant information in mind in the face of distractors (e.g., the environment, emotions). Working memory capacity is strongly associated with self-regulation (Hofmann, Gschwendner,

Friese, Wiers, & Schmitt, 2008). The ability to shield goal-relevant information from distraction is particularly important in those who experience binge eating, given the strength of binge eating cues. Weak working memory capacity would predispose an individual to let self-regulative goals (e.g., to not binge eat) be overcome by cues and the desire to start and continue eating. Two studies to date have examined working memory in a BED sample, both of which showing that individuals with BED displayed poorer working memory capacity than individuals without BED (Duchesne et al., 2010). Therefore, further investigation of working memory in a BED sample is warranted.

1.3 Potential Moderators

1.3.1 Implicit Attitudes and Reward Sensitivity

Recent theories of self-control (Hofmann, Friese, & Roefs, 2009) posit that executive functioning (i.e., inhibitory control and working memory) is most associated with enactment of self-regulative behavior for those who have higher implicit liking of a positive stimuli. EF thus would interact with an individual's implicit liking of highly palatable foods, such that those with higher implicit attraction to these foods may require a higher level of executive function to refrain from binge eating than those with lower implicit attraction to palatable foods.

Therefore, an increased attraction to, or liking of, food, particularly to those typically eaten during a binge episode (e.g., high fat, high sugar foods), may predispose an individual to binge eating episodes, especially for an individual with weaknesses in executive function. Likewise, individuals who are more sensitive to the reward derived from food may require a higher level of executive function to abstain from binge eating than those without high sensitivity to food reward. Consequently, the relationship

between binge eating and executive function may be moderated by implicit attitudes towards, or reward sensitivity to, food. Research has indicated differences in implicit attraction to food by BMI and type of food (e.g., high-fat, high-sugar) (Czyzewska & Graham, 2008). However, at this time, it is unknown what relationships exist between implicit attitudes and binge eating.

1.4 Other Factors

1.4.1 Types of Binge Eating

Binge eating has typically been conceptualized as an impulsive behavior (i.e., a sudden urge that one is unable to control). However, anecdotal evidence suggests that some individuals who binge eat "plan" binges, for example, making a trip to a grocery store to purchase foods to eat during a subsequent binge. No study to date has examined differences in the types of binge eating that individuals engage in (e.g., planned vs. unplanned).

We propose the creation of an exploratory measure that will investigate the extent to which individuals with BED plan binges, or, engage in binges in an impulsive manner. We will examine possible differences in groups who engage in one type of binge eating more often than another. These differences may include specific neurocognitive abilities, such as inhibitory control. For example, an individual with poor inhibitory control may be more likely to engage in unplanned binge eating, due to unexpected presence of a trigger food. Additionally, an individual who is more heavily restricting their food intake may also be more likely to engage in unplanned binge eating due to extreme hunger.

1.5 The Current Study

The current study was designed with the aim of painting a more accurate presentation of the neurocognitive profile of binge eating. We aimed to accomplish this through several methods, including assessment of binge eating behavior and eating disorder symptomatology through a semi-structured interview (the most well-validated method), well-defined executive functioning constructs with a selection of tasks that are most sensitive to differences in these areas, and use of a comprehensive neuropsychological battery that measures several of the overlapping constructs within the umbrella of executive function. Also, given converging evidence that clinically significant binge eating exists on a continuum, we examined the relationship between neurocognitive performance and binge eating both discretely and continuously.

1.6 Aims and Hypotheses

1.6.1 Primary Aims:

1. To investigate whether executive functioning differences exist between overweight individuals with LOC eating and overweight individuals without LOC eating.
    a. *Primary Hypothesis 1*: Overweight individuals with LOC eating will perform worse on neurocognitive tasks compared to overweight individuals without LOC eating, in the areas of cognitive flexibility, inhibitory control, planning, and decision-making.
2. To investigate whether binge eating severity (as measured by frequency of binge episodes) is associated with deficits in executive functioning.

   a. *Primary Hypothesis 2:* Neurocognitive performance will be negatively associated with severity, as measured by binge frequency.

3. Should a sufficient number of LOC participants who meet full DSM-5 criteria for BED (average of one objective binge episode per week for the past three months) exist in the sample, to compare neurocognitive performance among three overweight groups: DSM-5 BED, sub-threshold BED, and individuals without binge eating.

   a. *Primary Hypothesis 3:* Both DSM-V BED and sub-threshold BED will perform worse on neuropsychological tasks than controls, with full-threshold performing worse than sub-threshold BED participants.

1.6.2. Secondary Aims

1. To explore whether implicit attitudes moderate the relationship between performance on neuropsychological tasks, (specifically inhibitory control and decision-making) and binge eating frequency.

   a. *Secondary Hypothesis 1:* Implicit attitudes will moderate the relationship between performance on tasks measuring inhibitory control (i.e., SSRT and Color-Word Interference) and binge eating frequency

   b. *Secondary Hypothesis 2:* Implicit attitudes will moderate the relationship between performance on tasks of decision-making (Balloon Analogue Risk Task and Delayed Discounting) and binge eating frequency.

2. To examine whether implicit attitudes towards highly palatable foods differ between overweight individuals with and without LOC eating.

a. *Secondary Hypothesis 3:* Individuals with LOC eating will have more positive implicit attitudes towards highly palatable food than individuals without LOC eating.

1.6.3 Exploratory Aims

1. *Exploratory aim 1:* To examine whether individuals with LOC eating primarily engage in subtype of binge eating or another, specifically, e.g., planned or unplanned binge eating.
2. *Exploratory aim 2:* If individuals with LOC eating primarily engage in one primary subtype of binge eating (e.g., planned) or another, to evaluate whether such subtypes are associated with distinct characteristics, such as a distinct neurocognitive profile or different patterns of dietary restraint.

CHAPTER 2: METHODS

2.1 Participants

The current study included overweight (BMI > 26) adults who had significant LOC eating symptomology in the preceding three months (minimum four subjective binge episodes per month over past 3 months) and a control group of overweight adults without any LOC eating in the past three months. Overweight controls and individuals with LOC eating were recruited from a behavioral weight loss trial being conducted in our laboratory, and individuals with BED were recruited from an ongoing treatment trial for BED.

2.1.1 Recruitment

Recruitment took place over the course of one year (June 2013- May 2014). For the individuals entering the weight loss trial, the neuropsychological battery and binge eating screening were included as part of a baseline assessment prior to acceptance and entry into the intervention. Participants were not paid directly for this assessment, but did receive payment for a second baseline appointment and future assessment points throughout the trial (as well as receiving free treatment).

Individuals entered the study via psychotherapy trial for BED[1], and underwent a baseline assessment in which the neuropsychological battery, binge eating screen, and questionnaires were administered. Participants recruited from the BED trial were paid $50 for completing the assessment. Recruitment for the behavioral weight loss and binge eating trials took place through sources in the community (e.g., radio ads) and Internet. Flyers were key locations throughout the Philadelphia area (e.g., grocery stores, gyms). Announcements were also posted to relevant websites and listservs (e.g., Academy for Eating Disorders, Binge Eating Disorder Association). Clinicians and eating disorder treatment centers in the area (e.g., University of Pennsylvania Center for Eating and Weight Disorders, Renfrew Treatment Center) received information about all studies.

[1] It was originally proposed that recruitment include individuals who were seeking treatment and those who were not seeking treatment. However, virtually all those in the second category appeared (by clinician judgment) to have low interested in entering a treatment study and described their symptoms inconsistently, even within the same interview. Thus, it was concluded that these participants were motivated by monetary purposes to endorse binge eating. As a result, it was decided to restrict recruitment to those seeking treatment for binge eating.

2.1.2. Inclusion and Exclusion Criteria

All participants were overweight or obese adults (BMI > 26), between the ages of 18 and 70[2]. The following criteria must have been met for the individual to qualify for the current study: a) ability to give consent, b) ability to speak, write, and understand English, c) any psychiatric medication must have been stable for three months.

Overweight control participants must have been a) free from any LOC eating episodes in the past 3 months, and b) had no current or past history of binge eating or an eating disorder. BED participants must have endorsed an average of at least one subjective or objective binge episode per week over the past three months (12 total binge episodes over the past 3 months), and must not meet criteria for BN (i.e., regularly engage in compensatory behaviors, such as self-induced vomiting, laxatives, excessive exercise). Size of binge episodes were evaluated using criteria developed by Cooper & Fairburn (1987).

Individuals were excluded from the study if they had a history of neurological condition or traumatic brain injury.

2.2 Procedures

Participants who entered the study via a behavioral weight loss intervention came to Drexel University for a 2.5-hour clinic visit appointment which included the neuropsychological battery and EDE binge eating screen, both of which were

[2] While it was originally proposed that the maximum age was 60, this cut-off was raised to 70 because of recruitment concerns. Given concerns about neurocognitive differences among those between the ages of 61-70, all key analyses were re-run without this older group. These results were nearly identical to the first set. We additionally controlled for the effect of age in analyses.

administered by a trained assessor[3]. Between the clinic visit and baseline appointment for the weight loss trial, participants were sent a link to complete self-report questionnaires through a secure survey website.

Participants who entered the study via a BED intervention study came to Drexel for a 3-hour appointment after having met basic criteria as determined by a phone screen. During the assessment, participants were administered the EDE, neuropsychological assessments, all by a trained assessor. Participants were sent a link to complete self-report questionnaires through a secure survey website before the first session of the BED treatment trial.

A licensed clinical psychologist supervised all neuropsychological assessment, and order of neuropsychological tasks were counterbalanced to control for order effects. Specifically, order of administration of computer tasks was randomly generated for each participant.

2.3 Measures

Eating Disorders Examination (EDE) Version 16D (Zafra Cooper & Fairburn, 1987): The EDE is a standardized semi-structured interview, measuring the severity and frequency of the characteristic psychopathology and key behaviors of eating disorders during the past 4 weeks or, for diagnostic items, the previous 3 months. Inter-rater reliability between trained interviewers and test-retest reliability is high (Rizvi, Peterson, Crow, & Agras, 2000) and the measure has good internal consistency among eating

[3] Several participants were excluded from the control group. Two reasons for exclusion included: 1) male gender, given no male individuals with BED were recruited, and 2) exclusion from the weight loss trial prior to completion of the neuropsychological battery.

disorder samples (Z. Cooper, Cooper, & Fairburn, 1989). The BED module of the EDE is considered the most reliable method for screening for objective and subjective binge eating episodes (Grilo, Masheb, Lozano-Blanco, & Barry, 2004; Wilfley, Schwartz, Spurrell, & Fairburn, 1997).

Weight and Height: A calibrated scale was used to take participants' weight. A stadiometer will was used to measure participants' height at the (to be used to calculate BMI).

Beck Depression Inventory-II (Beck, Steer, & Brown, 1996) : The BDI is a self-report measure of depression symptomatology in the previous two weeks. The BDI-II has adequate test-retest reliability and high internal consistency, and convergent validity has been established (Dozois, Dobson, & Ahnberg, 1998; Steer, Ball, Ranieri, & Beck, 1997).

Eating Disorders Examination Questionnaire (Fairburn & Beglin, 1994): The EDE-Q is a validated, short-form, self-report version of the EDE that has demonstrated reliability for the four subscales of the EDE (Restraint, Eating Concerns, Weight Concerns, and Shape Concerns) (Peterson et al., 2007).

Wechsler Test of Adult Reading (WTAR) (Wechsler, 2001): The WTAR is a reading recognition test used as a measure of estimated verbal intelligence. Using the normative data from the co-norming sample, WTAR scores can be converted to Full

Scale IQ (FSIQ) estimates. The WTAR has strong correlations (.70–.80) with WAIS-III FSIQ scores for a wide age range of WTAR scores *(Wechsler, 2001)*.

Cognitive Flexibility

Penn Conditional Exclusion Task (PCET)(Kurtz, Ragland, Moberg, & Gur, 2004): The PCET is a computerized task measuring cognitive flexibility, specifically set-shifting. It consists of four figures oriented horizontally on the screen, in which the subject is required to use the mouse to click on the figure that is different from the other three. For each trial, the participant selects one of the four items that does not belong with the other three based on one of three separate criteria. Upon selecting an item, the participant is presented with immediate feedback via a screen stating that their choice is "correct" or "incorrect" for 500ms. The PCET has been shown to have good construct validity (Kurtz et al., 2004).

Inhibitory Control

Delis-Kaplan Executive Functioning System (D-KEFS) (Delis, Kaplan, & Kramer, 2001): The D-KEFS evaluates executive functioning and has been normed for individuals aged 8 to 89 years.

D-KEFS Color-Word Interference Task: Color-Word Interference task is a Stroop task presented on flash cards. The task consists of four trials: 1) Participants are presented with blocks of color and are told to name the colors, 2) Participants are presented with words and told to read the words, 3) Color names written in dissonant color ink, and participants are told to name the color of the ink (and not read the word), 4) Same

instructions as 3) except if a word is in a box, participants are to read the word (and not name the ink color). This task assesses response inhibition in the presence of distractors.

Stop- Signal Reaction Time Task (SSRT)(Logan, 1994): The SSRT measures response inhibition across different types of stimuli. The SSRT involves repeated trials in which a blank screen is presented for 500ms, followed by an image on the top or bottom half of the screen for 1000ms. Participants are instructed to respond as fast as possible by pressing a left or right response key (on the keyboard) upon seeing the image on the top or bottom of the screen (whether the individuals presses the left or right key for top or bottom will switch between trials). During stop trials (prompted by an auditory tone through headphones) the trained response must be inhibited. The delay between the go and stop signal was initially set at 250ms, and depending on the participants performance it was be either increased or decreased by 50ms such that the task becomes more or less difficult (i.e., success at inhibition will prompt a decreased interval between stop times). First, there were two trials of neutral image stimuli (e.g. scissors), then two trials of pleasant stimuli (e.g. flowers), then two trials of highly palatable food stimuli (e.g. pizza). We used varied stimuli to reveal whether differences in inhibitory control depend on the stimuli.

Evaluation of risk

Balloon Analogue Risk Task (BART) (C. W. Lejuez et al., 2002): The BART is a computerized measure of risky decision-making. The BART is presented on a computer screen, which includes a small simulated balloon accompanied by a balloon pump button,

a ‘‘collect’’ button for stopping and getting money earned until that time (temporary bank) and an indicator presenting permanent money (permanent bank). The balloon inflates and the participant earns $.05 with each pump, and the task includes 10 trials. In each trial, the participant can stop pumping at any point and click on the collect button for transferring all points from the temporary bank to permanent bank. If the balloon explodes, the participant loses all collected money. Participants were told they will not receive the money they earn, but to play as if they were receiving the money. The BART has good construct validity (Hunt, Hopko, Bare, Lejuez, & Robinson, 2005), adequate test-retest reliability (White, Lejuez, & de Wit, 2008), and has been shown to predict real-life risk taking behavior (C. Lejuez, Aklin, Zvolensky, & Pedulla, 2003).

Delayed discounting

Delayed Discounting Task (DDT) (Robles & Vargas, 2007): This task will be a commonly used computerized monetary discounting task. Hypothetical monetary rewards were used because previous studies have shown that hypothetical monetary amounts produce results comparable to those obtained with real monetary amounts (Madden, Begotka, Raiff, & Kastern, 2003). Participants were asked in a series of trials to choose between two monetary amounts (by clicking on “z” or “m”), a variable amount that could be received immediately and a fixed, larger amount to be received after varying delays. For each delay, the choices presented were titrated to quickly determine each indifference point, or that point at which the subjective value of the delayed reward was equal to the amount of the immediate reward.

Planning

D-KEFS Tower Task (Delis, Kaplan, & Kramer, 2001): The tower task measures planning ability. The test requires participants to build a series of nine towers that become progressively more difficult. The apparatus includes a three-peg base and five colored disks that vary in size from small to large. For each item, participants are given the base with disks placed in a prearranged manner and are shown a picture of what the tower's ending position should look like. They are instructed to build the tower using as few moves as possible. All trials are timed. They are given two rules to follow: Move only one piece at a time using just one hand, and a larger disk may never be placed on top of a smaller disk.

Working Memory

Penn Letter N-Back Task (Ragland et al., 2002): The Letter N-Back is a commonly-used computerized task that measures working memory capacity in three conditions. In the 0-back condition, participants respond (by clicking the spacebar) to a single target (i.e.,*X*) on the screen. During the 1-back condition, participants responded if the consonant presented on the screen was identical to one preceding it. In the 2-back condition, participants responded if the letter was identical to one presented two trials back. Prior to starting to task, participants went through a "practice" round to ensure understanding of the directions.

Effort

Digit Span ((Wechsler, 1955): To ensure appropriate effort is devoted to the task, we intended to include the Digit Span from the Weschler Adult Intelligence Scale, using the Reliable Digit Span (RDS) to determine level of effort. However, this measure was inadvertently left out of the testing battery, and thus was not administered to any participants.

Implicit Attitudes

Implicit Attitudes Test (IAT) (Greenwald, McGhee, & Schwartz, 1998): The IAT requires participants to respond quickly to images on a computer screen so that immediate and uncensored association between two ideas is assessed. This version of the IAT measured implicit positive and negative associations with high calorie foods. In the instructions, participants were presented with 3 categories ("good," "bad," and food). Participants were to use the categories and respective keys (either "e" or "i") to sort the images into categories. Participants were instructed to move as quickly and accurately as possible. In each of the five trials, stimuli were presented in the center of the screen for 2000 ms, preceded by an inter-stimulus white box for 500ms. Participants are to place the stimuli into categories using keys on the keyboard. A longer response time in the task is representative of an association inconsistent with beliefs (e.g., pairing "negative" pictures with food), and a shorter response time is representative an association consistent with beliefs (e.g., pairing a "positive" picture with food).

Impulsivity

UPPS Impulsivity Scale (UPPS)(Carver & White, 1994): The UPPS is a 45-item self-report scale that measures impulsivity across the 5-Factor Model of personality. There are four subscales: Premeditation (Lack of; acting without thinking), Urgency (the tendency to act rashly when experiencing negative affect), Sensation-Seeking, and Perseverance (Lack of; the tendency to not complete a task).

Food Cue Sensitivity

Power of Food Scale (PFS) (Lowe et al., 2009): The PFS is a self-report measure which assesses the extent to which the availability or presence of highly palatable foods influences a person's food-related thoughts and feelings. The PFS has adequate internal and test-retest reliability and convergent and discriminant validity (Lowe et al., 2009).

Planned Binge Eating

We included two exploratory questions asking the extent to which individuals plan binge eating episodes in advance. These questions included: 1) "Do you know more than an hour in advance that a binge eating episode will occur?" 2) "Do you take steps to plan for, or to facilitate binge eating episodes to occur (e.g., grocery shopping specifically for food to eat during a binge, setting aside time for the binge to occur)?" Responses were recorded on a 5-point Likert scale of "Never" to "Always." These questions were developed after consultations with clinicians who treat binge eating disorder.

2.4 Data Analysis

Statistical Package for the Social Sciences (SPSS) v. 20.0 (IBM, 2013) was used to analyze data. All dependent variables were examined for skew. Where detected (i.e., DDT area-under-the-curve and all Color-Word Interference variables), variables were log transformed, and analyses were conducted using both non-transformed and transformed variables. Results using Color-Word Interference transformations did not substantively alter results; thus results using non-transformed variables are reported below for simplicity.

Data from the SSRT presented several serious issues. First, order of stimuli presentation appeared to impact results. Unfortunately, order was not counterbalanced, so data comparing SSRT scores between stimuli is confounded, rendering us unable to examine these hypotheses. Secondly, upon descriptive analyses, it was clear the data were presenting with inconsistent associations that are indicative of a likely error by the program in calculating scores. Thus, data from SSRT are not included in analyses.

2.4.1. Power Analyses

For primary hypotheses 1 and 3, G*power (Faul, Erdfelder, Lang, & Buchner, 2007) recommended 128 participants to obtain 0.80 power, assuming a medium effect size. For primary hypothesis 2, G*Power recommended 74 participants to obtain .80 power, assuming a medium effect size. However, given resource and recruitment limitations, a target of 60 participants was set. In fact, a total yield of 74 participants was achieved. Thus a priori power calculations (assuming medium effect sizes) ranged from .56-.80. Given the preliminary nature of the study, we emphasize effect sizes rather than statistical significance in study analyses. For ANCOVA and regression analyses, partial

eta squared (.03 = small, .06 = medium; .14 = large) was used as a measure effect size, and for t-tests, Cohen's *d* (.2 = small, .5 = medium, .8 = large) was used.

2.5 Ethical Issues

The study protocol was approved by Drexel University's Institutional Review Board (IRB) prior to the start of the study. All participants underwent informed consent for each of the respective treatment studies, which included consent to complete the assessments described above. We assigned participant numbers to each individual, which was used to label data. Thus, participant personal identifying information was not associated with the collected data. Also, all data and consent forms were stored in a locked filing cabinet.

No unforeseen risks or adverse events arose during the study.

CHAPTER 3: RESULTS

3.6 Participant Characteristics

Sample demographics and clinical characteristics are presented in Table 2. No differences in BMI or IQ were observed between groups. Consistent with previous research, the BED group (which included all individuals with significant LOC eating regardless of diagnostic categorization; $n = 31$) was significantly more depressed and presented with higher levels of eating disorder psychopathology (including Weight Concern, Dietary Restraint, Eating Concern) than the OWC ($n = 43$) group. In addition, the BED group was significantly younger than the OWC group. The two groups did not significantly differ in estimated IQ or BMI. Recruitment sources for each group are detailed in Table 3.

Because previous examinations of executive function in BED have inconsistently controlled for depression (despite the well-documented difference in depression between overweight BED and non-BED groups), analyses were run with and without depression as a covariate. This allowed for comparison of results to existing literature. Age was included as a covariate to control for pre-existing group differences in age and because of age's association with neurocognitive performance (Salthouse, Atkinson, & Berish, 2003). IQ was also included as a covariate, given its association with performance on several neurocognitive tasks in our sample. We considered including BMI as a covariate, however, we ultimately felt it unnecessary given that BMI did not differ between groups, and was not associated with any of the dependent variables.

3.7 Primary Aims

3.7.1 Executive Functioning Differences Between Groups

We hypothesized that the BED group would perform worse on all executive functioning tasks compared to the OWC control group. ANCOVA results (with age and IQ as covariates) comparing groups are listed in Table 4. Analyses revealed the BED group, compared to the OWC group, displayed significantly steeper monetary discounting on the DDT, and performed significantly worse on the tower task (as measured using Achievement Score, an index of number of moves taken to complete a tower), The two groups did not appear to differ on number of errors made on the Color-Word Interference Task; however, the BED group was significantly slower to complete the Inhibition condition and the Inhibition-Switch condition. No differences were detected between groups in cognitive flexibility, as measured by percent perseverative errors committed on the PCET, working memory, as measured by N-back efficiency score (an index of accuracy and response time on the task), or risk-taking as measured by the average adjusted pump count on the BART. Re-analyses with depression as a covariate did not appear to meaningfully alter the results of any analyses.

3.7.2 Executive Function as a Predictor of Frequency of Binge Episodes

Multiple regression analyses with a single predictor variable and two covariates (age, IQ) were conducted to examine individual relations of different executive function variables on total number of OBEs and SBEs. We hypothesized a negative relation between executive functioning performance and frequency of binge episodes. Unexpectedly, no relation was evident between frequency of binge episodes and any of the EF variables including delayed discounting ($F(1, 21) = .07$, $p = .79$, $\eta^2_p = .04$), Tower

task performance ($F(1,27) = .06$, $p = .81$, $\eta^2_p < .01$), Color-Word Task errors ($F(1,27) = .05$, $p = .82$, $\eta^2_p < .01$), Color-Word Inhibition time ($F(1, 27) = .01$, $p = .91$, $\eta^2_p < .01$), Color-Word Inhibition-Switch time ($F(1, 27) = 1.00$, $p = .33$, $\eta^2_p = .04$), adjusted average pumps on the BART ($F(1, 23) = .26$, $p = .62$, $\eta^2_p = .01$), N-back efficiency score ($F(1,23) = .04$, $p = .85$, $\eta^2_p < .01$), and percent perseverative errors on the PCET ($F(1, 23) = .52$, $p = .48$, $\eta^2_p = .02$).

3.7.3 Comparing Executive Function among Full and Sub-threshold Groups

Within the BED sample, 22 met full criteria for BED (full-BED) while nine were categorized into the sub-threshold group (sub-BED). As detailed in Table 5, the BMI and IQ, of the three groups appeared equivalent, but the full-BED group was younger than both the sub-BED and OWC groups. Consistent with previous research, the full and sub-threshold groups appeared to not differ in levels eating disorder pathology as measured by the EDE-Q (Crow, Agras, Halmi, Mitchell, & Kraemer, 2002).

In terms of EF, the three groups differed from each other on rate of discounting on the DDT, Tower Task Achievement Score, and on time to complete the Inhibition and Inhibition-Switch Conditions of the Color-Word Task, but differences were not apparent on other EF variables (Table 6). Consistent with hypotheses, post-hoc analyses revealed that the OWC group performed the best of the three groups on all tasks; however, we did not obtain support for the hypothesis that full-BED and sub-BED groups would differ in executive function, as determined by negligible to small effect sizes.

3.8 Secondary Aims

3.8.1 Between-group Differences in Implicit Attitudes and Food Cue Reactivity

A small and statistically non-significant difference BED and OWC groups was detected in implicit attitudes towards highly palatable foods, as measured by the IAT, $t(57) = .96$, $p = .34$, $d = .27$. However, consistent with hypotheses, the BED group displayed significantly higher food cue reactivity than the OWC group, as measured by the PFS, $t(59) = 4.54$, $p < .01$, $d = 1.27$, with a large effect size.

2.8.2 Interactions Between Implicit Attitudes and Executive Function on Binge Eating Frequency

Implicit attitudes significantly moderated the relation between delayed discounting and total number of OBEs and SBEs within the BED group, $F(1,11) = 5.12$, $p = .04$, $\eta^2_p = .32$ (see Figure 1). As expected, steeper discounting predicted greater frequency of binge episodes, but only for those with higher implicit attitudes towards highly palatable foods. It additionally appeared that for those with lower levels of liking, discounting was not associated with binge eating frequency. However, one unexpected pattern in this interaction effect was that the combination of positive implicit liking with lower levels of discounting resulted in the fewest number of binge episodes.

A medium moderation effect of balloon task pumps and implicit attitudes was observed, but the effect did not reach significance ($F(1, 12) = 1.53$, $p = .24$, $\eta^2_p = .11$; see Figure 2). This relation was in an unexpected direction such that number of balloon pumps positively predicted number of binge episodes, but the effect was stronger for those with positive implicit attitudes. Implicit attitudes did not appear to moderate the

relation between Color-Word Task errors and number of binge episodes, $F(1, 13) = .02$, $p = .88$, $\eta^2_p < .01$.

We did not obtain support for the hypothesized interaction between delayed discounting and frequency of binge episodes, $F(1, 12) = .01$, $p = .91$, $\eta^2_p < .01$, or number of balloon pumps on the BART and frequency of binge episodes, $F(1, 13) = .22$, $p = .65$, $\eta^2_p = .02$ or Color-Word Errors , $F(1, 14) = .62$, $p = .34$, $\eta^2_p = .01$

3.9 Exploratory Aims

3.9.1 Planning

In the BED group, 18.2% of participants reported "very often" or "always" having advanced knowledge that a binge episode would occur, 45.4% reporting "sometimes" more than an hour in advance, and 27.2% "never" or "rarely" knowing more than an hour in advance. For the second planning question, 61.8% of participants reported taking behavioral steps (e.g., grocery shopping, setting aside times for binge episodes to occur) to facilitate the occurrence of binge episodes from the range of "often" to "always," while the remainder reporting doing so "rarely," "never," or "sometimes."

Due to low sample size of individuals completing these questionnaire items (n=11; several individuals were lost to follow up after completion of neuropsychological assessment, and sub-threshold participants recruited via the behavioral weight loss study did not complete these items), Pearson's *r* correlation coefficients of each planning question with key variables were examined. As per Table 7, both items were strongly associated with eating disorder psychopathology as measured by the EDE-Q; the advanced knowledge item generally being negatively associated with ED pathology and the behavioral facilitation item positively associated.

Exploratory correlations of planning questions with neurocognitive variables were also examined. Advanced knowledge of a binge episode was negatively associated with inhibitory control, and positively associated with perseverative errors, and steeper monetary discounting, while behavioral facilitation of binge episodes was positively associated with planning and negatively associated with risk-taking (See Table 6).

CHAPTER 4: DISCUSSION

The current study sought to elucidate the neurocognitive profile of binge eating by comparing several different facets of executive functioning between an overweight binge eating and non-binge eating group. In addition, we examined relations of executive functioning and implicit attitudes towards highly palatable food intake on binge eating frequency, and investigated whether types of binge eating (i.e., planned or non-planned) had an effect on the neurocognitive profile of individuals with BED.

4.1 Group Differences in Executive Function

Overall, the current study supported the hypothesis that overweight individuals with BED display deficits in executive function compared to overweight individuals without BED, specifically in the areas of planning, delayed discounting, and inhibition/self-regulatory control. However, we did not obtain support for hypothesized differences between groups in set-shifting, working memory, or risk-taking. Our findings of an executive planning deficit in a BED sample are consistent with the two other existing examinations of planning in a sample with LOC eating (Duchesne et al., 2010; Manasse et al., in press).

Observed executive functioning deficits may help to explain the development and maintenance of binge eating. For example, poor executive planning ability may contribute to irregular eating patterns (e.g., going long periods of time without eating, skipping meals and snacks) that lead to extreme hunger, thus increasing susceptibility to LOC eating. In addition, given the multidimensionality of the executive planning construct (completion of the Tower Task requires focused attention, working memory,

and ability to stay within rules during completion) poorer performance on this task by the BED group may represent a deficit in the ability to simultaneously utilize several executive functioning processes (e.g., rule learning, inhibition, and maintaining cognitive set) to develop and execute planned behavior. Such deficits could be particularly relevant in the maintenance of binge eating; overeating and binge eating more generally appears to develop in response to dietary restriction or as a coping strategy in the context of negative emotion, but deficits in planning and delayed discounting may be especially relevant in maintaining, and difficulties changing, such behavior.

The current study additionally provided support for the hypothesis that LOC eating may, in part, be driven by overvaluation of immediate versus delayed reward. This finding is consistent with one study examining delayed discounting in a BED sample (Manwaring et al., 2011); however, two other studies failed to detect differences in this variable between groups (Davis et al., 2010; Manasse et al., in press), although these studies were characterized by methodological idiosyncrasies that had the potential to cloud detection of differences (e.g., BMI inequivalence between groups, use of a primarily sub-threshold BED sample). Binge eating may serve the purpose of numbing, or escaping from, negative emotions, or otherwise providing a sense of comfort or pleasure. Binge eating behavior thus provides short-term gratification, but at the expense of long-term consequences (e.g., feelings of guilt, fullness, and weight gain). More steeply discounting future, greater rewards in exchange for smaller, sooner rewards could serve as both a risk and maintenance factor for binge eating. For example, abstaining from binge eating, once established as a learned behavior, requires ability to give up short-term reward of eating and tolerate the discomfort of negative affect, urges, and

cravings in order to reap later rewards of not engaging in binge eating behavior (e.g., prevention of weight gain and reduced feelings of guilt).

Consistent with several previous studies (Manasse et al., in press; Mobbs et al., 2011; Svaldi et al., 2010), our results indicate that those with BED have weaker inhibition and self-regulatory capabilities. Deficits in inhibitory control may increase susceptibility to binge eating, particularly in food environments where palatable food, or food associated with past binge episodes, is available. In the current study, the BED sample did not make significantly more errors in the Color-Word Task than the OWC group. However, the BED group showed slower performance on the Inhibition and Inhibition-Switch Conditions, suggesting that binge eating may be characterized by a reduced ability to quickly recruit inhibition processes, or that increased effort is necessary to do so. This finding of similar accuracy, but slower performance, on a Stroop task is consistent with a recent study which reported that individuals with BED showed diminished activation in brain regions implicated in impulse control, including the ventromedial pre-frontal cortex and inferior frontal gyrus, during the Stroop Task (Balodis et al., 2013). Thus, individuals with BED may have lessened ability to quickly enact inhibitory processes, including in the context of impulses to continue eating. Lessened ability to enact inhibitory processes may be especially pertinent in the presence of highly palatable foods or negative affect.

Given that depression is associated with neurocognitive deficits (Porter, Gallagher, Thompson, & Young, 2003) and is highly co-morbid with binge eating (Grucza, Przybeck, & Cloninger, 2007), we repeated analyses with depression as a covariate in the event that depression explained any differences between groups. Overall,

adding depression as a covariate did not change the pattern of results, with the exception of slight attenuation of level of statistical significance to trend level for the group differences in delayed discounting and inhibitory control (although effect sizes remained similar). The attenuation of effects observed when depression was added to the model could be due to co-morbid depression partially explaining executive functioning differences between groups; however, an alternative explanation is that depression in this group is inextricably linked with binge eating behavior (i.e., depressive symptoms are a result of binge eating, and could remit alongside the disorder). Thus separately accounting for variance explained by depressive symptoms may not be the optimal method through which to parse out executive functioning characteristics specifically pertaining to binge eating.

We did not obtain support for hypothesized differences between groups on working memory, cognitive flexibility, and risk-taking. Lack of differences in working memory and cognitive flexibility are inconsistent with previous studies (Duchesne et al., 2010), but consistent with several others (Kelly et al., 2013; Manasse et al., in press). One possible reason for this is the marked lack of consistency of set-shifting and working memory tasks used in the literature. This raises the possibility that 1) different tasks tap into slightly different facets of cognitive flexibility and working memory; and 2) it is possible that such deficits in individuals with BED may be specific to food or emotional stimuli, which may not be detected by traditional EF tasks with neutral stimuli. For example, a recent study observed a memory bias for words with body/shape-related stimuli in those with BED (Svaldi, Schmitz, et al., 2014). It is also possible that a different tenant of cognitive flexibility may be more relevant to binge eating, such as a

bias towards local versus global processing (central coherence), which has been shown to be impaired in other eating disorder populations (Lopez, Tchanturia, Stahl, & Treasure, 2008). Additionally, given the mixed results in the literature thus far, it is possible that set-shifting or working memory deficits may serve as a risk or maintenance factor for obesity and dsysregulated eating behavior more generally, and is not binge eating specific. Lack of differences in risk-taking may indicate that poor evaluation of risk does not underlie binge eating; in fact, for a subset of BED patients, engaging in binge eating behavior may be a risk-averse behavior, as it allows an individual to engage in a behavior that is comforting in the short-term, perhaps a perceived "safer" option than experiencing distressing thoughts and feelings.

The fact that differences were observed between groups on some variables suggests that EF deficits underlie binge eating. However, an alternate explanation is that the weight-matched sample utilized were exhibited unusually strong EF. As a partial and informal method of evaluating this alternative explanation, OWC means were compared against available norms for the D-KEFS Tower Task and Color-Word Interference Task (Delis et al., 2001). These means fell at or about the 50th percentile, suggesting that the OWC sample was, in fact, "average." The BED sample means were, of course, lower, but were also well within "average" range.

The clinical significance of observed group differences is difficult to assess, but use of a treatment-seeking sample may lead to an underestimation of differences between groups, and/or an overall overestimation of overweight and binge eating samples' performance compared to group norms. However, threshold of >1.5 SDs difference has

been used as a marker of clinical significance in previous studies (J Gunstad et al., 2007), which is greater than the differences observed in the current study.

4.2. Associations of Executive Function with Binge Eating Frequency

The current study additionally sought to test the hypothesis that executive functioning capacity would be negatively associated with binge eating severity, as measured by frequency of binge episodes. However, our results suggest that executive functioning was not predictive of total number of binge episodes, as demonstrated by negligible to small effect sizes in all analyses. Given that participants are asked to retrospectively recall frequency of binge episodes, these data may not be accurate, due to either poor recall or to the embarrassment of reporting binge episodes. It is additionally possible that while executive functioning deficits play a risk or maintenance factor role for binge eating pathology, they are not be as relevant as other factors (e.g., level of dietary restriction, emotion regulation skills) in determining how often an individual engages in binge eating. Another possibility is that frequency and size of binge episodes are not valid proxies for illness severity, and that other variables should be examined in conjunction with executive function as potential severity markers. Possible severity markers of binge eating include degree of perceived loss-of-control over eating (using continuous measurement rather than dichotomous categorization), degree of distress caused by binge eating, and quality of life impairment.

4.3 Comparison of Full and Sub-threshold BED Groups

Given that not all participants in the current study met full criteria for DSM-5 BED, we sought to compare executive functioning among full-threshold, sub-threshold, and control groups, with the hypothesis that full-threshold groups would perform worse

than sub-threshold groups, with both groups performing worse than the OWC group. Overall, these hypotheses were not supported. Although the BED group as a whole, including sub-threshold groups, performed worse than the OWC group on several tasks of executive function, post-hoc analyses suggested that the BED and sub-BED groups did not significantly differ from each other in performance on any task, as evidenced by small effect sizes. Consistent with previous findings, results suggest that any executive functioning deficits found in BED groups may pertain more to the presence of LOC, than to size or frequency of binge episodes. The findings that full and sub-threshold groups did not differ in EF build upon a greater body of evidence suggesting that the presence of LOC is the most important feature of binge eating as far as prognosis and psychological impairment (Fitzsimmons‐Craft et al., 2014; Latner et al., 2007).

4.4 Moderators of Binge Eating Frequency

Secondary aims of the current study were to examine implicit attitudes and food cue reactivity as factors that may differentiate BED and non-BED groups, and moderate the relation between executive functioning and binge episodes. Implicit attitudes towards highly palatable food did not appear to differ between groups, but the BED group demonstrated higher food cue reactivity. Consistent with hypotheses, implicit attitudes moderated the relation between decision-making (specifically, delayed discounting and risk-taking) and binge eating frequency within the BED group. Both interaction effects were in the expected direction, such that steeper discounting and more risk taking predicted more binge episodes, but only for those with stronger implicit attitudes towards palatable food. Thus, implicit attraction to highly palatable foods, paired with propensity towards prioritizing short-term reward and increased risk-taking, may lead to more

frequent binge episodes. This relation between delayed discounting, risk-taking and implicit attitudes is consistent with recent dual-process theories of self-regulation, which posit that desire for appetitive stimuli (e.g., implicit attitudes towards palatable food) and lessened self-regulatory resources (e.g., executive function) interact to produce difficulties in regulating health behavior even when there are explicit goals to do so (Hofmann, Friese, & Strack, 2009). However, unexpectedly, in both interactions, the combination of positive implicit attitudes and less discounting/less risk-taking resulted in the *fewest* number of binge episodes. Perhaps for those who do not engage in increased risk-taking or display deficits in delayed discounting (i.e., are better able to prioritize long-term over short-term reward), positive implicit attitudes reflect a healthier relationship with food (e.g., not strictly avoiding specific foods, or having fear of specific foods due to possibility or weight gain). It is possible that for those with stronger decision-making skills (less discounting of future rewards and less risk-taking), positive implicit attitudes lessen perceived threat of highly-palatable foods, and lessen extreme dieting behavior, and thus decrease the frequency of binge episodes.

Our results suggest that implicit attitudes may play a role in the frequency of binge eating pathology, but it appears to do so via interactions with other self-regulatory decision-making processes. Indeed, positive implicit attitudes may serve as either a risk for, or protective factor against, increased binge eating depending on one's ability to prioritize delayed over immediate gratification. However, food cue reactivity appears to be associated with binge eating pathology in isolation of executive functioning processes. Even if food is not implicitly perceived as more palatable, reactivity may still be high, which is consistent with literature demonstrating that individuals with BED show greater

neural reward center reactivity to images of food than individuals without BED, although ratings of pleasantness of the images are comparable (Schienle, Schäfer, Hermann, & Vaitl, 2009). This higher level of reactivity may be a risk factor for developing LOC over eating, or could be a consequence of repeated binge eating, representing a learned responsiveness to food.

4.5 Planned and Unplanned Binge Eating

As an exploratory aim, the current study sought to examine whether individuals in the BED group engaged in planned versus unplanned binge eating, and whether type of binge eating was associated with certain neurocognitive characteristics. Overall, the degree to which individuals planned binge episodes was normally distributed and individuals did not fall into discrete groups. We explored associations of each item (advanced knowledge of a binge episode, and behaviorally facilitating the occurrence of binge episodes) with the executive functioning variables of interest. Advanced knowledge of a binge episode (> 1 hour) was positively associated with levels of eating psychopathology and deficits in set-shifting, and negatively associated with inhibitory control. Tendency to not have advanced knowledge of a binge episode may mean that binge episodes occur impulsively, e.g., when put into an unexpected situation where highly palatable food is available, or if an emotionally difficult event suddenly occurs. Those with advanced knowledge that a binge are likely a subset of individuals with BED whose binges are not driven by poor inhibitory control. Instead, these individuals may seek the temporary comfort of binge eating; despite knowing in advance that they are at risk (and likely will regret the decision later), these individuals may still have difficulties shifting behavioral patterns (perhaps due to lack of other effective coping strategies).

The second item, behavioral facilitation of binge episodes, was positively associated with performance on the Tower Task and negatively associated with risk-taking. Thus, taking behavioral steps to facilitate the occurrence of a binge may represent a severity marker; this finding is consistent with a body of literature positing that binge eating, among other behaviors, may develop as an impulsive behavior, but transitions to a compulsive behavior as the disorder progresses (Pearson, 2013; Robbins, Gillan, Smith, de Wit, & Ersche, 2012). Individuals who do not take steps to "plan" binge episodes may represent a younger subtype characterized by lower executive planning ability and higher risk-taking, perhaps a more "impulsive" group potentially at the earlier stages of the disorder, or who developed binge eating at a younger age.

One consideration in interpreting these findings is that the wording of the items may have affected the manner in which participants responded; the first item (advanced knowledge) was more passively worded, while the second item (behavioral facilitation) was more active, which could have influenced results. Future investigations with the binge planning construct should incorporate several more items and ensure consistency in wording. A future measure of binge planning should attempt to tap into both the impulsive and compulsive nature of binge eating, as well as level distress associated with planned versus unplanned binge episodes. Lastly, future investigations should examine the developmental trajectory of binge eating and whether binge eating transitions from being impulsive to compulsive in nature.

4.6 Implications for Treatment Development and Future Research

The current study's findings have implications for future research and treatment development. The finding that executive planning is impaired in BED groups suggests

that executive planning, specifically with regards to normalization of eating, should be emphasized in treatment. In CBT for BED, an emphasis is placed on regular eating patterns and planning meals and snacks, however, increased emphasis on *how* to plan (e.g., provision repeated planning exercises) may be warranted. Overvaluation of short-term versus long-term reward may additionally have implications for treatment development. Acceptance-based treatments, such as Acceptance and Commitment Therapy, emphasize using movement towards long-term values (e.g., a healthy lifestyle, serving as a role model for children), rather than short-term avoidance of everyday distress, as the primary motivator for choosing behavior. Inclusion of a values-based intervention component in standard treatment for BED may aid individuals with BED to tolerate the discomfort of giving up short-term comfort in the service of greater goals or life values. Additionally, the provision of distress tolerance skills (e.g., crisis survival strategies from Dialectical Behavior Therapy) may be useful for coping with uncomfortable emotions and urges when choosing to give up the short-term reward of binge eating.

Given the interaction between low implicit attitudes and poor executive functioning in predicting frequency of binge episodes, additional strategies for improving attitudes towards food may be implicated in conjunction with improving planning and long-term decision-making. For example, food exposures, in which an individual confronts a "bad" food in an environment where a binge is unlikely to occur (e.g., with friends, or where portion size is limited) may increase positive experiences with such foods and thus improve implicit attitudes.

In terms of future research examining executive functioning deficits in individuals with BED, the literature would benefit from investigations of executive function under the context of negative emotions or palatable food stimuli. It may be that individuals with BED present with limited executive functioning deficits in "normal" contexts, however, when in emotional distress may be less able to effectively use pre-frontal lobe functions compared to weight-matched peers. Future studies could induce negative affect prior to completion of executive functioning tasks to test these hypotheses.

4.7 Strengths and Limitations of the Current Study

The current study had a number of strengths. First, we used a wide range of well-validated neuropsychological tasks that tapped into a number of executive functioning constructs, as well as several other relevant measures which allowed us to examine interaction effects, such as food cue responsivity and implicit attitudes. Additionally, we had a weight- and IQ-matched sample, and controlled for several potential alternative explanatory variables, allowing us to be more confident that detected differences can be attributed to the presence of binge eating.

However, a number of important limitations are relevant when considering study findings. First, the cross-sectional design of the study precludes our ability to derive temporal relations of findings; we are unable to determine if executive functioning deficits precede the onset of the illness or represent a "scar." Additionally, our sample size was small; replication of the current study with larger samples across sites is necessary to confirm findings, especially given mixed findings in the literature. The two groups were additionally not matched on age, which could possibly reflect slight differences in recruitment strategies for weight loss and binge eating studies. However,

because both samples were treatment seeking, and there was overlap in recruitment methods for all studies that served as recruitment sources, we do not believe the age difference to be reflective of a major confound. We also controlled for the age difference statistically in an effort to ensure that differences detected between groups could not be attributed to age. Another limitation is that our sample only included overweight and obese females, all of whom were treatment seeking, limiting our ability to generalize to males and non-treatment-seeking groups. It is possible that treatment-seeking individuals may present with a differential neurocognitive profile than those who do not seek treatment, especially given the large percentage of individuals with eating disorders who never seek treatment. Treatment seeking individuals may thus represent a specific subset of individuals with BED that may not be generalizable to the BED population. Future research should also examine whether specific deficits predict or moderate response to psychological interventions, to further reveal whether such deficits interfere with treatment outcome. Additionally, use of overweight samples allowed us to compare weight-matched groups; however, not all individuals with BED are overweight. Future studies should seek to include a normal-weight BED group to examine the interplay of weight status and binge eating in order to gain a more complete picture of the neurocognitive profile of binge eating pathology. Furthermore, BED is the most common eating disorder in males, and given established gender differences in neurocognition, future research should also include males.

4.8 Conclusion

Overall, the current study demonstrated that the neurocognitive characteristics of overweight individuals with BED differ from those of overweight individuals without

BED. Additionally, it appears that implicit attitudes towards highly palatable food interacts with executive function to predict binge eating severity. The degree to which an individual plans binge episodes may represent subtypes characterized by distinct executive functioning strengths and weaknesses. These findings have direct implications for treatment components that may increase the efficacy of existing treatments for binge eating. Replication of the current findings with a greater sample size is necessary; future research would additionally benefit from the inclusion of neuroimaging to elucidate neural mechanisms of executive functioning deficits in this population in order to reveal cognitive endophenotypes of binge eating.

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APPENDIX A: TABLES AND FIGURES

Table 1. *Summary of literature examining executive function in BED*

Study	Sample	Construct(s) measured	Tests used	Findings	Notes
Dushesne et. al (2010)	N = 38 BED N = 38 OWC	Working Memory Cognitive Flexibility Cognitive Flexibility Cognitive Flexibility Inhibition Planning Problem Solving	Digit Span Backwards Trail Making B WSCT Rule Shift Cards Stroop Test Zoo Map Test Action Program Test	**BED < OWC** BED = OWC **BED < OWC** BED = OWC BED = OWC **BED < OWC** **BED < OWC**	Trail Making B (p = .06) and Rule shift Cards (p = .07) trended towards significance (BED < OWC)
Svaldi et. al (2010)	N = 17 BED N = 17 OWC	Decision-making (under risk) Cognitive Flexibility	Game of Dice Task Trail Making B	**BED < OWC** **BED < OWC**	
Mobbs et. al (2011)	N = 16 BED N = 16 OWC N = 16 NWC	Inhibition Set-shifting	Mental Flexibility Task Mental Flexibility Task	**BED < OWC < NWC** BED = OWC; **BED < NWC**	Task simultaneously measured set-shifting and inhibition
Kelly et. al (2013)	SubBED = 50 NWC = 66	Attention/inhibition/ impulsivity Cognitive Flexibility	Continuous Performance Task Wisconsin Card Sort	SubBED=NWC SubBED=NWC	Number of perseverative errors on WCST was correlated with binge frequency
Danner et. al (2011)	BED = 20 OWC = 21	Decision-making	Iowa Gambling Task	BED = OWC, **BED < NWC**	Overall IGT score was negatively correlated

Davis et. al (2009)	BED = 65 OWC = 73 NWC = 71	Decision Making Delay of Gratification	Iowa Gambling Task Delay Discounting	BED = OWC **BED < NWC** BED = OWC **BED < NWC**	All results not significant when controlling for education level
Galioto et. al (2012)	BED = 41 OWC = 90	Cognitive Flexibility Executive function	Trail Making B Maze Task	BED = OWC BED = OWC	BED group included current and past BED
Manasse et al. (under review)	LOC = 19 OWC = 62	Cognitive Flexibility Delay of Gratification Planning Inhibition Working Memory	Penn Exclusion Task Delayed Discounting DKEFS Tower Task DKEFS Color-Word Letter N-back	BED = OWC BED = OWC **BED < OWC** **BED < OWC** **BED < OWC**	After controlling for depression, working memory no longer significant
Wu et. al (2013)	BED = 54 OWC = 43	Inhibitory Control Decision-making (under risk)	Stop Start Task Game of Dice Task	BED = OWC BED = OWC	
Svaldi et. al (2014)	BED = 31 OWC = 29	Inhibitory Control	Stop Start Task	**BED < OWC**	Relative deficits were found in food-based and general inhibitory control

SubBED = Subthreshold BED
OWC = Overweight controls
LOC = individuals with loss-of-control eating
NWC = Normal weight controls

Table 2. *Sample descriptive and clinical characteristics by group*

	BED Group (n=31)	OWC Group (n=43)	*t*	*p*	Cohen's *d*
Age (yrs)	45.06 (14.86)	51.09 (8.26)	2.04	< .05*	.50
Body Mass Index (Kg/m^2)	36.84 (7.97)	37.85 (6.27)	.02	.61	.14
IQ	111.74 (12.31)	112.63 (10.52)	.33	.54	.08
BDI-II	17.94 (10.17)	7.58 (6.78)	5.26	< .01**	1.20
OBEs in past month	10.97 (9.32)	0.00 (0)	7.74	< .01**	1.60
SBEs in past month	5.74 (11.39)	0.00 (0)	2.80	< .01**	.71
EDE-Q Restraint	1.76 (1.34)	1.45 (1.22)	.90	.37	.24
EDE-Q Eating Concern	2.52 (1.35)	1.04 (.97)	4.65	< .01**	1.26
EDE-Q Shape Concern	4.06 (1.48)	3.54 (1.20)	1.42	.16	.39
EDE-Q Weight Concern	3.80 (1.17)	3.04 (.82)	2.79	.01*	.75
EDE-Q Global Score	3.07 (1.07)	2.27 (.75)	3.1	< .01**	.87

* $p < .05$
** $p < .01$

Table 3. *Sample recruitment sources by group*

	BED group	OWC group
Mind Your Health Obesity Trial	n=15 (48%)	n = 41 (100%)
CARE Project (BED Treatment Study)	n = 16 (52%)	n = 0 (0%)

Table 4. *Group differences in executive function, controlling for age and IQ*

	BED Group (n=31)	OWC Group (n=43)	*F*	*p*	η^2_p
Delayed Discounting		.			
Level of discounting,[b, c]	.62 (.16)	.72 (.18)	6.00	.02*	.09
Planning (Tower Task)					
Achievement Score[a]	14.90 (3.66)	17.51 (3.71)	8.06	<.01**	.10
Inhibitory Control					
(Color-Word Task)					
Total Errors[a]	3.71 (4.03)	3.35 (3.46)	.59	.44	.01
Inhibition Time[b]	56.57 (15.89)	53.11 (10.92)	4.38	.04*	.06
Inhibition-Switch Time[b]	65.92 (20.66)	60.59 (17.05)	5.94	.02*	.08
Cognitive flexibility					
(Conditional Exclusion Task)					
Percent perseverative errors[a]	.23 (.10)	.22 (.08)	.88	.35	.01
Working Memory (N-back)					
Efficiency Score[a]	4.38 (.50)	4.46 (.68)	.14	.71	.00
Risk Taking (Balloon Task)					
Adjusted average pumps[a]	20.54 (15.05)	23.65 (15.92)	1.26	.27	.02

* $p < .05$
** $p < .01$
[a]Results were unchanged after depression added as a covariate
[b]Significance level lowered to trend level after depression added as covariate
[c] Smaller numbers indicate steeper discounting

Table 5. *Demographic and clinical characteristics of full and sub-threshold groups*

	BED (n=22)	SubBED (n=9)	OWC (n=43)	*F*	*p*	η^2_p
Age (yrs)	42.05 (15.45)	52.44 (10.72)	51.09 (8.26)	5.43	<.01**	.13
BMI	36.46 (8.58)	37.76 (6.60)	37.85 (6.28)	.29	.75	.01
IQ	112.09 (8.62)	110.89 (19.29)	112.63(10.52)	.09	.91	<.01
BDI-II	18.18 (10.59)	17.33 (9.63)	7.58 (6.77)	13.67	<.01**	.28
OBEs in past month	14.32 (8.84)	2.78 (3.76)	0.00 (0.00)	60.99	<.01**	.63
SBEs in past month	6.00 (13.19)	5.11 (5.42)	0.00 (0.00)	5.47	<.01**	.13
EDE-Q Restraint	2.11 (1.32)	1.00 (1.13)	1.45 (1.20)	2.10	.13	.07
EDE-Q Eating Concern	2.68 (1.29)	2.12 (1.57)	1.04 (.97)	11.24	<.01**	.30
EDE-Q Shape Concern	4.17 (1.33)	3.83 (1.88)	3.54 (1.20)	1.13	.33	.04
EDE-Q Weight Concern	3.91 (1.20)	3.57 (1.27)	3.04 (.82)	5.68	<.01**	.19
EDE-Q Global Score	3.21 (.95)	2.68 (1.38)	2.27 (.75)	10.18	<.01**	.26

* $p < .05$
** $p < .01$

Table 6. *Differences in executive function among full and sub-threshold groups, controlling for age and IQ*

	Group			ANCOVA			Post-hoc comparisons		
	BED (n=22)	SubBED (n=9)	OWC (n=43)	*F*	*p*	η^2_p	*BED v OWC* η^2_p	*Sub v OWC* η^2_p	*Sub v BED* η^2_p
Delayed Discounting									
Level of discounting[a]	.63 (.17)	.62 (.14)	.73 (.18)	2.81	.07	.09	.07	.08	.02
Planning (Tower Task)									
Achievement Score	15.41 (2.92)	13.67 (5.03)	17.51 (3.71)	4.86	.01**	.12	.06	.12	.03
Inhibitory Control (Color-Word Task)									
Total Errors	3.36 (4.38)	4.56 (3.09)	3.34 (3.46)	.33	.72	.01	--	--	--
Inhibition Time	53.40 (11.62)	64.32 (22.30)	53.11 (10.92)	3.05	.05*	.08	.02	.09	.03
Inhibition-Switch Time	62.50 (19.69)	74.28 (21.73)	60.60 (17.05)	3.11	.05*	.08	.05	.08	.01
Cognitive Flexibility (Conditional Exclusion)									
Percent perseverative errors	.22 (.08)	.25 (.12)	.22 (.08)	.43	.65	.01	--	--	--
Working Memory									
N-back Efficiency Score	4.29 (.54)	4.59 (.33)	4.46 (.68)	.94	.40	.03	--	--	--
Risk-Taking (Balloon Task)									
Average adjusted pump count	11.92 (11.92)	22.59 (20.68)	23.65 (15.92)	1.11	.34	.03	--	--	--

[a] Smaller numbers indicate steeper discounting

Table 7. *Correlations with planning of binge episodes in a subset of the BED (n=11) group*

	Advanced knowledge of a binge episode (> 1 hour)	Behavioral facilitation of binge episodes
Behavioral facilitation of binge episodes	-.55[o]	--
Age	-.35	.43[a]
Frequency of binge episodes	-.14	.72*
EDE-Q Restraint	.25	-.29
EDE-Q Weight Concern	-.30	.21
EDE-Q Shape Concern	-.50[a]	.43[a]
EDE-Q Eating Concern	-.48[a]	.71*
EDE-Q Global Score	-.34	.33
Planning (Tower Task)	-.18	.46[a]
Delayed Discounting	.31	-.26
Total Inhibition Errors	-.47[a]	-.03
Percent perseverative errors	.35	-.18
Working memory (N-back efficiency score)	.08	-.28
Risk-Taking (Balloon Task adjusted average pump count)	.22	-.46[a]

[a]p = .10-.20
[o]p = .05 - .09
*p < .05

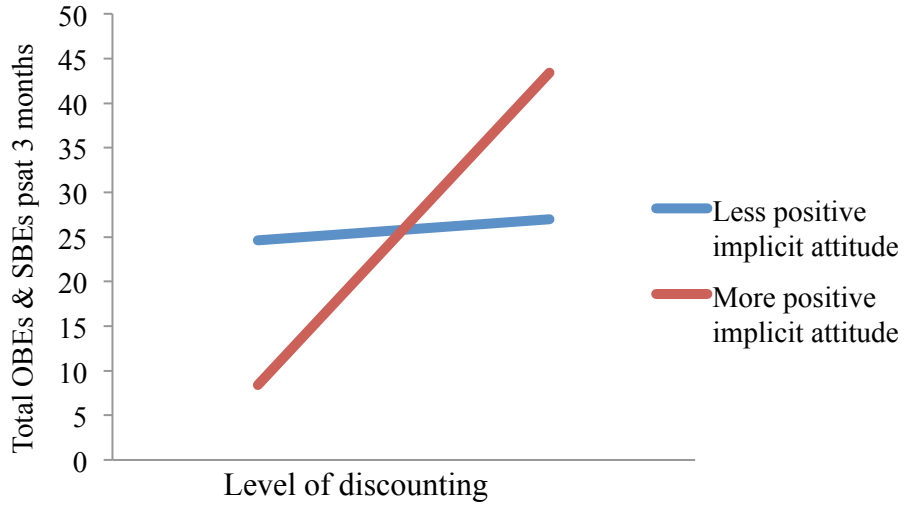

Figure 1. *Interaction between implicit attitudes and delayed discounting on binge eating frequency*

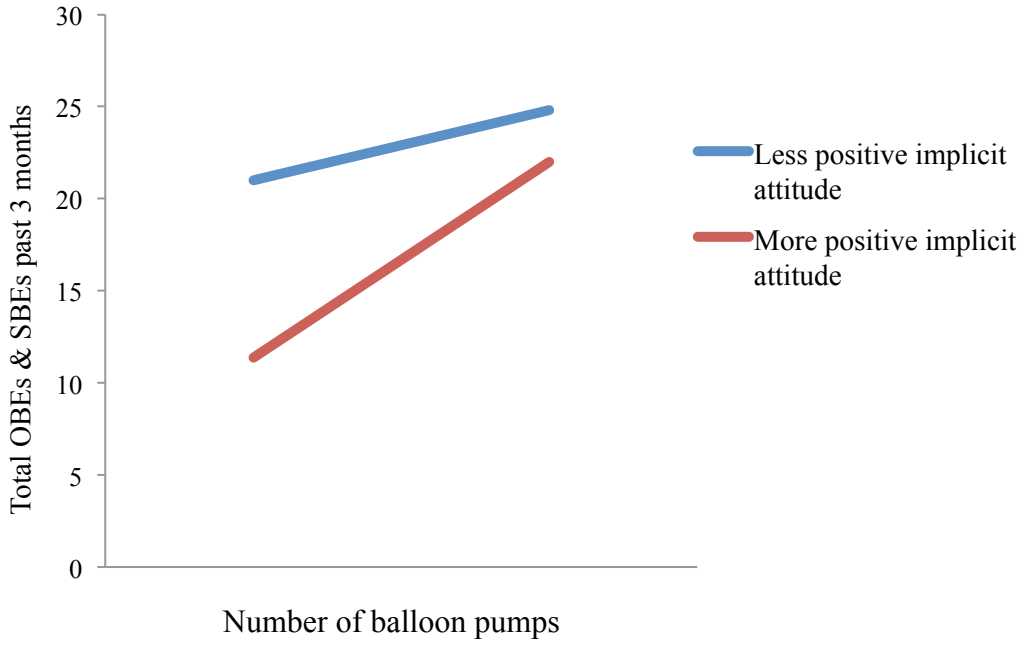

Figure 2. *Interaction between implicit attitudes and risk-taking on binge eating frequency*

APPENDIX B: SELF-REPORT MEASURES

Eating Disorders Examination-Questionnaire.

EATING QUESTIONNAIRE

Instructions: The following questions are concerned with the past four weeks (28 days) only. Please read each question carefully. Please answer all the questions. Thank you.

Questions 1 to 12: Please circle the appropriate number on the right. Remember that the questions only refer to the past four weeks (28 days) only.

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

	working, following a conversation, or reading)?							
8	Has thinking about shape or weight, made it very difficult to concentrate on things you are interested in (for example, working, following a conversation, or reading)?	0	1	2	3	4	5	6
9	Have you had a definite fear of losing control over eating?	0	1	2	3	4	5	6
10	Have you had a definite fear that you might gain weight?	0	1	2	3	4	5	6
11	Have you felt fat?	0	1	2	3	4	5	6
12	Have you had a strong desire to lose weight?	0	1	2	3	4	5	6

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

Over the past four weeks (28 days)…….

13 Over the past 28 days, how many times have you eaten what other people would regard as an unusually large amount of food (given circumstances)?

14 On how many of these times did you have a sense of having lost control over your eating (at the time that you were eating)?

15 Over the past 28 days, how many **DAYS** have such episodes of overeating occurred (i.e., you have eating an unusually large amount of food and have had a sense of loss of control at the time)?

16 Over the past 28 days, how many times have you made yourself sick (vomit) as a means of controlling your shape or weight?

17 Over the past 28 days, how many times have you taken laxatives as a means of controlling your shape or weight?

18 Over the past 28 days, how many times have you exercised in a "driven" or compulsive way as a means of controlling your weight, shape or amount of fat, or to burn off calories? _____

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

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

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

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

What is your weight a present? (Please give your best estimate.) _____

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

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

If so, how many? _____

Have you been taking the “pill”? _____

Beck Depression Inventory –II.

Please read each group of statements carefully, and then pick out the **one statement** in each group that best describes the way you have been feeling during the **past 2 weeks, including today**. Mark the number next to the statement you have picked. If several statements in the groups seem to apply equally well, simply choose the statement which has the **largest number**.

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

(2) Pessimism
0 ____ I am not discouraged about my future.
1 ____ I feel more discouraged about my future than I used to be.
2 ____ I do not expect things to work out for me.

3 ____ I feel that the future is hopeless and that things cannot improve.

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

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

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

(6) Punishment Feelings
0 ____ I don't feel I am being punished.
1 ____ I feel I may be punished.

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

(8) Self Criticism
0 ____ I don't criticize or blame myself any more than usual.
1 ____ I am more critical of myself than I used to be.
2 ____ I criticize myself for all my faults.
3 ____ I blame myself for everything bad that happens.

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

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

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

(12) Loss of Interest
0 ____ I have not lost interest in other people or activities.

2 ____ I expect to be punished.
3 ____ I feel I am being punished.

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

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

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

(16) Change in Sleeping Pattern
0 ____ I have not experienced any change in my sleeping pattern.

1a ___ I sleep somewhat more than usual.
1b ___ I sleep somewhat less than usual.

2a ___ I sleep a lot more than usual.
2b ___ I sleep a lot less than usual.
---

1 ____ I am less interested in other people or things than before.
2 ____ I have lost most of my interest in other people or things.
3 ____ It's hard to get interested in anything.

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

(18) Changes in Appetite
0 ____ I have not experienced any changes in my appetite.

1a ___ My appetite is somewhat less than usual.
1b ___ My appetite is somewhat greater than usual.

2a ___ My appetite is much less than before.
2b ___ My appetite is much greater than usual.

3a ___ I have no appetite at all.
3b ___ I crave food all the time.

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

(20) Tiredness or Fatigue
0 ____ I don't get more tired than usual.
1 ____ I get tired or fatigue more easily than usual.
2 ____ I am too tired or fatigued to do a lot of the things I used to do.
3 ____ I am too tired or fatigued to do most of the things I used to do.

(21) Loss of Interest in Sex
0 ____ I have not noticed any recent change in my

3a ___ I sleep most of the day.
3b ___ I wake up 1-2 hours early and can't get back to sleep.

interest in sex.
1 ____ I am less interested in sex than I used to be.
2 ____ I am much less interested in sex now.
3 ____ I have lost interest in sex completely.

UPPS

Below are a number of statements that describe ways in which people act and think. For each statement, please indicate how much you agree or disagree with the statement. If you **Agree Strongly** circle **1**, if you **Agree Somewhat** circle **2**, if you **Disagree somewhat** circle **3**, and if you **Disagree Strongly** circle **4**. Be sure to indicate your agreement or disagreement for every statement below. Also, there are a few more questions on the next page

	Agree Strongly	Agree Some	Disagree Some	Disagree Strongly
1. I have a reserved and cautious attitude toward life.	1	2	3	4
2. I have trouble controlling my impulses.	1	2	3	4
3. I generally seek new and exciting experiences and sensations.	1	2	3	4
4. I generally like to see things through to the end.	1	2	3	4
5. My thinking is usually careful and purposeful.	1	2	3	4
6. I have trouble resisting my cravings (for food, cigarettes, etc.).	1	2	3	4
7. I'll try anything once.	1	2	3	4
8. I tend to give up easily.	1	2	3	4
9. I am not one of those people who blurt out things without thinking.	1	2	3	4
10. I often get involved in things I later wish I could get out of.	1	2	3	4
11. I like sports and games in which you have to choose your next move very quickly.	1	2	3	4
12. Unfinished tasks really bother me.	1	2	3	4
13. I like to stop and think things over before I do them.	1	2	3	4
14. When I feel bad, I will often do things I later regret in order to make myself feel better now.	1	2	3	4
15. I would enjoy water skiing.	1	2	3	4
16. Once I get going on something I hate to stop.	1	2	3	4
17. I don't like to start a project until I know exactly how to proceed.	1	2	3	4
18. Sometimes when I feel bad, I can't seem to stop what I am doing even though it is making me feel worse.	1	2	3	4
19. I quite enjoy taking risks.	1	2	3	4
20. I concentrate easily.	1	2	3	4
21. I would enjoy parachute jumping.	1	2	3	4
22. I finish what I start.	1	2	3	4
23. I tend to value and follow a rational, "sensible" approach to things.	1	2	3	4

Please go to the next page

	Agree Strongly	Agree Some	Disagree Some	Disagree Strongly
24. When I am upset I often act without thinking.	1	2	3	4
25. I welcome new and exciting experiences and sensations, even if they are a little frightening and unconventional	1	2	3	4
26. I am able to pace myself so as to get things done on time.	1	2	3	4
27. I usually make up my mind through careful reasoning.	1	2	3	4
28. When I feel rejected, I will often say things that I later regret.	1	2	3	4
29. I would like to learn to fly an airplane.	1	2	3	4
30. I am a person who always gets the job done.	1	2	3	4
31. I am a cautious person.	1	2	3	4
32. It is hard for me to resist acting on my feelings.	1	2	3	4
33. I sometimes like doing things that are a bit frightening.	1	2	3	4
34. I almost always finish projects that I start.	1	2	3	4
35. Before I get into a new situation I like to find out what to expect from it.	1	2	3	4
36. I often make matters worse because I act without thinking when I am upset.	1	2	3	4
37. I would enjoy the sensation of skiing very fast down a high mountain slope.	1	2	3	4
38. Sometimes there are so many little things to be done that I just ignore them all.	1	2	3	4
39. I usually think carefully before doing anything.	1	2	3	4
40. Before making up my mind, I consider all the advantages and disadvantages.	1	2	3	4
41. In the heat of an argument, I will often say things that I later regret.	1	2	3	4
42. I would like to go scuba diving.	1	2	3	4
43. I always keep my feelings under control.	1	2	3	4
44. I would enjoy fast driving.	1	2	3	4
45. Sometimes I do impulsive things that I later regret.	1	2	3	4

Power of Food Scale

Please indicate the extent to which you agree that the following items describe you. Use the following 1-5 scale for your responses.

1 don't agree at all
2 agree a little
3 agree somewhat
4 agree
5 strongly agree

---

1. I find myself thinking about food even when I'm not physically hungry. ___
2. I get more pleasure from eating than I do from almost anything else. ___
3. If I see or smell a food I like, I get a powerful urge to have some. ___
4. When I'm around a fattening food I love, it's hard to stop myself from at least tasting it. ___
5. It's scary to think of the power that food has over me. ___
6. When I know a delicious food is available, I can't help myself from thinking about having some. ___
7. I love the taste of certain foods so much that I can't avoid eating them even if they're bad for me. ___
8. Just before I taste a favorite food, I feel intense anticipation. ___
9. When I eat delicious food I focus a lot on how good it tastes. ___
10. Sometimes, when I'm doing everyday activities, I get an urge to eat "out of the blue" (for no apparent reason). ___
11. I think I enjoy eating a lot more than most other people. ___
12. Hearing someone describe a great meal makes me really want to have something to eat. ___
13. It seems like I have food on my mind a lot. ___
14. It's very important to me that the foods I eat are as delicious as possible. ___
15. Before I eat a favorite food my mouth tends to flood with saliva. __