CORTICAL RESPONSE TO A CHOCOLATE CRAVING INDUCTION AMONG RESTRAINED AND UNRESTRAINED EATERS

By

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Abstract

Interest in the cortical response to food craving in restrained eaters is a relatively unexplored area. Typically when presented with images of highly appetizing food, healthy individuals will show greater left than right frontal hemispheric activity, an event indicative of heightened approach motivation. To date there are no known studies showing this same effect in restrained eaters. However, it has been shown that restrained eaters have greater right frontal cortical activity at rest compared with unrestrained eaters. The purpose of this study was to examine cortical asymmetry in restrained eaters using an electroencephalogram (EEG) while undergoing a craving induction. We proposed that compared to unrestrained eaters, restrained eaters would show greater right than left frontal asymmetry at baseline. When instructed to crave chocolate, we then hypothesized that restrained eaters would show greater right than left hemispheric activation, indicative of a motivation to withdraw. Data were collected from 52 university women, 29 of which were classified as restrained eaters and 23 were classified as unrestrained eaters. The results showed no significant difference in predicted frontal asymmetry between restraint groups either at baseline or during the craving induction. However, when collapsed across the entire experimental manipulation, significant differences in regional asymmetry were found. Specifically, both groups showed greater alpha power scores in the parietal versus frontal region, with restrained eaters evidencing less left relative to right hemispheric cortical activity in the parietal region relative to their unrestrained counterparts. Additionally, participants evidenced a significant shift to greater left hemispheric asymmetry over the course of the craving induction. To date, this is the first known study to show this effect using pictures. Explanations for these findings along with the influence of methodological variations and participant characteristics are discussed.

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Cortical Response to a Chocolate Craving Induction Among Restrained and Unrestrained Eaters

Interest in the psychobiological processes of food cravings is a relatively new phenomenon in the area of craving research. Originally, the vast majority of literature on craving has been applied to the study of drugs and alcohol. However, with rising incidence rates of obesity, bulimia nervosa, and anorexia nervosa, research interest in craving has begun to direct its attention on understanding the aetiology of food cravings. Although food cravings do lie at the heart of most clinical eating disorders, one larger, non-clinical population which food cravings greatly affect are restrained eaters: individuals who chronically restrict, and periodically disinhibit, their consumption of food (Herman & Polivy, 1988; Polivy, Coleman, & Herman, 2005). Currently, there are a number of theories as to why food cravings occur and why they can become maladaptive. As summarized by Cepeda-Benito and Gleaves (2001), craving theories have typically been partitioned into three systems: bioneurological, cognitive, and affective. Previous research has shown that each of these three systems has a role in regulating the craving response in restrained eaters (Avena, Long, & Hoebel, 2005; Avena, Rada, & Hoebel, 2008; Kavanagh, Andrade, & May, 2005; Willner et al., 1998). However, there is rapidly accumulating evidence which suggests that theories that address each of these systems alone are not sufficient to suitably explore food cravings in restrained eaters. A more appropriate theory would be one that is able to combine key aspects from each of these three systems to create a more complete picture of the craving response in this population. One theory that has shown the potential to do this is the cortical frontal asymmetry theory of motivation which aids in evaluating and classifying the appetitive valence of target stimuli (Davidson, 1992; Davidson, 1993; Tomarken, Davidson, Wheeler, & Doss, 1992).

This thesis will first begin by explaining the construct of craving followed by a brief introduction to restrained eaters. Next, this paper will introduce the concept of frontal asymmetry and show how it can contribute to the theoretical understanding of the craving response in restrained eaters. Finally, the proposed goals of this study will be stated.

Craving

Both researchers in the areas of substance use craving (Anton, 1999) and food craving (Weingarten & Elston, 1990) have had difficulty creating a uniform definition of what *craving* actually is, as it has long been labeled as a subjective state (Westerberg, 2000) that varies from person to person. According to Hill (2007), craving is a hypothetical construct in which evidence for its occurrence has been gathered from reports of subjective experiences and from changes in physiology and behaviour. Hill and other researchers in the areas of food and drug cravings (Gendall, Joyce, & Sullivan, 1997; Kozlowski & Wildinson, 1987) state that the core motivating components of craving are its strength and specificity. The operational definition of craving is a very "intense desire" (strength) which is aimed at ingesting or experiencing a specific item of food, drink, or taste (specificity). Evidence for this definition has been identified in studies which show that people often experience a craving for a particular food (e.g., a chocolate bar) and they will work hard to get it (Williner et al., 1998). Moreover, the same gratifying sensation of satiety is not experienced if another food is substituted (e.g., broccoli) for the food being craved (Fedoroff, Polivy, & Herman, 2003).

All craving urges are not considered equal. Hill (2007) describes craving as a continuum of experiences. At the lowest end of the spectrum one would experience a mild, benign desire to eat an occasional treat, whereas at the highest end of the spectrum one would find clinical eating disorders and the symptom of binge eating where the craving response has become overpowering

and pathological. One caveat that should be noted concerning this conceptual definition is that craving is not synonymous with consumption (Hill, 2007). One can crave food but not eat it, and one often eats food that is not craved.

Experiencing an appetitive desire to consume a particular substance is not an uncommon phenomenon. In a study conducted by Gendall et al. (1997), it was estimated that approximately 58% of individuals ages 18 to 45 have experienced food cravings. Of this sample, 7% stated that they have only experienced food cravings while pregnant. However, Gendall et al. also indicated that estimates of experienced food cravings are entwined with how one has chosen to operationalize the construct of craving. Other studies that may have used less stringent criteria have found higher estimates wherein 97% of women and 68% of men have had food cravings at some point during their lives (Weingarten & Elston, 1991). Regardless of the prevalence, researchers have continually found that more women than men have cravings for sweet food (Lafay et al., 2001; Zellner, Garriga-Trillo, Rohm, Centeno, & Parker, 1999).

Food cravings are heavily influenced by cultural factors (Barns, 1995). In the western hemisphere, the most commonly craved foods are often characterized as "forbidden", "bad", and "unhealthy" because of their nutritional content (O'Dea, 1999). Chocolate is by far the most intensely and commonly craved food, with ice-cream and pizza in second and third places, respectively (Beckley & Moskowitz, 2002; Rodin, Mancuso, Granger, & Nelbach, 1991; Rozin, Levine, & Stoess, 1991). It is no coincidence that the foods we want to eat most and find the most appetizing are the same foods that we try to resist. It has been argued that as a result of the negative valence placed on certain foods of desire, attempted efforts to suppress cravings for these "bad" foods are made in order to restrict consumption (O'Dea, 1999). As it has been

previously noted, one group in particular that attempts to chronically limit their consumption of these forbidden foods are restrained eaters.

Restrained Eaters

Restrained eating is defined as the conscious effort to suppress and control the physiological desire to eat in an attempt to lose weight or to maintain a reduced weight (Herman & Polivy, 1988). Restrained eaters are typically overly concerned with thoughts of body shape and food (Green & Rogers, 1993; Mills, Polivy, Herman, & Tiggemann, 2002), have greater body dissatisfaction (Ogden, 1995) and often try to limit their diet to dangerously low calorie levels in order to obtain their desired weight or shape (Tuschl, Laessle, Platte, & Pirke, 1999). It has also been established that women are far more likely to restrict their eating behaviour than men (Alexander & Tepper, 1995; Jeffery, Adlis, & Forster, 1991).

One attribute that is paradoxically associated with restrained eating is the sudden and intermittent over-indulgence of self-classified "forbidden foods". Research has shown that restrained eaters will disinhibit their restricted eating patterns when in the presence of a calorically dense preload, such as a milkshake (Herman & Polivy, 1980). One explanation as to why this occurs is that increased food cravings result from nutritional deficiencies caused by dieting (Herman et al.). As a result of being hungry and calorically deprived, one will then typically over-indulge when the opportunity arises. Due to chronic dieting, this theory of restraint contends that restrained eaters will again begin to restrict their eating habits, or engage in other forms of counter-regulatory behaviours following the over-eating episode (Herman & Polivy, 2003).

Although it is more common for a restrained eater to disinhibit their restrictive eating behaviours in response to "forbidden", calorically dense food, it is not just high calorie foods that

elicit disinhibited eating. Research has shown that even a low calorie substitute of a "forbidden" food can be a craving trigger among restrained eaters (Mills & Palandra, 2008).

Compared with unrestrained eaters, restrained eaters also seem to be differentially responsive to pre-eating food cues. Fedoroff, Polivy, and Herman (1997) exposed restrained and unrestrained eaters to the smell of pizza, cookies, or to no smell for 10 minutes. They were then asked to write their thoughts about the cued food, and finally were asked to 'taste and rate' the smelled food. Restrained eaters were shown to be much more responsive to the food cues than unrestrained eaters, and ate more after each cue. Restrained eaters specifically ate the most when the food cue matched the food they were later presented with.

The disinhibited eating that is characteristic of restrained eaters has been associated with a wide range of negative effects. Disinhibited eating and subsequent overindulgence in restrained eaters has been linked with low self-esteem (Polivy, Heatherton, & Herman, 1988), loneliness (Rotenberg & Flood, 1999), guilt, depression, anxiety (Fletcher, Pine, Woodbridge, & Nash, 2007), increased preoccupation with food (Odgen, 1995), and having a higher body mass (Williamson et al., 1995). Following this evidence, there has been substantial research focusing on how restrained eaters may eat to escape negative emotions. Schotte, Cools, and McNally (1990) found that overeating was triggered by negative affect in restrained eaters. When unrestrained and restrained eaters were shown a frightening film, the study demonstrated that restrained eaters had greater increases in anxiety, sadness, and anger relative to their unrestrained counterparts. Restrained eaters also ate more following the film than did the unrestrained eaters, and other restrained participants who watched a neutral film.

Restrained eaters are also known to over-indulge when emotionally aroused. Studies have found that restrained eaters eat the most when in a dysphoric mood (experiencing feelings of

depression, anxiety, and hostility) compared with being in a nondysphoric mood (experiencing feelings of accomplishment and success), but there is no difference in amount eaten in either mood state with unrestrained eaters (Chua, Touyz, & Hill, 2004; Ruderman, 1985). Based on this accumulation of evidence, it is apparent that there are many complex psychological experiences occurring in a restrained eater during a craving episode such as the negative affective states of guilt, anxiety, and depression. Although various explanations have been proposed as to why restrained eaters experience negative emotions associated with food cravings, one area that has received recent attention is the theory of frontal asymmetry. Specifically, this theory suggests that the asymmetrical cortical activation of the anterior left and right hemispheres of the brain may play a significant role in moderating the unique motivations and behaviours displayed by restrained eaters.

Frontal Asymmetry

The proposed theory of frontal asymmetry suggests that individual differences in frontal cortical activity are responsible in influencing both an individual's trait predisposition to respond to emotional stimuli as well as influencing an individual's emotional state (Coan & Allen, 2003). As suggested by Davidson (1993), asymmetrical electroencephalographic (EEG) alpha wave activity between the right and left frontal hemispheres may simultaneously moderate cortical activity and mediate cortical activation when responding to emotionally-charged stimuli. Specifically, these two frontal brain hemispheres are thought to be responsible for determining the affective valence of target stimuli and deciding whether or not to engage with, or withdraw from, a target (Davidson, 1992). The principle mechanism by which this paradigm is exhibited is that relative greater right than left frontal hemispheric activity is associated with withdrawal and avoidance behaviours and negative affect, whereas greater left frontal hemispheric activity is

associated with approach behaviours and positive affect (Davidson, 1992; Harmon-Jones & Allen, 1997). Simply stated, when one experiences a craving for an appetitive target they are engaging in an approach behaviour. Thus, when one has a craving for a chocolate bar, and allows themselves to give in to the craving, they have just engaged in an appetitive approach behaviour as a result of actively seeking out and obtaining that chocolate bar.

One of the most widely accepted paradigms in the literature on frontal asymmetry is the idea that greater left frontal hemispheric alpha-band activity is associated with approach behaviours while greater right frontal hemispheric activity is associated with withdrawal behaviours. However, more recent research suggests that this relationship may be more complex. Harmon-Jones, Gable, and Peterson (2010) propose that the greater left frontal activity associated with approach motivations can actually be positive or negative in emotional valence. Thus, an individual is just as likely to evidence greater left frontal activity when feeling excited and enthusiastic as they would be when experiencing anger towards an individual or event.

Clinically, evidence that greater right than left frontal hemispheric asymmetry influences how an individual will respond to emotionally valent stimuli has been demonstrated in individuals with depression (Allen, Iacono, Depue, & Arbisi, 1993), general anxiety disorder (De Bellis et al., 2002), and schizophrenia (Bilder et al., 1994). Research has shown that because these groups are typically disposed to experiencing greater negative affect compared with the general population, as well as more social isolation and withdrawal, they are also more likely to evidence greater right versus left resting frontal EEG alpha-band activity. Individuals with eating disorders have also been categorized as exhibiting behaviours that may be indicative of frontal dysfunction (Spinella & Lyke, 2004). Using the Frontal Systems Behavior Scale and the Eating Inventory, Spinella et al. examined the relationship between executive functioning and

eating behaviour. They found that individuals possessing traits reflecting a lack or excess of inhibition, impulsive eating patterns, and greater right frontal involvement were more likely to exhibit disinhibited eating and greater food cravings. In contrast, frontal lateralization has also shown to be a very powerful and stable state-independent measure of affect in non-psychiatric populations of men (Jacobs & Snyder, 1996) and women (Tomarken, Davidson, Wheeler, & Doss, 1992). Thus, right hemispheric dominance relating to states of negative emotion and withdrawal behaviours appears to be consistently evidenced in clinical populations. In addition, frontal hemispheric dominance also appears to be a relatively stable phenomenon in non-clinical populations (Tomarken, Davidson, Wheeler, & Kinney, 1992; Tomarken, Keener, & Neubauer, 1994). However, situational influences do impact hemispheric dominance. Hagemann, Naumann, Thayer, and Bartussek (2002) estimate that approximately 52% to 64% of the variance in frontal asymmetry is due to individual trait differences while 35% to 45% is due to situational variations.

Research on affective cortical lateralization has not been confined to the frontal lobes; the parietal lobes are also thought to be asymmetrically involved in the perception of affect (Borod et al., 1998 as cited in Harmon-Jones et al., 2010, p. 459). Evidence suggesting that the right parietal region is involved in emotional perception, in spite of its valence or motivational direction (Harmon-Jones et al., 2010), has been shown in patients with right parietal lesions using facial identification and facial affect tasks (Bowers, Bauer, Coslett, & Heilman, 1985) and in research examining event-related potentials using affective pictures (Keil et al., 2001) and words (Thomas, Johnstone, & Gonsalvez, 2007) as stimuli.

As discussed by Wheeler, Davidson, and Tomarken (1993), there are also great individual differences in the quality and strength of response to affective stimuli. The authors attempted to

test the theory that these individual differences are actually mediated by activity in the left and right frontal hemispheres. To do this, the researchers examined the brain waves of participants periodically over a 3 week period while each participant watched a short positive and negative emotional film clip. The researchers found that activation in the left hemisphere was associated with viewing the positive emotion inducing film clip, whereas there was greater right frontal activation while watching the negative film clips.

In a study using functional magnetic resonance imaging (fMRI), Beaver and colleagues (2006) looked at individual variations in trait reward sensitivity while participants viewed images of appetizing, bland, and disgusting foods. Given that individual differences in trait reward sensitivity can be used to predict food cravings (Davis, Strachan, & Berkson, 2004, as cited in Beaver et al., 2006), Beaver et al. found that individuals who were high on trait reward sensitivity were more likely to show greater left frontal hemispheric activation to images of appetizing food compared with images of disgusting food. They also found that when viewing photographs of disgusting food, participants showed significantly greater right frontal hemispheric activation compared to viewing images of appetizing foods. The authors conclude that appetitive neurological responses to food cues can actually be predicted based on an individual's level of trait reward sensitivity.

Armed with the information that restrained eaters typically have high levels of angst and negative affect after disinhibition of eating, and that negative affect has been linked with greater right than left frontal hemispheric activation, Silva, Pizzagalli, Larson, Jackson, and Davidson (2002) conducted a novel study to see if chronically restrained eaters would show greater right than left frontal hemispheric asymmetry compared with unrestrained eaters. After comparing the

EEG data from 23 restrained and 32 unrestrained eaters while at rest, they found that greater right frontal asymmetry was more prominent among restrained eaters.

In a related study, Rodriguez and colleagues (2007) used a quantitative electroencephalogram (qEEG) to examine cortical activity in participants diagnosed with anorexia and bulimia nervosa. The researchers found that when compared to a healthy control group, participants with anorexia or bulimia nervosa were more likely to show lower relative current density of alpha source activity in the central, limbic, temporal, occipital, and parietal regions. With specific reference to the frontal lobe, no differences in alpha activity were found between groups. However, significant differences between groups were found in the parietal region. Specifically, Rodriguez et al. found that individuals who were diagnosed as having anorexia or bulimia nervosa were more likely to show less alpha 1 and alpha 2 frequency-band activity compared to controls. The authors conclude that these findings support the hypothesis that individuals with eating disorders are more likely to show abnormal neural synchronization of the alpha frequency-band.

Based on the aforementioned research, it appears that individuals who exhibit high levels of dietary restraint show a unique pattern of emotional regulation and are highly sensitive to affective food cues. Thus, if individual differences in trait-reward sensitivity can be used to predict a cortical response to pictures of food (Beaver et al., 2006), it remains to be observed if individuals who exhibit high or low dietary restraint can be distinguished based on cortical frontal asymmetry particularly during exposure to appetitive food cues.

Goals of the Present Study

Presently, there is a general consensus that individuals who show greater right than left frontal asymmetry are more likely to show negative affect and withdrawal behaviours compared with individuals who have greater left frontal asymmetry (Davidson, 1992; Silva et al., 2002;

Wheeler et al., 1993). There also appears to be evidence that, upon presentation of appetitive food cues, healthy volunteers show more approach related left frontal asymmetry (Beaver et al., 2006). To date there are no known published studies examining whether or not restrained eaters would also show similar greater left than right frontal activation when shown images of appetizing foods, or if they would show the same right frontal EEG activation that is characteristic of individuals who are high on dietary restraint. Based on recent evidence showing that restrained eaters typically attempt to avoid highly caloric food (Herman & Polivy, 1988; Tuschl et al., 1999), it is likely that when presented with appetizing food cues, restrained eaters will show greater right than left frontal asymmetry.

The present study attempts to build on previous research examining the role of frontal asymmetry in restrained eaters versus unrestrained eaters by investigating how the former respond to the presentation of appetitive food cues. More specifically, the present study attempts to expand upon previous research by measuring frontal asymmetry in restrained eaters who have first undergone an experimental craving induction using chocolate.

Hypotheses.

Two primary predictions were hypothesized for the current study.

1. To replicate the findings of the Silva et al. (2002) study and demonstrate that restrained eaters do show greater right than left frontal hemispheric activation in the resting state.

2. To replicate the findings of Beaver et al. (2006) and demonstrate that unrestrained eaters will show greater left than right frontal activation when presented with appetizing food cues (i.e. chocolate). Further, to extend the results of the Beaver et al. study and test the hypothesis that restrained eaters will show greater right frontal asymmetry when presented with chocolate. In

short, an interaction was predicted between restraint status and differential hemispheric activity as a function of exposure to chocolate stimuli.

Method

Participants

The initial participant sample (N=209) for the first portion of this study was recruited from female undergraduate students enrolled in an introductory Psychology course at Lakehead University. To recruit participants, a mass e-mail was sent out to all female students enrolled in this course inviting them to participate in an online eating attitudes survey for which they would receive one point towards their final course mark (Appendix A). This e-mail contained a link that directed participants to an online psychometric testing battery using www.SurveyMonkey.com. This battery included demographic questions and assessed participant's attitudes and behaviours concerning the consumption of food. Before beginning the psychometric testing battery the participants were required to read the participant information and contact sheet and sign a consent form (Appendix B). The psychometric testing battery took approximately 20 – 30 min to complete and consisted of the Revised Restraint Scale (RRS; Polivy, Herman, & Warsh, 1978; Appendix C), and questions concerning demographic information (Appendix D), along with a small package of other questionnaires that were not used in the present study.

The RRS is a brief, self-report measure used to assess dietary restraint as well as to discriminate restrained from unrestrained eaters. This scale consists of 10 items with a total score ranging from 0 (no restraint) to 35 (high restraint). As convention dictates, participants scoring 15 points or higher on this scale were classified as restrained eaters while those scoring 14 points or below were classified as unrestrained eaters (Heatherton, Herman, Polivy, King, & McGree, 1988). Previous research has documented the validity and reliability of this scale in being able to

adequately differentiate these two populations (Allison, Kalinsky, & Gorman, 1992; Laessle, Tuschl, Kotthaus, & Pirke, 1989; van Strien, Herman, Engles, Larsen, & van Leeuwe, 2007) along with having excellent test-retest reliability (r = .95; Allison et al.) and good internal consistency (Cronbach's α = .82; Allison et al.).

Before the potential participants began the online psychometric testing battery, they were made aware that they were completing the battery in order to partake in two separate studies; one by this author and one by Monique Mercier, a fellow graduate student in the same research laboratory. The participants were required to state whether or not they would be willing to be contacted for the two experiments if they met the eligibility criteria. If the participants did not want to participate or be contacted regarding possible inclusion in the experiments, they were not permitted to complete the online testing battery. The participants who were willing to be contacted were permitted to complete the testing battery, despite eligibility status, and were awarded one credit point toward their introductory Psychology course final grade. Upon completion of the testing battery, eligible participants received another e-mail from the experimenter inviting them to participate in their respective study (Appendix E). All participants were awarded another credit point towards their introductory Psychology course final grade for their participation in the study.

Only women were included in this study because food cravings have been found to be more prevalent in women than men (Weingarten et al., 1991). Participants who endorsed any of the following criteria were not invited to participate in the experimental portion of this study: had allergies to chocolate or chocolate containing products, self-identified as left-handed, or was currently in treatment for an eating disorder, depression, or anxiety disorder. In addition, all participants had to profess a liking for, and be consumers of, chocolate containing products.

Sixty-five females expressed interest in participating and responded to the e-mail by scheduling appointments at the lab. The final sample size was a result of incomplete questionnaire data for one individual and technical EEG errors for 12 individuals. Additional data were also missing for one item for one individual for the RRS. It was replaced with prorated scores for the items within the individual.

Utilizing the recommended RRS cut-point score of 15 (Polivy et al., 1978), over half (57%) of the sample who underwent the experimental portion of this study were classified as restrained (n = 29) while the remainder of the sample were classified as unrestrained (n = 23). The average age of the participants was approximately 20 years (M = 19.96, SD = 5.49). Most participants classified themselves as Caucasian (94%). The remainder of the participants identified as being of European (2%), Native-Canadian (2%), and East Asian (2%) descent. The majority of participants reported being single (92%), with only a small number reporting being either married or in a common law relationship (6%) or divorced or separated (2%). Most of the participants were enrolled in a full-time academic program (98%), while one (2%) was enrolled in a part-time program. When asked to rate their liking for chocolate from 1 (*not at all)* to 5 (*very strongly*), the average participant reported that they "usually" liked to eat chocolate or chocolate-containing products, (M = 4.2, SD = 0.9), that they ate chocolate or chocolate containing products often (1 = *never*, 5 = *always*; M = 3.45, SD = 8.08), and that in an average week they ate chocolate two to three times a week in the past month, M = 3.14, SD = 1.35.

Procedure

Each experimental lab session lasted approximately 60 min. Participants were instructed to abstain from eating chocolate for 24 hr prior to the experiment. They also received instructions not to eat for 2 hr prior to the experiment to insure that each participant was at similar levels of

hunger. Upon entering the lab, participants were asked to sit at a private desk and to read the provided participant information sheet and consent form (see Appendix F and G, respectively). Next, the participants were informed that their heart rate would be measured during the study for a separate researcher who was studying sympathetic arousal. They were then instructed to strap a heart rate transmitter around their chest. Once this was completed, participants were seated in a private, dimly lit room in front of a television and fitted with an EEG cap.

In order to assess each participant's current desire or urge to eat, participants were asked to complete a Craving Visual Analog Scale (CVAS) at the beginning of the experimental procedure. Visual analog scales are commonly used in many areas of craving research, such as to measure cigarette (Maude-Griffin & Tiffany, 1996; Tiffany & Drobes, 1990) and alcohol cravings (Paille et al., 1995). Participants were asked to indicate on a 10 cm visual analog scale their current desire or urge to eat from 0 = *no desire or urge to eat* to 10 = *extremely strong desire or urge to eat* (adapted from Kemps & Tiggemann, 2007; Appendix H). Following this, the first 35 s EEG recording was taken with the participant's eyes closed. Next, the first EEG eyes open recording along with the imagery presentation began (approximately 660 s in total; see Figure 1). The participant began by viewing 12 neutral, nonfood images (12 s each) alternating with 12 black blank slides (6 s each) and 12 fixation crosses (2 s each). In order to obtain a reflection of how each participant responded to the craving induction, the 6-item collection of neutral images was presented prior to the chocolate images. This method used to establish an initial comparison of EEG activity is similar to that implemented by Beaver et al. (2006). Images were chosen based on similar criteria to that of Beaver et al. Each image was a full-colour, visually complex neutral object that lacked any obvious affective/motivational value but would still require similar perceptual analysis as when viewing the chocolate images. Examples

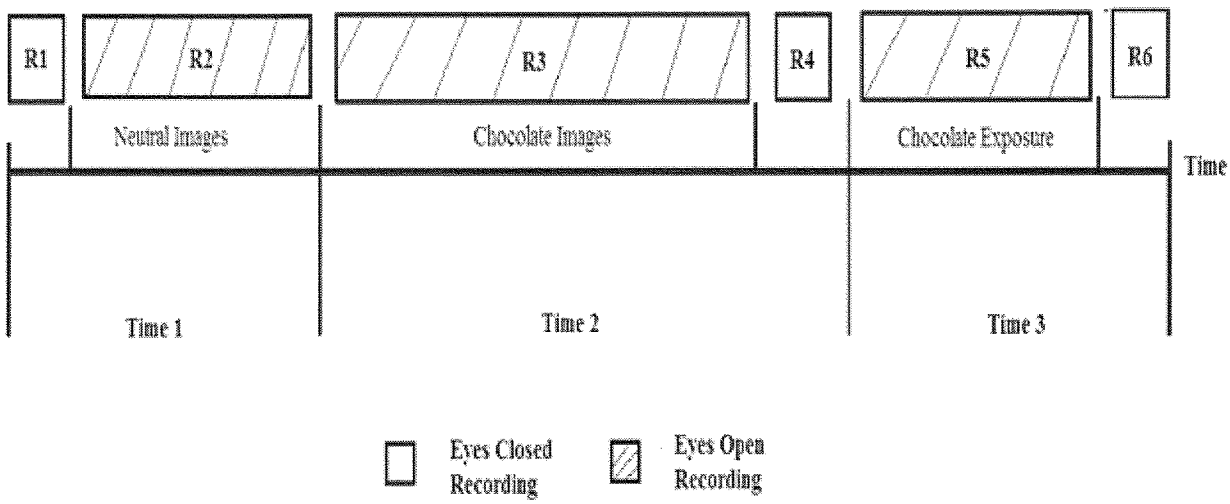

Figure 1. Timeline of experimental procedure.

of the neutral images are as follows: blender, light-bulb, battery, paint brush (see Appendix I). Each neutral image was presented in an identical format to that of the chocolate images.

After viewing the neutral images, the second EEG eyes open recording was taken while the participants simultaneously watched the presentation of the chocolate images and read an imagery induction script. Chocolate was chosen as the craving induction cue because it is one of the most commonly and intensely craved foods (Rodin et al., 1991). Currently, there have been numerous successful attempts to elicit chocolate cravings in a lab using a variety of different methods. Tuomisto et al. (1997) found that it was possible to get participants to crave by instructing them to imagine having chocolate in their possession and to imagine smelling and tasting the chocolate. Similarly, other studies have found that cravings can be elicited simply through instructed imagery (Harvey, Kemps, & Tiggemann, 2005; Kemps, Tiggemann, Woods, & Soekov, 2004), by presenting the word "*chocolate*" (Pelchat, Johnson, Chan, Valdez, & Ragland, 2004), and by presenting visual images of chocolate (Rodriguez, Fernandez, Cepeda-Benito, & Vila, 2005). The present study used 21 visually appealing, full colour images of

chocolate and the written word "*chocolate*" (see Appendix J). The images for this study were selected based on the results of a pilot study implemented by this researcher. The pilot study contained 40 different images of chocolate. The images were presented to participants drawn from a separate, but similar population to that which was examined in the main experiment (n = 24). Participants in the pilot study were asked to rate how "delicious each photo looks" by indicating on a 7–point Likert scale ranging from 1 (*Does not look good, I would never eat this*) to 6 (*Looks so delicious I would eat this right now*). The mean rating for the chosen food stimuli was 5.26 (*SD* = 0.33). In the main study each image was presented for 12 s on a 72 in. television screen positioned approximately 2 m directly in front of the participant.

An imagery induction script (Appendix K) was simultaneously presented on the screen along with each chocolate image. The imagery induction script prompted the participant to imagine "*having chocolate in your possession,*" "*imagine eating chocolate,*" and "*to imagine the smell and taste of chocolate*" (adapted from Tuomisto et al., 1997). Again, each slide alternated with 21 black blank slides (12 s each) and 21 fixation crosses (2 s each). After watching the imagery presentation, the second 35 s EEG eyes closed recording was taken. Next, the third EEG eyes open recording began while the participant was instructed via text on the monitor to remove a cloth concealing a plate revealing two similar chocolate bars of different sizes: Cadbury Dairy Milk Thins bar (thin bar; 18 g, 100 calories) and Cadbury Dairy Milk bar (full size bar; 100 g, 535 calories). The participant was then instructed to choose the bar that they found most appealing, to unwrap it, smell it, break it in half, and imagine eating it over the next 4 min (but to not actually eat it). During this period, every 30 s a slide would appear on the monitor instructing the participants to "*imagine you are about to eat the chocolate,*" "*smell the chocolate,*" and "*imagine rolling the chocolate around in your mouth.*" Finally, the participant was instructed to

place the chocolate bar onto a plate in front of them, pick up the plate, and position the plate under their nose while resting their elbows comfortably on the arms of their chair. Then they were instructed to concentrate on the smell of the chocolate while they sat still with their eyes closed for the final, 35 s EEG recording. Directly following this, the participants were again asked to complete a CVAS. This was done to identify any change in each participant's urge or desire to eat that may have occurred over the course of the experimental procedure. Participants were then asked to complete one additional questionnaire; the Orientation to Chocolate Questionnaire (OCQ).

The OCQ (Cartwright et al., 2007; Cartwright & Stritcke, 2008; Appendix L) is a three-factor model of chocolate craving and is used to discriminate individuals who strongly crave chocolate from those who do not crave chocolate as well as predict the frequency and quantity of chocolate consumption and various forms of eating-disordered behaviours (Cartwright et al., 2008). The three factors used by this questionnaire to assess chocolate cravings are Approach, Avoidance, and Guilt. These three factors identify the likelihood that one may approach or avoid chocolate related cues, as well as experience feelings of guilt related to chocolate consumption. An additional scale included in this questionnaire addressed the frequency with which participants consume chocolate. This scale ranged from 0 (*Never*) to 6 (*Every day*). The OCQ is comprised of 14 items plus the scale measuring the frequency of chocolate consumption. Bivariate correlation coefficients have demonstrated that all three constructs are moderately related (Approach and Avoidance, $r = .68, p < .01$; Approach and Guilt, $r = .53, p < .01$; Avoidance and Guilt, $r = .68, p < .01$). Standardized item loadings for the three factors of Guilt, Approach, and Avoidance varied between $r = .91$ to $.97$, $r = .86$ to $.95$, and $r = .91$ to $.97$, respectively (Cartwright et al., 2008).

After completing the final questionnaire, the participants were unhooked from the EEG, debriefed, and excused. At the behest of the Research Ethics Board, a list of counseling resources was made available if a participant expressed interest (see Appendix M).

Recording of the Electroencephalograms

The EEG was used in this study to measure the frontal asymmetry in alpha power (square volts = μV^2) of participants before, during, and after the craving induction episode. The procedure used followed that of Hofmann (2007). This study used electrode placements which complied with the International Electrode Placement System as follows: left and right parietal (P3 and P4); left and right frontal (F3 and F4); midline central (Cz) and right mastoid (A2), both referred to left mastoid (A1). The participant was fitted with a 128-channel Active Shield cap with specified electrodes fed through a 72-channel amplifier and into a recording PC with acquisition software (all EEG apparatuses were supplied by Advanced Neuro Technology, Enschede, the Netherlands). The researcher strove to obtain impedance values that were less than 10 kΩ, and this was achieved with the use of ElectroGel. Cortical activity was continuously sampled three times for 35 s eyes closed intervals at 512Hz, and one time for 7 min and twice for 4 min at 512Hz with eyes open. Electro-oculogram channels placed above, below, and on each side of the left eye were used to correct for EEG eye-movement artifacts (see Appendix N for an example of an alpha wave recording at each electrode placement site).

Preparation of the EEG recordings for statistical analysis also followed that of Hofmann (2007) which is congruent with established methods of calculating cortical asymmetry (Allen, Coan, & Nazarian, 2004). To begin, artifacts due to eye blinks, movements or gross muscle activity as detected by the electro-oculogram electrodes were removed using Advanced Neuro Technology software (Enschede, Netherlands). EEG data were analyzed using a high-pass filter

and a low cut-off frequency of 1 Hz. The interval between epochs was 0.5 s. Next, because this study was exclusively interested in examining alpha-band activity, a filter was used to reflect only data contained within 8 – 13 Hz. Epochs were extracted using a Hanning Window. Using a Fast Fourier Transformation (FFT), data were then partitioned into windows of 1 s duration with a 50% overlap. This was done to minimize data loss due to windowing. For each of the 1 s 50% overlapping windows, a μV^2 value was calculated by taking the square of the results of the FFT algorithms. The μV^2 values were then averaged across epochs for each EEG recording window. Raw EEG alpha μV^2 output for left and right frontal and parietal hemispheres were separately subjected to the natural log (LN) transformation in order to address the problem of positively skewed data that is commonly found in the respective distributions. As outlined in Silva et al. (2002) and documented by Sutton and Davidson (1997) and Wheeler et al. (1993), the midfrontal F3/F4 sites carry the greatest correlation with frontal dimensions of approach and avoidance whereas the parietal P3/P4 sites do not. The addition of recording information from the P3/P4 sites was done in order to establish control sites by which to test hypotheses relevant to frontal F3/F4 recordings. A difference score was then calculated by subtracting left from right recordings (LN (Right) – LN (Left)) for the homologous pairs of frontal (LN F4 – LN F3), and parietal (LN P4 – LN P3) electrodes. When interpreting this metric, the assumption is made that alpha μV^2 is the inverse of cortical activity; therefore, decreases in alpha μV^2 reflect increases in cortical activation. Thus, positive asymmetry difference scores indicate relatively greater left-sided cortical activation, zero difference represents symmetrical activity, and negative difference scores reflect greater right-sided activity (Allen et al., 2004). Means and standard deviations of the EEG logarithmically transformed alpha μV^2 values during the three eyes closed and three eyes

open EEG recordings are presented in Table 1. These values are similar to those found by Hofmann (2007). The averaged logarithmically transformed frontal (F4 – F3) and parietal (P4 – P3) asymmetry scores for each recording are also presented in Table 1.

Sixty-five participants took part in the experimental portion of the study. Thirteen of these participants were deleted from the final data set. One participant was deleted due to missing questionnaire data and twelve participants were deleted due to technical and EEG recording errors. Regarding EEG data, seven of the twelve deleted participants were deleted due to technical errors during recording. Three participants were deleted from the data set due to failures to follow instructions during the craving induction (e.g., did not unwrap chocolate bar) and for uncontrollable outside interference during the craving induction (i.e., cell phone ringing, problem with a bar of chocolate). Two participants were also deleted from the final data set due to outlying values for EEG data across all recordings. Of the remaining participants, seven outliers were identified using *z* scores exceeding 3.29 and were replaced with the next highest non-outlier EEG value plus one (Tabachnick & Fidell, 2001). Missing data were detected in eight cases across all participants. This data was replaced with the sample mean. Of the sixty-five participants who took part in the experimental portion of the study, data were retained and analyzed for a total of fifty-two participants.

Results

Experimental Manipulation Check

To ascertain the effectiveness of the craving induction, CVAS scores were analyzed using a one-within (time; pre vs. post experiment), one-between (restraint status) Analysis of Variance (ANOVA). A statistically significant time main effect was observed, $F(1, 50) = 78.9, p < .001$, partial $\eta^2 = .615$, wherein participants went from $M = 5.94$ ($SE = 0.26$) to 7.75 (0.25) on the 10

Table 1

EEG Recording Values

	Recording					
EEG sites	1	2	3	4	5	6
F3	2.19 (0.51)	2.88 (0.74)	2.2 (0.43)	2.17 (0.46)	2.05 (0.47)	3.11 (0.66)
F4	2.19 (0.53)	2.88 (0.74)	2.2 (0.45)	3.13 (0.67)	2.06 (0.46)	3.14 (0.67)
P3	2.27 (0.70)	3.32 (1.01)	2.3 (0.66)	3.6 (0.80)	2.09 (0.59)	3.56 (0.79)
P4	2.22 (0.70)	3.34 (1.03)	2.3 (0.66)	3.67 (0.87)	2.1 (0.61)	3.6 (0.84)
F4 – F3	-.003 (0.07)	.01 (0.12)	-.001 (0.07)	.02 (0.08)	.01 (0.08)	.02 (0.09)
P4 – P3	-.05 (0.15)	.01 (0.22)	-.01 (0.20)	.06 (0.24)	.01 (0.13)	.04 (0.28)

Note. The table shows means and standard deviations of logarithmically transformed EEG alpha power (μV^2) in the left and right frontal (F3, F4) and the left and right parietal (P3, P4) electrode sites, and the averaged logarithmically transformed frontal (F4 – F3) and parietal (P4 – P3) asymmetry scores during the three eyes closed recordings (recordings 1, 4, 6) and the three eyes open recordings (recordings 2, 3, 5) during the craving induction experimental manipulation.

cm scale. There was no significant main effect for restraint status, or interaction of Time × Restraint status. Thus, the craving induction had its intended effect among participants upon their subjective state of craving.

Questionnaire Data

Descriptive statistics and Cronbach's alpha for the RRS and OCQ are presented in Table 2. Aside from the OCQ Avoidance subscale, the psychometric variables possess good internal consistency wherein Cronbach's $\alpha > .8$.

Table 3 displays the intercorrelation matrix among the psychometric variables of the RRS and OCQ. The RRS bears a strong positive relationship with the OCQ Guilt subscale, with higher scores of restraint being associated with greater feelings of guilt.

Table 2

Scale Reliability Coefficients and Descriptive Statistics

Variable	Chronbach's Alpha	Number of Items	Theoretical Range	*M*	*(SD)*
RRS	.83	10	0-44	16.74	7.34
OCQ:					
Approach	.83	6	0-54	29.12	9.96
Avoidance	.77	3	0-18	5.38	3.39
Guilt	.95	6	0-54	23.85	14.56

Note. RRS = Revised Restraint Scale; OCQ = Orientation to Chocolate Questionnaire. Higher scores on the RRS and OCQ indicate a greater degree of disordered eating attitudes and behaviours, and greater approach, avoidance, and guilt related behaviours towards chocolate, respectively.

Table 3

Intercorrelation Matrix of Psychometric Variables

Variables	1	2	3	4	5
1. RRS	----				
OCQ:					
2. Guilt	.47**	----			
3. Approach	.18	.36*	----		
4. Avoidance	.12	.36*	.54**	----	
5. Frequency	-.04	.08	.51**	.25	----

Note. RRS = Revised Restraint Scale; OCQ = Orientation to Chocolate Questionnaire.
** .001 significance level, * .05 significance level

Analytic Strategy

Both hypotheses were investigated using a mixed model ANOVA. The analytic strategy for the first hypothesis was modeled on that of Silva et al. (2002) by confining analysis to EEG recorded during the resting state (i.e., R1 eyes closed and R2 neutral pictures). In this analysis, alpha μV^2 of the frontal and parietal hemispheric asymmetry difference scores served as the dependent variable (LN F4 – LN F3; LN P4 – LN P3) in a two-within (eyes: open vs. closed; region: frontal vs. parietal), one-between (restraint status) ANOVA. For hypothesis 2, a third within-subjects independent factor was added to the above analytic strategy; specifically, stimuli (neutral images vs. chocolate images vs. chocolate exposure) in order to investigate potential differential EEG response of participants to the varying stimuli as a function of restraint status. Next, supplemental analysis of the actual alpha μV^2 was conducted along the lines of Silva et al. and Rodriguez et al. (2007) by expanding the above ANOVA to a four-within analytic design that included a fourth independent variable comprising hemisphere; left versus right. This omnibus analysis allowed for a determination of differential electrical activity across hemispheres, regions, eyes, and stimuli as a function of restraint status. Mauchly's test was used to evaluate the sphericity assumption for all potential ANOVA main and interaction effects that involved stimuli which comprised three levels of this within-subjects independent variable. In instances where the assumption of sphericity was violated, degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity. Finally, Pearson correlation and hierarchal multiple regression analyses were used to explore psychometric correlates of various EEG recordings of interest.

Hypothesis 1

The first goal of this study was to replicate the findings demonstrated by Silva et al. (2002) to show that restrained eaters do exhibit greater right than left frontal hemispheric activity. The

two-within, one-between ANOVA on the asymmetry values failed to produce a significant main effect for restraint status, $F(1, 50) = 1.33$, $p = .254$, partial $\eta^2 = .026$, or significant interaction with either of the two within-subjects independent variables: Restraint Status × Region, $F(1, 50) = 1.56$, $p = .217$, partial $\eta^2 = .03$; Restraint Status × Eyes, $F(1, 50) = 2.47$, $p = .122$, partial $\eta^2 = .047$. Similar to the analysis performed by Silva et al., Pearson correlations were computed between the scores on the RRS and, separately, with asymmetry values at the frontal and parietal sites, each averaged over the R1 and R2 recordings. No significant correlations were found at either the frontal ($r = .07$, $p = .61$) or parietal ($r = .06$, $p = .69$) regions. The lack of correlation between the RRS and frontal or parietal asymmetry values in either cortical region, coupled with the finding that restrained and unrestrained eaters do not exhibit statistically significant differences in frontal asymmetry, indicates an inability to replicate the findings originally observed by Silva et al.

Hypothesis 2

The second goal of this study was to replicate and then extend the findings of Beaver et al. (2006) whose fMRI investigation observed a left anterolateral orbitofrontal cortical activation among an unselected group of participants when exposed to pictures of appetizing food (e.g., chocolate) relative to non-food pictures. First, we wanted to demonstrate that unrestrained eaters would evidence a positive right – left hemispheric asymmetry value (i.e., greater right than left EEG alpha μV^2) when presented with chocolate; that is, greater cortical activity in the left hemisphere, representing approach motivation. Second, we wanted to extend these results and test the hypothesis that restrained eaters would show greater negative right – left hemispheric asymmetry (i.e., greater left than right EEG alpha μV^2) when presented with chocolate, consistent with greater cortical activity in the right hemisphere and signaling withdrawal motivation. In

other words, an interaction was predicted between restraint status and asymmetry values. To test hypothesis 2, a three-within, one-between ANOVA on asymmetry values was performed. This analysis produced a statistically significant main effect of stimuli, $F(2, 100) = 5.08$, $p = .008$, partial $\eta^2 = .092$, the results of which are depicted in Figure 2. However, contrary to prediction, this main effect was not moderated by its interaction with restraint status, $F(2, 100) = 0.74$, $p = .482$, partial $\eta^2 = .014$. Thus, we observed among participants a migration toward greater right than left EEG electrical activity recorded over the frontal and parietal regions of the scalp, reflecting greater cortical activity in the left hemisphere as a function of the phases of the craving induction.

The above analysis also produced a significant Restraint Status × Region interaction, $F(1, 50) = 4.06$, $p = .049$, partial $\eta^2 = .075$, the effect of which is depicted in Figure 3. To decompose the source of this interaction, a follow-up t test of the simple effect of restraint status upon asymmetry values in the parietal region was conducted which proved to be significant, $t(50) = 2.1$, $p = .041$. Restrained eaters appear to experience less left relative to right hemispheric cortical activity in the parietal region relative to their unrestrained counterparts over the course of the entire experiment. Furthermore, restraint status did not significantly interact with any other within-subjects variables: Restraint Status × Eyes, $F(1, 50) = 3.67$, $p = .061$, partial $\eta^2 = .068$; Restraint Status × Stimuli × Eyes, $F(2, 100) = 0.019$, $p = .981$, partial $\eta^2 < .001$; Restraint Status × Eyes × Region, $F(1, 50) = 2.21$, $p = .143$, partial $\eta^2 = .042$; Restraint Status × Stimuli × Eyes × Region, $F(2, 100) = 0.31$, $p = .736$, partial $\eta^2 = .006$.

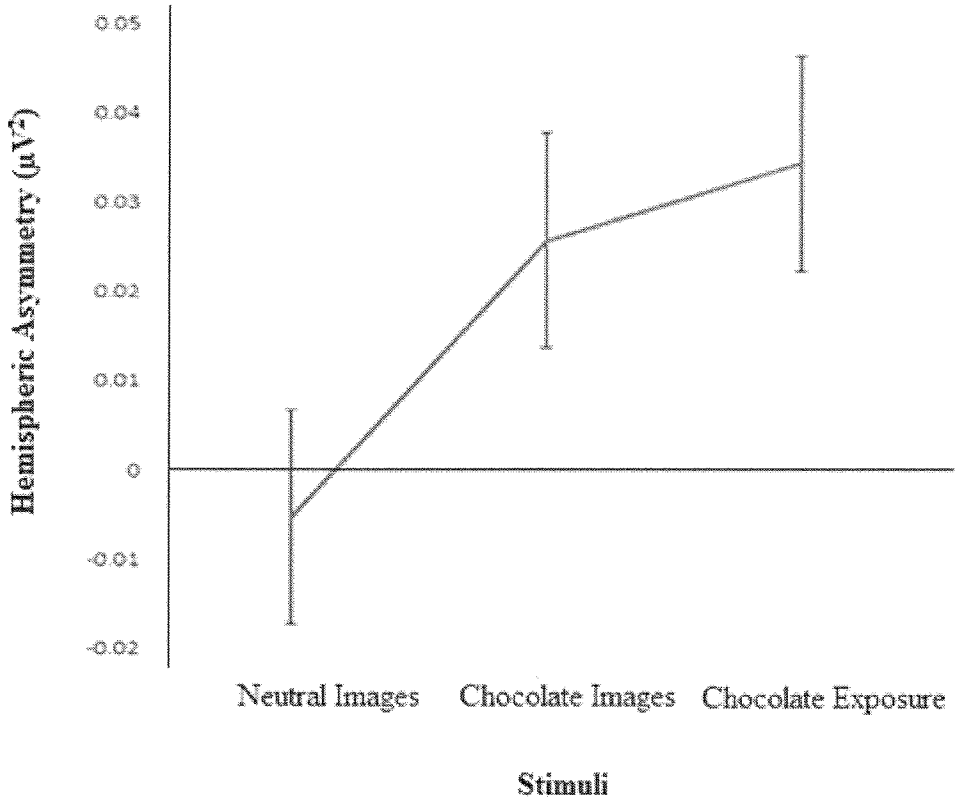

Figure 2. Mean values of hemispheric asymmetry (right minus left alpha μV^2 averaged over the frontal and parietal regions) plotted as a function of stimuli. Error bars reflect $\pm$ one standard error.

Analysis of Alpha Power

The four-within, one-between ANOVA was performed on the logarithmically transformed alpha μV^2 values. No significant between-subjects main effect of restraint status was found, $F(1, 50) = 0.28$, $p = .6$, partial $\eta^2 = .006$. However, the analysis did produce a significant main effect of region, $F(1, 49) = 35.6$, $p < .001$, partial $\eta^2 = .42$, which was qualified by a Restraint Status × Region interaction, $F(1, 50) = 8.81$, $p = .005$, partial $\eta^2 = .15$, the latter depicted in Figure 4. To decompose the source of this interaction, a follow-up t test of the simple effect of restraint status upon alpha μV^2 in the parietal region was conducted which proved to be nonsignificant, $t(50) = 1.24$, $p = .222$. To test for differences within participants as a function of region, a regional

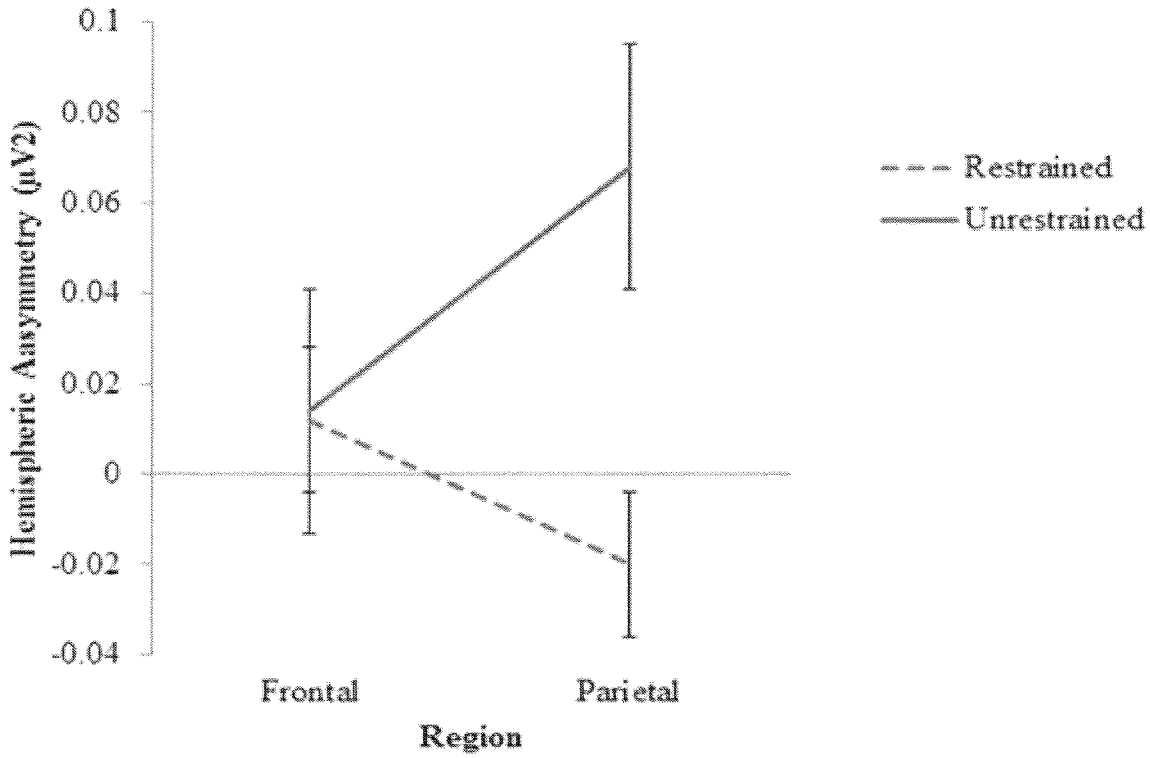

Figure 3. Mean values of hemispheric asymmetry (right minus left alpha μV^2) in restrained and unrestrained eaters plotted as a function of region. Error bars reflect $\pm$ one standard error.

asymmetry difference score in alpha μV^2 was calculated as follows; parietal - frontal, wherein positive scores are indicative of greater frontal cortical activity. The simple effect of region was significant among unrestrained participants, $t(21) = -4.32$, $p < .001$, as well as restrained individuals, $t(28) = -3.89$, $p = .001$. However, a Pearson correlational analysis revealed the effect of region was greater for the unrestrained than restrained groups (coded 1 vs. 0, respectively for correlational purposes), $r(51) = .42$, $p = .001$, indicating that these individuals experienced greater cortical activity in their frontal relative to parietal region.

The analysis also produced a significant Restraint Status × Region × Hemisphere interaction, $F(1, 50) = 4.06$, $p = .049$, partial $\eta^2 = .075$. This effect is identical to the Restraint Status × Region interaction found in the previous 3-within, 1-between ANOVA using scores of frontal

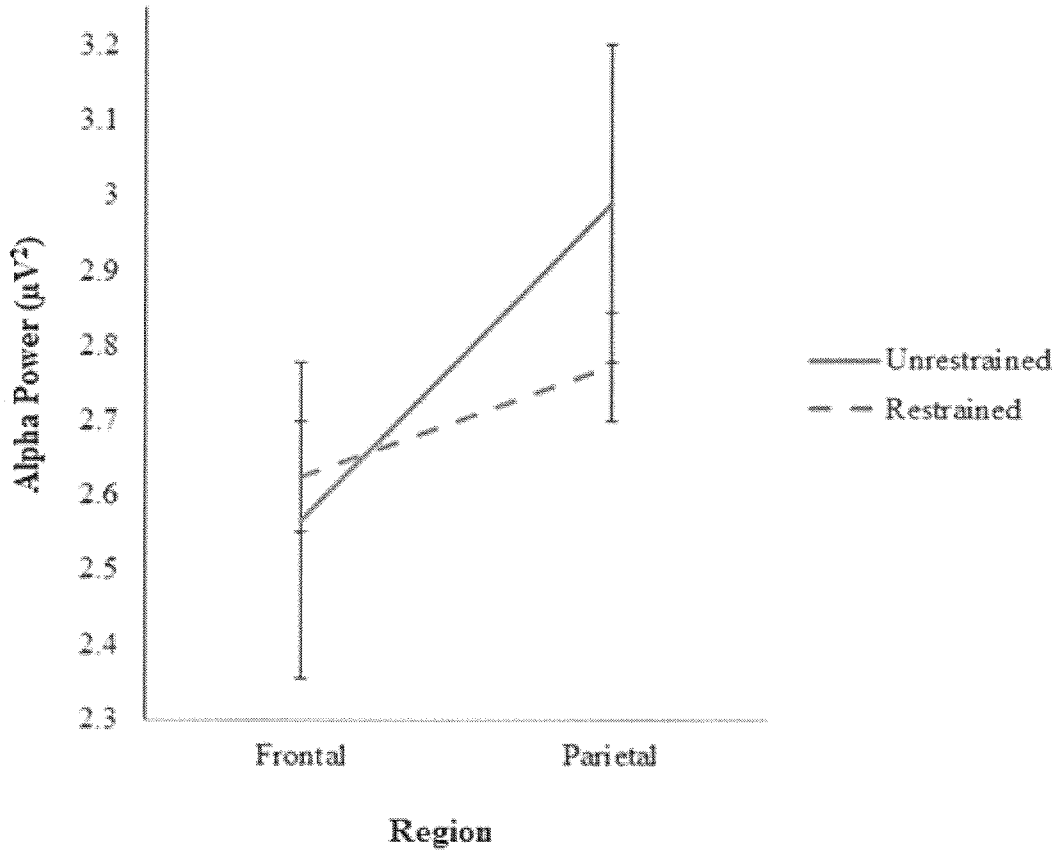

Figure 4. Mean values of logarithmically transformed alpha power (μV^2) in the frontal and parietal cortical regions in restrained and unrestrained eaters. Error bars reflect $\pm$ one standard error.

asymmetry as the dependent variable. Restraint status did not significantly interact with any other within-subjects variables: Restraint Status × Hemisphere, $F(1, 50) = 3.1$, $p = .084$, partial $\eta^2 = .06$; Restraint Status × Stimuli × Eyes, $F(2, 100) = 0.22$, $p = .81$, partial $\eta^2 = .004$; Restraint Status × Stimuli × Region, $F(2, 100) = 1.73$, $p = .18$, partial $\eta^2 = .03$; Restraint Status × Eyes × Region, $F(1, 50) = 1.44$, $p = .24$, partial $\eta^2 = .03$; Restraint Status × Stimuli × Eyes × Region, $F(2, 100) = 0.2$, $p = .82$, partial $\eta^2 = .004$; Restraint Status × Eyes × Region × Hemisphere, $F(1, 50) = 2.22$, $p = .14$, partial $\eta^2 = .04$; Restraint Status × Stimuli × Region × Hemisphere, $F(2, 100) =$

0.31, $p = .74$, partial $\eta^2 = .006$; Restraint Status × Eyes × Hemisphere, $F(1, 50) = 3.67$, $p = .06$, partial $\eta^2 = .07$.

Exploratory Prediction

A series of hierarchical multiple regression analyses were computed to determine whether participants' attitudes and behaviours toward chocolate incrementally added to the prediction of EEG hemispheric asymmetry (see Figure 3) and regional asymmetry (see Figure 4) over and above that which was accounted for by participants' restraint status as revealed in the above ANOVA results. For each analysis, restraint status was entered in the first step. The second step included the simultaneous entry of the OCQ subscales: Guilt, Approach, Avoidance, and Frequency. To this second step the participants' choice of chocolate bar during the chocolate exposure phase of the experiment was added; thin or full size bar (coded 1 versus 2) wherein 71% chose the latter.

Various parametric assumptions of regression were evaluated according to Field (2009). Specifically, the Durbin-Watson test for the assumption of independent errors and the assumption of homoscedasticity were evaluated. The Durbin-Watson statistic tests the assumption that the residual terms for any set of observations should be uncorrelated. The obtained test values ranged from a low of 1.65 to a high of 2.55 across each of the separately conducted regression analyses. The values lie within the acceptable range of 1 to 3, suggesting the assumption of independent errors is tenable. The assumption of homoscedasticity states that the residuals of an analysis are approximately equal for all predicted scores of the dependent variable. This assumption was evaluated by examining the separate scatterplots of the standardized residual values. Since each residuals plot showed equal distribution for all values of the predicted dependent variable, the assumption of homoscedasticity is tenable.

Regarding the prediction of overall hemispheric asymmetry in the parietal region, the results indicated that restraint status explained approximately 8% of the variance, $R^2 = .08$, $F(1, 50) = 4.19$, $p = .046$. Variables in step 2 did not significantly add to the prediction, $\Delta R^2 = .10$, $F(5, 45) = 1.05$, $p = .403$ (see Table 4). As for regional asymmetry (see Table 5), once again restraint status was a significant predictor in step 1, $R^2 = .15$, $F(1, 50) = 8.81$, $p = .005$, whereas step 2 did not incrementally add to the prediction, $\Delta R^2 = .17$, $F(5, 45) = 2.25$, $p = .065$.

Finally, the same prediction model was run on frontal hemispheric asymmetry results (see Figure 2); specifically, prediction of change in the dependent variable observed during chocolate exposure minus that observed during neutral images. Neither step 1, $R^2 = .007$, $F(1, 49) = 0.34$, $p = .56$, or step 2, $\Delta R^2 = .03$, $F(5, 44) = 0.25$, $p = .94$, significantly predicted the observed migration towards left frontal asymmetry among participants over the course of the craving induction.

Discussion

Previous research (Beaver et al., 2006) utilizing fMRI has demonstrated in a small sample of healthy men and women an activation of the left orbitofrontal cortex when presented with pictures of appetizing food like chocolate and ice cream in contrast to nonfood objects and pictures of such disgusting foods as rotten meat and moldy bread. Furthermore, there is some evidence to suggest that, independent of food cues, during a resting state restrained eaters show greater right than left frontal asymmetry (Silva et al., 2002). This phenomenon is thought to be related to the negative or depressive dispositional affect that is often characteristic of this population, and to their increased tendency to struggle with emotional regulation and anxiety. However, to date there has been no published research using EEG to investigate how restrained eaters react when presented with appetizing food cues.

Table 4

Multiple Regression Predicting Hemispheric Asymmetry in the Parietal Region

	B	*SE B*	β
Constant	-0.02	0.03	
Restraint Status	0.09	0.04	.28*
Step 2			
Constant	-0.03	0.10	
Restraint Status	0.04	0.05	.14
Chocolate Bar Choice	0.04	0.05	.12
OCQ: Frequency	0.02	0.02	.13
OCQ: Guilt	-0.004	0.002	-.32
OCQ: Approach	0.00	0.003	-.04
OCQ: Avoidance	0.003	0.007	.06

Note: $R^2 = .08$ for Step 1 ($p = .046$), $\Delta R^2 = .10$ for Step 2 ($p = .403$).
* $p < .05$.

The present study sought to address this gap in the literature by investigating the relationship between cortical asymmetry and the individual difference variable of dietary restraint during a craving induction. Specifically, the present study had two principal aims. The first goal was to replicate the findings of Silva et al. (2002) and demonstrate that individuals who exhibit high dietary restraint would show greater right frontal hemispheric activation during the resting state. The second goal was to replicate the findings of Beaver et al. (2006) and demonstrate that unrestrained eaters would show greater left frontal activation when presented with chocolate.

Table 5

Multiple Regression Predicting Alpha Regional Asymmetry

	B	*SE B*	β
Step 1			
Constant	0.15	0.06	
Restraint Status	0.28	0.09	.39**
Step 2			
Constant	-0.23	0.21	
Restraint Status	0.24	0.1	.34*
Chocolate Bar Choice	0.17	0.11	.22
OCQ: Frequency	0.06	0.04	.22
OCQ: Guilt	-0.002	0.004	-.08
OCQ: Approach	-0.008	0.007	-.20
OCQ: Avoidance	-0.03	0.02	.34*

Note: $R^2 = .15$ for Step 1 ($p = .005$), $\Delta R^2 = .17$ for Step 2 ($p = .065$).
* $p < .05$, ** $p < .01$.

Furthermore, we attempted to extend these findings and demonstrate that individuals high in dietary restraint would show greater right frontal asymmetry when presented with chocolate.

Contrary to predictions, a test of the first hypothesis revealed no significant differences in cortical asymmetry between restrained and unrestrained eaters during the resting state. In addition, no correlation was found between the RRS and asymmetry values in either the frontal or parietal regions for either group. As such, the original hypothesis was not supported for this sample as we were not able to replicate the findings originally observed by Silva et al. (2002).

A potential explanation for the failure to replicate Silva et al. (2002) may relate to differences in experimental methodology. Specifically, the timing of the collection of EEG data and scores of dietary restraint varied between the present study and that of Silva et al. In the present study, restraint status was assessed within one to two months of EEG data collection, while the restraint status of participants in Silva et al.'s study was assessed 18 - 24 months after the EEG recordings were collected. Additionally, the recording of EEG activity also differed between the present study and that of Silva et al. The participants in Silva et al.'s study underwent two EEG recording sessions, separated by 6 weeks. During each of these sessions, EEG recordings were administered in eight, 1-min resting trials: four trials with eyes open and four trials with eyes closed, presented in counterbalanced order. The participants in the present study, however, only underwent one EEG recording session. Due to the nature of our experimental design, instead of administering EEG recordings in eight, 1-min resting trials, cortical activity in the present study was sampled continuously three times for 35 s with eyes closed, and one time for 7 min and twice for 4 min with eyes open. Additionally, during the eyes open EEG recordings in Silva et al.'s study participants were seated in a dimly lit room without any obvious visual imagery presentation. This differs from the present study where participants were required to either view images or manipulate chocolate during the eyes open recordings.

Another explanation for the failure to replicate Silva et al.'s (2002) study could be a result of participant self-selection bias. When agreeing to participate in the experimental portion of the present study our participants were aware that they would be taking part in an experiment featuring chocolate. Our participants were also aware that they would be required to view pictures of chocolate as well as be exposed to actual bars of chocolate. As a result of knowing they would be taking part in a c*hocolate study*, participants who did not like or were allergic to

chocolate, or did not want to be exposed to pictures of chocolate or actual chocolate bars may have chosen not to participate in our experiment. During recruitment for the experiment, participants were also made aware that they would be required to abstain from eating for 2 hr and from eating chocolate or chocolate containing products for 24 hr prior to the experiment. Thus, participants who would not be able to meet these demands would have chosen to not participate. In contrast, the participants in Silva et al.'s study were not exposed to food and therefore were under no instructions to avoid eating prior to the experiment. Consequently, participants wanting to avoid exposure to food would not have avoided participating in Silva et al.'s study.

The results of the present study did support the first objective of the second hypothesis. Specifically, we were successful in demonstrating findings using an EEG that are comparable to that of Beaver et al. (2006). By designing a craving induction that paired chocolate exposure with pictures of chocolate, this study was successful in eliciting a shift in cortical asymmetry to the left hemisphere (see Figure 2). The observed shift to greater left asymmetry as a result of viewing emotionally evocative stimuli has been documented in different populations and using different stimuli such as film clips (Davidson, 1992; Tomarken, Davidson, & Henriques, 1990), facial expressions (Davidson & Fox, 1982), conditions of reward and punishment (Sabotka, Davidson, & Senulis, 1992), and pleasant and unpleasant odours (Kline, Blackhart, Woodward, Williams, & Schwartz, 2000). However, to date, no known EEG study has proved successful in their attempts to capture this shift in cortical hemispheric activity to the left as a function of viewing affective pictures (Elgavish, Halpern, Dikman, & Allen, 2003; Gable & Harmon-Jones, 2008; Hagemann, Ewald, Becker, Maier, & Bartussek, 1998). In a study examining the cortical response to affective pictures, Gable and Harmon-Jones (2008) attempted without success to elicit asymmetrical frontal cortical activation by showing participants pictures of appetizing

dessert foods. Gable et al. speculated that affective pictures may not be sufficient in intensity to evoke the emotional or motivational response needed to engage asymmetrical frontal cortical activations. Thus, by broadening our craving induction to include the actual exposure to chocolate along with pictures of chocolate, we were able to show that appetitive stimuli such as chocolate can be used effectively to elicit a shift in cortical hemispheric activity to the left hemisphere, indicative of approach motivation. To date this is the first known EEG study that has been able to elicit a shift to greater left than right cortical activity after exposing participants to pictures as part of a craving induction. It is important to note that the observed effect was not moderated by an interaction with any other independent variables, including the type of chosen chocolate bar or by one's attitudes and behaviour toward chocolate, as evidenced in the hierarchical multiple regression performed in the exploratory analysis. As a result, the observed shift in cortical asymmetry to the left hemisphere was not confounded by other properties specific to our experimental design and can be attributed to the stimuli used in our craving induction.

The second objective of hypothesis 2 attempted to extend the finding of Beaver et al. (2006) and demonstrate that individuals high on dietary restraint would show greater right frontal asymmetry when presented chocolate. Contrary to prediction, restrained eaters did not show this predicted shift in frontal asymmetry after the craving induction. Thus, we were unable to extend the results of Beaver et al. to show that restrained eaters exhibit greater right than left hemispheric asymmetry, indicative of withdrawal motivations, when presented with chocolate.

Despite the inability to differentiate our restrained and unrestrained groups based on hemispheric asymmetry over the course of the experimental manipulation, one notable effect produced by the above analysis was the unanticipated interaction between restraint status and

region in the analysis of hemispheric asymmetry (see Figure 3). Our results show that over the course of the craving induction, restrained eaters showed less left than right cortical activity in the parietal region relative to unrestrained eaters. This effect is particularly noteworthy since the inclusion of the parietal region was not expected to play a pivotal role when interpreting the results of our analyses. As mentioned previously, the parietal region was only included in Silva et al.'s (2002) analysis to act as a control site with which to compare activity found in the frontal region.

Although the finding that the restrained eaters in our study showed less left than right activity in the parietal region relative to unrestrained eaters was not predicted, it is not unsubstantiated. This pattern of differential cortical activity found in the parietal region may actually be reflective of the cortical asymmetry found in depressed individuals. As previously noted, research suggests that posterior cortical regions may be asymmetrically involved in emotional perception (Borod et al., 1998 as cited in Harmon-Jones et al., 2010, p. 459), especially in clinically depressed populations (Manna et al., 2010). Whereas past research has shown that depressed individuals typically show greater right than left frontal activity, an accumulation of evidence suggests that in depressed individuals, alpha activity in the parietal region may actually show an asymmetry that is opposite to that of the frontal region; that is, greater left than right parietal activity (Bruder et al., 1997; Henriques & Davidson, 1990). This effect has been demonstrated in various clinical populations such as individuals diagnosed with major depression with and without a comorbid anxiety disorder (Kentgen et al., 2000), posttraumatic stress disorder (Metzger et al., 2004), and in a nondepressed subgroup of female suicide attempters (Graae et al., 1996). As previously discussed, restrained eaters, especially those with a diagnosed eating disorder, frequently exhibit depressive symptoms (Fletcher et al., 2007) and poor psychological health (Appleton &

McGowan, 2005). Thus, the parietal region should be observed as a critical site of interest when studying cortical arousal in both restrained and unrestrained populations.

The next analysis was focused on examining the effect of restraint status on alpha μV^2. Our results showed no significant main effect between restrained and unrestrained eaters in values of alpha μV^2. However, there was a significant interaction between restraint status and cortical region (see Figure 4). Specifically, when collapsed across the complete experimental manipulation, both restrained and unrestrained eaters evidenced higher values of alpha μV^2 in the parietal region compared to the frontal region (indicative of less cortical activity in the parietal region). This effect was especially pronounced for unrestrained eaters, who showed greater cortical activity in the frontal compared to the parietal region. Since alpha μV^2 is inversely related to cortical activity, the results of this analysis show that both restrained and unrestrained eaters experience greater cortical activity in their frontal versus parietal regions, and that unrestrained eaters evidenced significantly more cortical activity in their frontal region compared with restrained eaters. These results are comparable to the findings by Rodriguez et al. (2007) using qEEG values modeled by LORETA solutions. Rodriguez et al. found that when compared to individuals diagnosed with anorexia and bulimia nervosa, a control group of healthy individuals without an eating disorder showed significantly greater alpha activity in the parietal region. Rodriguez et al. interpret this finding to be an indication that eating disorders, such as anorexia and bulimia nervosa, are related to abnormal mechanisms of neural synchronization; specifically, alpha frequencies. Although the participants used in the present study were specifically chosen because they were not currently in treatment for a mood disorder, it is important to observe that individuals who display restrained eating behaviours, but without a diagnosed eating disorder,

exhibit a similar neuronal pattern of alpha activity in the frontal and parietal regions as those found in Rodriguez's study.

In addition to using different sample populations, one difference between the present study and that of Rodriguez et al. (2007) that may impact the comparisons of these findings was their failure to control for psychotropic medication use. In the present study, potential participants in treatment for a mood, anxiety or eating disorder were excluded from participation, thereby attenuating the possibility that our EEG findings were influenced by medications. The experimental group in the Rodriguez et al. study was currently undergoing treatment for an eating disorder, wherein 79% of these clinical patients were taking some form of psychotropic medication compared to none in the healthy control group. Rodriguez et al. admits that it is not clear if the results observed in their clinical participant group were influenced by the effects of these drugs, namely SSRIs and benzodiazepines. However, Rodriguez et al. speculate that it is unlikely that these medications would significantly affect alpha activity. Based on past research, benzodiazepines typically affect fast, not slow, alpha frequencies (Bauer & Bauer, 2005; Blume, 2006; Van Cott & Brenner, 2003). Similarly, SSRIs, specifically citalopram, have also been demonstrated to affect fast alpha frequencies, particularly in the right frontal-temporal region (Saletu, Andere, & Saletu-Zyhlarz, 2006).

An important question not addressed in the present study is whether the observed hemispheric asymmetry findings of Figure 2 reflect certain, as yet unknown individual trait-linked differences not examined in this experiment, or merely a physiological response to the experimental manipulation that anyone would experience. This question was the topic of investigation in a 2001 study by Coan, Allen, and Harmon-Jones, who sought to investigate the robustness of state versus trait frontal EEG asymmetries across individuals. Frontal EEG

asymmetries were obtained from 36 participants at rest and while performing voluntary facial expressions denoting anger, disgust, fear, joy, and sadness. These emotions were then grouped according to the approach/withdrawal motivational model of emotion. The results indicated that variations in frontal asymmetry during trait and state manipulations are approximately equal. Thus the researchers conclude that state changes in frontal EEG asymmetry resulting from an emotional manipulation task can be reliably elicited in the laboratory regardless of individual trait predispositions in frontal asymmetry. However, the researchers found that trait predispositions are only moderately preserved within state manipulations. Thus, when undergoing a state manipulation task, differences in frontal asymmetry are more likely to reflect that of the induced state rather than that of unique and individual trait differences. Coan and Allen (2004) note that each individual possesses a certain pattern of cortical asymmetry as a relatively stable trait. These traits then serve as diatheses for increased risk of various forms of psychopathology and act as moderators of state measures of emotional reactivity that are typically evidenced in the form of verbal reports. Similar findings were demonstrated in a study by Hagemann, Naumann, Thayer, and Bartussek (2002). These researchers found that cortical asymmetry may be thought to represent a trait-like activation which is substantially influenced by state-dependent fluctuations. In addition, numerous studies have demonstrated the stability of baseline EEG asymmetry over time (Tomarken et al., 1992; Wheeler et al., 1993). Thus, although the observed differential effects of cortical asymmetry in both restrained and unrestrained eaters may have been induced by the experimental manipulation, it is unlikely that this effect was solely shaped by state-dependent influences.

It is unclear why the participants in this study did not show the predicted differential shift in hemispheric asymmetry over the craving induction; that is, shift left for unrestrained eaters and

shift right for restrained eaters. Both groups did report an increase in their desire or urge to eat as evidenced by the change in CVAS self-report after the craving induction. A possible explanation for this finding could be because the participants did not actually have to restrain from eating. It is possible that the present study failed to create an atmosphere where restrained eaters would be expected to exercise the cognitive dietary control that is characteristic of restrained eaters. Similarly, by simply alerting the participants to the fact that they would be instructed to not eat the presented chocolate during the craving induction, thus rendering the desired food unattainable, it is possible that they were able to attenuate their craving response. Had the participants been presented with the opportunity to consume chocolate during the experiment, it is possible that frontal asymmetry would have shifted towards the right frontal region as predicted for restrained eaters.

In a fMRI study by Coletta et al. (2009), the authors tested the hypothesis that when compared with normal weight unrestrained eaters, normal weight restrained eaters would be more responsive to food presented after a meal when sated than they would when hungry. They also predicted that unrestrained eaters would show the opposite effect and would be less responsive to food presented after a meal and more responsive to food presented when hungry. The authors found that when hungry, unrestrained eaters showed significant cortical activation in many of the brain areas associated with hunger. Restrained eaters however, only showed significant cortical activation in the cerebellar lingual, an area that is responsible for the lower level processing of food stimuli. Interestingly, when tested again after being fed, restrained eaters showed activation in the orbitofrontal cortex and the left insular cortex, areas which are associated with hunger, desire for food, and expectation of rewards, and in the left dorsolateral prefrontal cortex which is associated with reward, decision making, and monitoring of behavioural consequences. Equipped

with this information, the authors concluded that when energy deprived, restrained eaters do not generate normal hunger signals and ultimately experience hunger differently than unrestrained eaters. They also remarked that in restrained eaters, the appetitive drive to attain food only activates after having already eaten.

Beaver et al. (2006) also recognized that even though the aforementioned areas were activated when viewing appetizing food images, the activation of some regions such as the amygdala are only observed in individuals who are hungry (LaBar et al., 2001). Consequently, participant hunger levels were not directly measured in the present study. Thus, it could be hypothesized that since the restrained eaters in the present study were instructed to abstain from eating for at least two hours prior to the experiment, and had been informed that they would not be required to eat anything during the experiment, they did not need to exercise the same level of dietary restraint needed if they had been required to eat during the craving induction. In light of the Coletta et al. (2009) research, it is possible that the exaggerated withdrawal response that was expected of restrained eaters in the present study when presented with highly appetizing food cues was not observed because of their ability to suppress this response when unfed. Coletta et al. also speculate that the activation of the orbitofrontal cortex in restrained eaters after eating may represent an effort to modulate fear instigated by the sight of highly palatable food, due to their already well-established fear of weight gain and high levels of body dissatisfaction. This research indicates that the prefrontal cortex is activated in restrained eaters more to cope with the perceived threat posed by highly caloric food, rather than as a result of a positive reward response. Thus, participants in the present study may not have perceived the craving induction in the same threatening way as if they were required to consume chocolate. Frontal asymmetry may

have looked quite different if the participants had been required to consume a highly caloric preload prior to the craving induction.

A similar example illustrating the differential response to food cues in restrained and unrestrained populations is shown in a study examining the cortical response to food odour by Kemmotsu and Murphy (2006). In their study, the frontal cortical activity of restrained and unrestrained eaters was measured using an EEG while the participants were instructed to rate the pleasantness of different odours. The researchers found that restrained eaters paid less attention to hedonic food odours compared with unrestrained eaters. They suggest that since restrained eaters have a tremendous amount of practice in attempting to ignore food cues, they may have used this skill to actually suppress thoughts of food during the experiment and, thus, showed less cortical response to food odour cues. Another explanation as to why restrained and unrestrained eaters show differential frontal activation when fed versus when hungry is offered by Coletta et al. (2009). The authors suggest that when presented with appetizing food cues, cortical activity of restrained eaters may actually be more reflective of the cognitive self-control that they are typically used to employing in such situations, rather than responding to the appeal of the food itself.

Accordingly, another explanation as to why the results found in the present study differed from that found by Silva et al. (2002) may reflect a failure to correctly measure dietary restraint. The RRS has been widely criticized for its inability to correctly distinguish restrained from unrestrained populations (Ogden, 1993; Stice, Fisher, & Lowe, 2004; van Strien, 1999). Specifically, the RRS has been accused of being better suited to identify restrained eaters who are likely to disinhibit their eating rules when they feel they have broken their diets rather than identifying restrained eaters who do not disinhibit their eating boundaries (Ouwens, van Strien, &

van der Staak, 2003). It is possible that this study did not successfully classify participants based on restraint status and thus the group of unrestrained eaters may have problematically contained participants with very high levels of dietary restraint, but not dietary inhibition.

Another element that was not addressed in the present study was the effect of the passage of time. Since the participants in the present study were not compared to a control group of participants who did not undergo the experimental manipulation, we are unable to discount that the observed migratory shift in cortical activity to the left hemisphere is not due to the passage of time or by simply participating in the experiment. However, in a similar study examining asymmetrical frontal activity in response to affective pictures, Gable and Harmon-Jones (2008) did not observe a passage of time effect. The researchers demonstrated that individual differences predicted greater left than right frontal activity within the first second of viewing dessert pictures and this effect lasted for the duration of the experiment.

Based on the disparate findings between this study and previous research examining the role of cortical asymmetry in restrained and unrestrained eating populations, it is evident that future research in this area is needed. Due to the inability of this study to replicate the findings made by Silva et al. (2002), in order to fully understand the role of cortical asymmetry and restraint status it would be useful to compare resting frontal and parietal asymmetry in individuals diagnosed with a clinical, restrictive eating disorder such as anorexia nervosa, with those who exhibit high levels of restrained eating behaviours but who do not meet the criteria for an eating disorder. This comparison may help shed light on whether the results found in the Silva et al. study and the present study were a reflection of differences in populations, experimental methodology, or of additional factors. Accordingly, the use of an alternate measure of restraint that does not simultaneously measure the tendency to disinhibit one's eating style to classify

participants, such as the Eating Disorder Examination Questionnaire (Fairbum & Beglin, 1994), would be useful. This may help discriminate individuals with restrained eating behaviours who tend to disinhibit and 'break' their dietary rules in certain circumstances from restrained eaters who do not disinhibit their eating rules.

Another area that warrants attention is the role that other measures of cortical activity may play in influencing approach and avoidance responses in both restrained and unrestrained eaters. Evidence that beta activity may have an influential role in the cortical activity of individuals with diagnosed eating disorders was observed by Berkman and Lieberman (2011). This study found that disinhibtion of eating was associated with greater beta activity in the prefrontal cortex in obese binge-eating women. This finding leaves room to question the possibility that this effect may also be observed in other disordered eating populations. Differences in alpha activity between restrained and unrestrained eaters may only be a small piece of a phenomenon that is yet to be fully understood.

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Appendix A

Initial E-mail Contact to All Potential Participants

Dear Potential Participant,

There are two research studies that are being conducted by M.A. Clinical Psychology candidates, Monique Mercier and Genevieve Berube-Hayward in the Department of Psychology under the supervision of Dr. Ron Davis. In general, one study will be examining a biological correlate of satiety and the other looking at physiological responses to appetizing food.

We are inviting females to participate in these studies involved in reactions to food. Participants can receive up to 3 bonus points for participation in these two studies. The initial phase of this study involves the completion of an online battery of questions pertaining to eating behaviours and attitudes in general and specifically to certain foods. This questionnaire should take no more than 30 minutes to complete. By completing this questionnaire you will be awarded one grade point towards your final grade in Introductory Psychology 1100 course. If you qualify, you may be asked to participate in the experimental portion of one or both of the studies being conducted. You will receive one grade point for each additional study that you participate in following completion of the questionnaire.

If you are interested in participating in these studies please follow the link below. If you have any questions or concerns about this study, please do not hesitate to contact either Genevieve (gmberube@lakeheadu.ca) or Monique (mkmerci1@lakeheadu.ca). We hope that you will take interest in our studies and thank you for helping us with our study.

www.surveymonkey.com/eatingbehav/

Sincerely,

Genevieve Berube-Hayward, M.A. Clinical Psychology candidate

Monique Mercier, M.A. Clinical Psychology candidate

Dr. Ron Davis, Ph.D., C. Psych., Associate Professor of Psychology

Appendix B

Participant Information Sheet

Dear Participant,

Thank you for your interest in this research study. Researchers, Geneveive Berube-Hayward and Monique Mercier, will be directly involved in the present study under the supervision of Dr. Ron Davis. The purpose of this study is to investigate eating attitudes and behaviours among women. In the pages that follow, you will find a series of questions asking about how your eating attitudes and behaviours in general and towards specific foods. It will take approximately 15 to 30 minutes to complete. Please answer all questions as honestly as you can. By filling out the survey, you may be eligible to participate in two additional studies investigating physiological correlates of eating attitudes and behaviours.

Your participation in these studies is completely voluntary and the information you provide will be kept confidential. Your name will only be used to ensure you receive a bonus mark (if enrolled in Introduction to Psychology). The information you provide will be coded, analyzed, and securely stored at Lakehead University for 7 years. No individual will be identified in any report of the results. The results will be shared with the Psychology Department at Lakehead University and an article will be prepared for publication in an academic journal. This study has been approved by the Lakehead University Research Ethics Board, located in the Office of Research at Lakehead University. If you have any concerns regarding this study you are welcome to contact the Research Ethics Board at 343-8283.

If you have any questions about the above, or at any point during or after the completion of the questionnaire please contact Genevieve Berube-Hayward (gmberube@lakeheadu.ca), Monique Mercier (mkmerci1@lakeheadu.ca), or Dr. Ron Davis (343-8646).

If you have read the above information and wish to continue with this survey, please check the box below our signature and click "Next."

Sincerely,

Genevieve Berube-Hayward, B.Sc. M.A. Candidate Clinical Psychology
Department of Psychology, Lakehead University
E-mail: gmberube@lakeheadu.ca

Monique Mercier, B.A. M.A. Candidate Clinical Psychology
Department of Psychology, Lakehead University
E-mail: mkmerci1@lakeheadu.ca

Ron Davis, Ph.D., C. Psych.
Associate Professor Department of Psychology
E-mail: ron.davis@lakeheadu.ca

[ ] I have read the above information and wish to continue with this survey. By checking this box I am also affirming that I am female, as required for my completion of this questionnaire.

Consent to Participate

By providing my name, student number, and birth date below, I indicate that I have read the previous "Participant Information Letter" and that I have had the opportunity to receive satisfactory answers from the primary researchers, Genevieve Berube-Hayward or Monique Mercier, as to any questions that I might have about my participation. Providing my name, student number, and birth date below, I understand and agree to the following:

1. I am a volunteer and can withdraw at any time from the survey without penalty of any kind.
2. I may choose not to answer any question asked in the questionnaire without penalty of any kind.
3. There are no anticipated physical risks associated with participation in this project. However, I do realize that I will be asked a number of personal questions during this study. Should I experience any psychological distress or discomfort, I am entitled to request a list of counselling resources from the examiner.
4. If eligible, I agree to be contacted for potential participation in either or both aforementioned experiments.
4. The information I provide by way of my responses to questionnaires will remain confidential, and will be securely stored in the Department of Psychology at Lakehead University for 7 years.
5. I may receive a summary of the project, upon request, following its completion.

[ ] I have read and understand the above "Consent to Participate"

Before continuing with the survey, please provide the information below. This information will only be used as an indication of your age, consent to participate, to ensure you receive one bonus point (if applicable). Please note that your information will be kept separate from your responses. Also, the information you provide here will NEVER be used for any purpose other than the bonus point (if applicable).

Full Name: _____
Lakehead University
Student Number: _____
Birth Date
(mm/ dd/ yyyy): _____
Age: _____
E-mail: _____

**Please Note:*
In order to protect your privacy your responses will not be saved on this computer. It is important that you complete the entire survey in order for your responses to be received. You will be notified when the survey is completed and it is safe to close the window. Thank you again for your participation. Please click "next"

Appendix C

The Revised Restraint Scale (Polivy, Herman, & Warsh,1978)

The following questions refer to your normal eating patterns and weight fluctuations.

1. How often are you dieting?

   a. Never b. Rarely c. Sometimes d. Usually e. Always

2. What is the maximum amount of weight (in pounds) you have ever lost within a month?

   a. 0-4 b. 5-9 c. 10-14 d. 15-19 e. 20+

3. What is the maximum weight you have gained within a week?

   a. 0-1.0 b. 1.1-2.0 c. 2.1-3.0 d. 3.1-5.0 e. 5.1+

4. In a typical week, how much does your weight fluctuate?

   a. 0-1.0 b. 1.1-2.0 c. 2.1-3.0 d. 3.1-5.0 e. 5.1+

5. Would a weight fluctuation of 5 pounds affect the way you live your life?

   a. Not at all b. Slightly c. Moderately d. Very much

6. Do you eat sensible in front of others and splurge when alone?

   a. Never b. Rarely c. Sometimes d. Usually e. Always

7. Do you give too much time and thought to food?

   a. Never b. Rarely c. Sometimes d. Usually e. Always

8. Do you have feelings of guilt after overeating?

   a. Never b. Rarely c. Sometimes d. Usually e. Always

9. How conscious are you of what you are eating?

   a. Not at all b. Slightly c. Moderately d. Very much

10. How many pounds over your desired weight were you at your maximum weight?

    a. 0-1 b. 1-5 c. 6-10 d. 11-20 e. 21+

11. What is your maximum weight?

12. When you break your diet, do you react by?

    a. Going right back on the diet

    b. Compensating by eating less for a little while

    c. Continuing to eat non-diet foods and start the diet another day

    d. Get rid of the food by vomiting or taking laxatives

    e. Not applicable

Appendix D

Demographic Questionnaire

Age: _____

Marital status:

Married/common law_____ Divorced/Separated_____ Single_____ Widowed_____

What is your ethnic background?

Caucasian____ South Asian____ Hispanic____ African-Canadian_____ European____
Native-Canadian_____ East Asian____ Other (Please specify)_____

School Enrolment: Full time student _____ Part time student _____

What academic program(s) are you in? _____

What is/are our major(s)? _____

Do you have any food aversions/allergies? _____

Are you currently in treatment for depression, an eating disorder, or an anxiety disorder?_____

Do you like chocolate containing products? _____

Do you typically eat chocolate containing products? _____

Appendix E

Second E-mail Contact to Recruit Participants for Laboratory Experiment

You are receiving this e-mail because you filled out a brief questionnaire and indicated that you are interested in participating in a research study for bonus points. I am a graduate student in psychology and am currently looking for females to participate in research that is looking at how food cravings influence cortical brain activity. During this study, you will be connected to an EEG machine, by wearing a special cap and presented with various appetizing images of chocolate and actual chocolate bars. You will then be instructed to concentrate on the food and to imagine eating it. I will be asking that you do not eat or drink (except water) for the 2 hours prior to coming into the lab. You will also be asked to wrap an elastic band around your chest to measure your heart rate.

This study is worth 1 grade point toward your Introductory Psychology 1100 final grade. This study will last for approximately 40 min. The available time slots will be listed for you on Experiment Manager when you click on the link located at the end of this message. Thank you again for your interest in participating in my study! I look forward to hearing from you soon.

Sincerely,

Genevieve Berube-Hayward M.A. Clinical Psychology candidate

Dr. Ron Davis, Ph.D., C. Psych., Associate Professor of Psychology

Appendix F

Participant Cover Letter and Information Sheet for Laboratory Portion of the Study

Dear Potential Participant,

You are being invited to participate in a research study about food cravings and frontal asymmetry in restrained and unrestrained eaters. This study is being conducted by Genevieve Berube-Hayward, a Master's candidate and supervised by Dr. Ron Davis from the Psychology Department at Lakehead University.

The purpose of the study is to examine physiological reactions to food during a food craving induction. We think that individuals with different eating styles will show different cortical reactions when asked to crave appetizing food.

If you volunteer to participate in this study, you will be asked to do the following:

1. Undergo several electroencephalogram (EEG) recordings.
2. View images of appetizing food on a television screen.
3. Undergo a craving induction procedure, which will require you to imagine eating the food presented on the television screen, as well as some chocolate bars that will be presented.
4. Complete two batteries of questionnaires, one before and after the experiment.
5. Wear a heart-rate monitor around your chest.

This study will take approximately 45 minutes to complete. There are no anticipated risks to completing this study. However you will be asked a variety of questions, some of which may be personal in nature that may produce emotional discomfort. If during or after the study you have concerns you wish to discuss, a counselling resource sheet will be made available to you upon request.

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission. Any information you provide will be used for research purposes in Dr. Ron Davis's research lab only, which may eventually include publication in a research article. Your name will not appear on any of the questionnaires you fill out or in any future publications. The data you supply will only be

identified by number. Data will be stored securely for 7 years. A summary of findings will be available to those interested upon request.

If you participate in this study, you will receive one grade point toward your Introductory Psychology 1100 final course mark.

Your participation in this study is completely voluntary, so you may refuse to participate or withdrawal from the study at any time without consequences. The investigator may also exercise this right and may withdraw you from this research if circumstances arise that warrant doing so.

Thank you very much for helping us out.

Sincerely,

Genevieve Berube-Hayward B.Sc, M.A. Clinical Psychology candidate

E-mail: gmberube@lakeheadu.ca

Dr. Ron Davis, Ph.D., C. Psych., Associate Professor of Psychology

E-mail: ron.davis@lakeheadu.ca

mailto:gmberube@lakeheadu.ca

Appendix G

Participant Consent Form

My signature on this form indicates that I agree to participate in the study investigating the physiological responses that people have when they crave food. I am fully aware that by participating in this study, I will be asked to do the following things:

1. I will be hooked up to an electroencephalogram (EEG) which will measure my brain waves.
2. I will be viewing images of appetizing food on a television screen.
3. I will be asked to imagine eating the food presented on the television screen, as well as some mini chocolate bars that will be presented to me.
4. I will be completing 3 brief questionnaires, one before and two after the experiment.
5. I will be wearing an elastic heart rate monitor around my chest.

I also understand that my participation in this study is conditional on the following:

1. I have read the participant information sheet and I fully understand what it is that I am being asked to do as a participant in the study.
2. I am a volunteer and may withdraw from the study at any time without penalty.
3. There are no anticipated physical risks associated with my participation in this study. However, I do realize that I will be asked a number of personal questions during this study. Should I experience any psychological distress or discomfort, I am entitled to request a list of counselling resources from the examiner.
4. My data will be confidential and stored in the Department of Psychology for a period of 7 years.
5. I may receive a summary of the project, upon request, following the completion of the project.

Name of Participant (Please Print)	Date of Birth
Signature of Participant	Date
E-mail Address	Name of Psychology Professor and course number for course bonus mark
Student number	

Appendix H

Craving Visual Analogue Scale

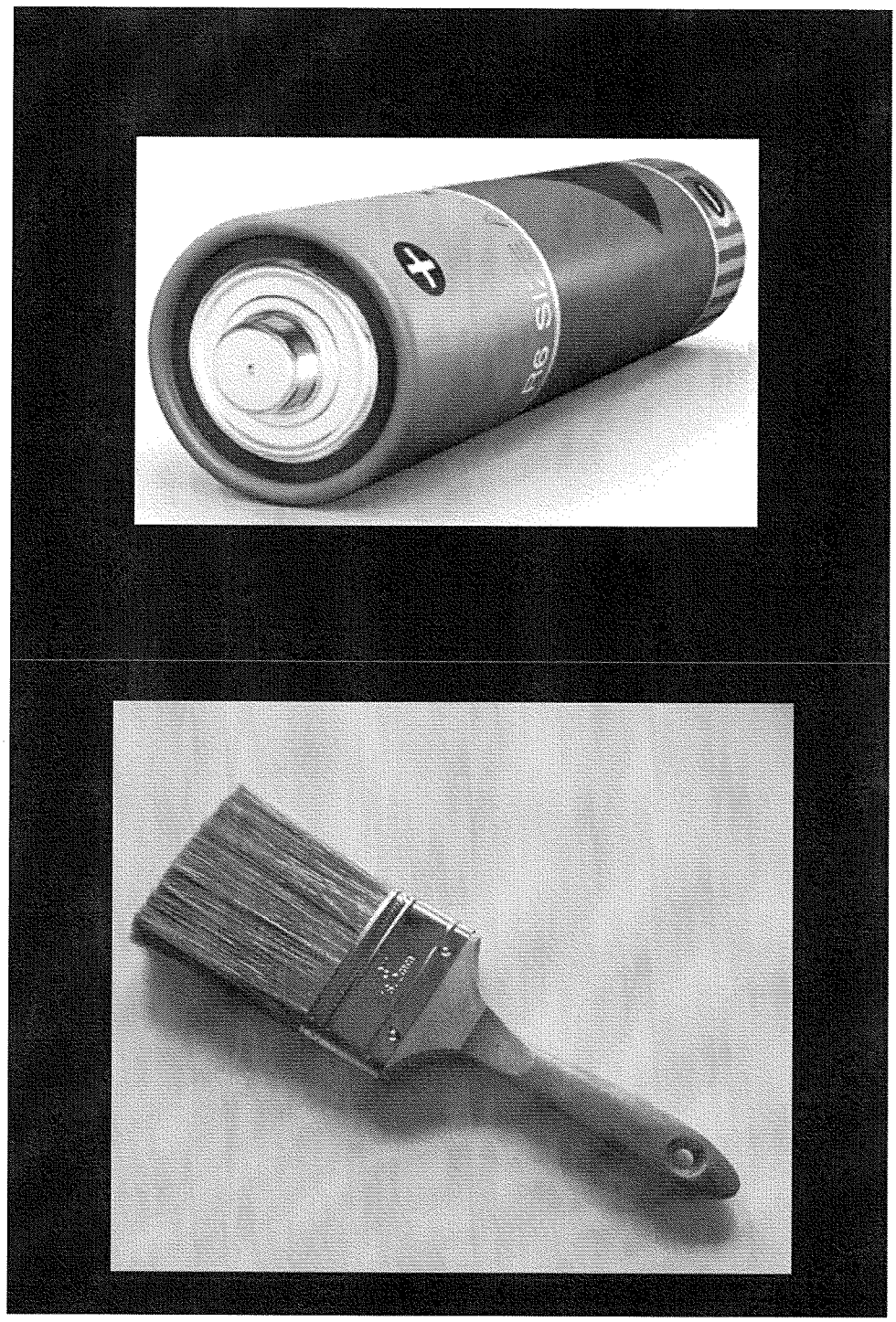
Please rate your current desire and urge to eat, from *no desire or urge to eat* to *extremely strong desire or urge to eat.* Please place a small vertical line on this scale, where it best represents your current desire or urge to eat.

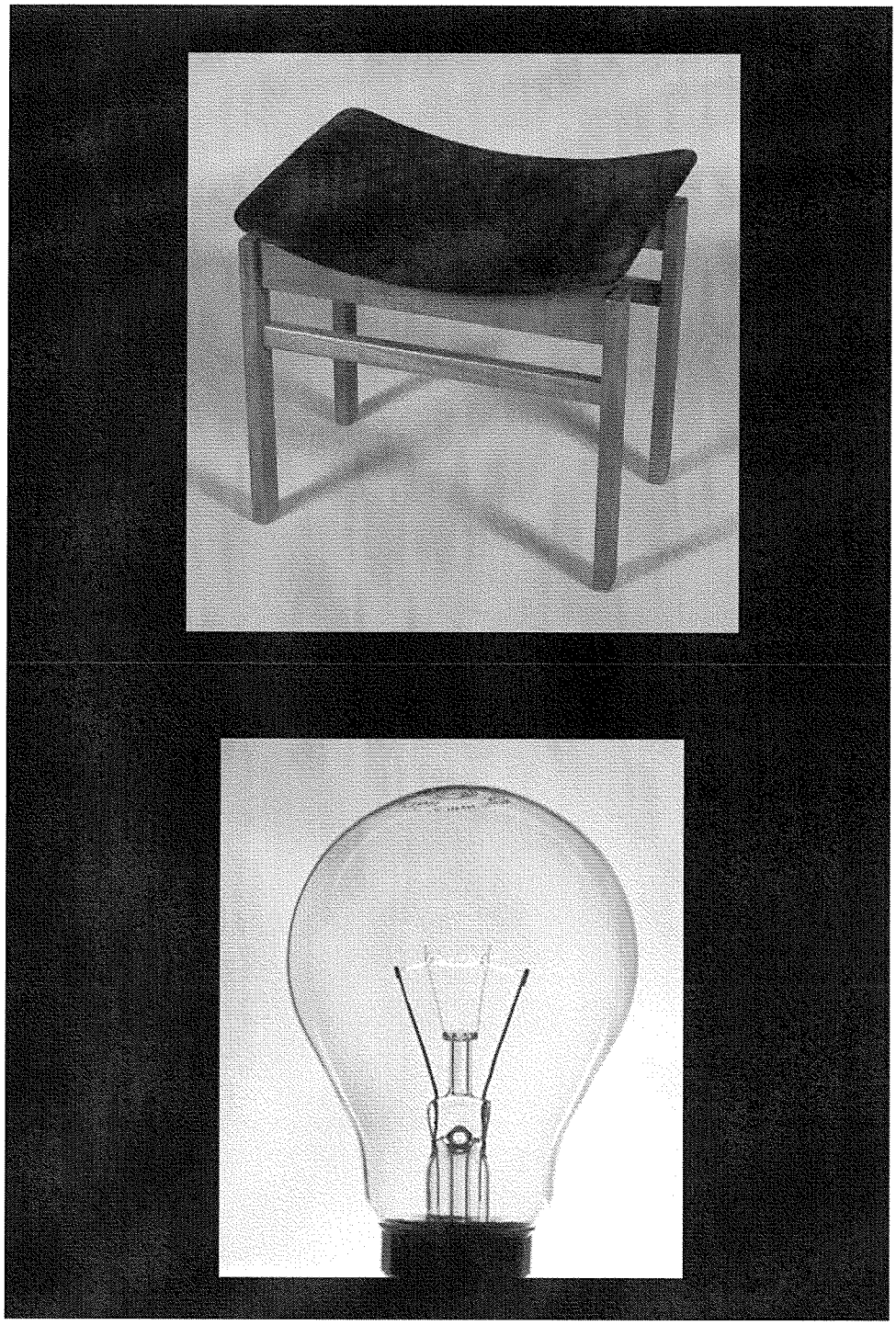
0_____100

No desire or urge to eat	Neutral	Extremely strong desire or urge to eat

Appendix I

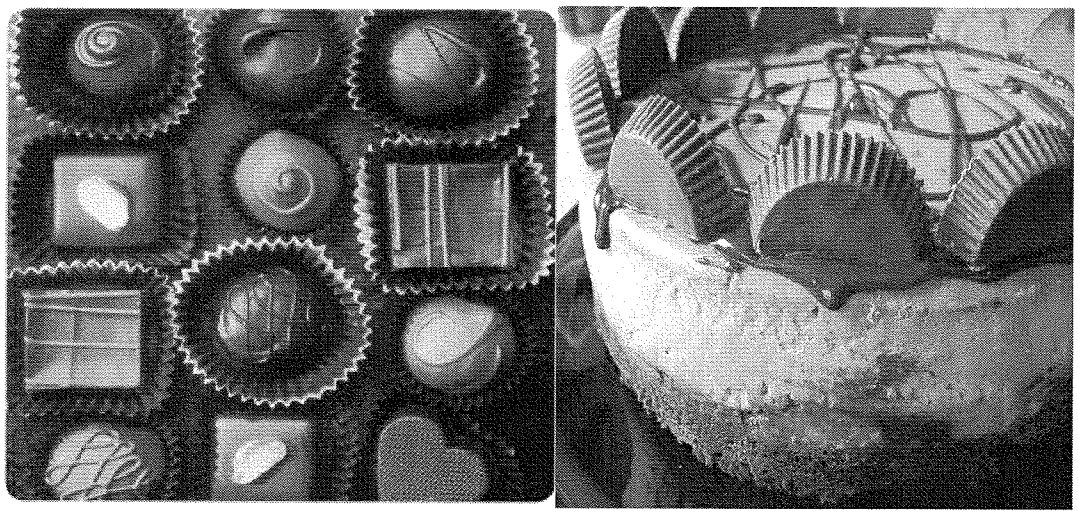
Sample of Neutral Images





Appendix J

Sample of Food Images



CHOCOLATE

Appendix K

Imagery Induction Script (adapted from Tuomisto, Hetherington, Morris, Toumisto, Turjanmaa, & Lappalainen, 1997).

While the participant is viewing the chocolate images on the monitor, the experimenter will repeat these instructions at 15 and 60 s intervals:

00 s: *"I want you to concentrate on the images presented in front of you".*

15 s: *"I don't want you to think about anything else except chocolate".*

30 s: *"I want you to imagine having that chocolate in your possession".*

90 s: *"I want you to imagine the smell of the chocolate".*

150 s: *"I want you to imagine what the chocolate would taste like".*

When the participant is presented with the bowl of chocolate bars, the experimenter will repeat these instructions at 30 s intervals:

00 s: "*I want you to look closely at the bowl of chocolates in front of you".*

30 s: *"I want you to pick your favourite chocolate bar from the bowl".*

1 m: *"Now I want you to slowly unwrap the chocolate bar".*

1 m 30 s: *"As you unwrap the chocolate, I want you to smell the chocolate".*

2 m: "Now I want you to look at the chocolate".

2 m 30 s: "*Again, smell the chocolate".*

3 m: "*Imagine that you are about to eat the chocolate*".

3 m 30 s: *"I now want you to break the chocolate in half".*

4 m: *"Concentrate on the smell of the chocolate".*

4 m 40 s: *"Again, look at the chocolate".*

5 m: *"Concentrate on how delicious the chocolate looks".*

5 m 30 s: *"Imagine how rich and creamy the chocolate would taste".*

6 m: *"Imagine you are moving the chocolate around in your mouth".*

6 m 30 s: "*Imagine again that you are about to eat the chocolate".*

7 m: *"Imagine you are moving the chocolate around in your mouth".*

7 m 30 s: *"Imagine you are eating the delicious chocolate".*

Appendix L

The Orientation to Chocolate Questionnaire – Revised

This questionnaire relates to YOUR ATTITUDES towards chocolate in the LAST MONTH. Please indicate how much you agree with the statements below by circling the number corresponding most closely to your attitude during the LAST MONTH. Your answers may range from AGREE NOT AT ALL (1) with the statement to AGREE VERY STRONGLY (9) with the statement.

		I AGREE WITH THIS STATEMENT...								
		Not At All								**Very Strongly**
1.	I wanted to eat chocolate as soon as I had the chance.	1	2	3	4	5	6	7	8	9
2.	I deliberately occupied myself so I would not want chocolate.	1	2	3	4	5	6	7	8	9
3.	I liked to indulge in chocolate.	1	2	3	4	5	6	7	8	9
4.	I felt guilty after eating chocolate.	1	2	3	4	5	6	7	8	9
5.	I considered myself weak when I gave in to my chocolate cravings.	1	2	3	4	5	6	7	8	9
6.	My desire to have some chocolate seemed overwhelming.	1	2	3	4	5	6	7	8	9
7.	I felt unhealthy after I'd eaten chocolate.	1	2	3	4	5	6	7	8	9
8.	I wanted to eat chocolate so much that one bite would not have been enough.	1	2	3	4	5	6	7	8	9
9.	I did things to take my mind off chocolate.	1	2	3	4	5	6	7	8	9
10.	I felt dissatisfied with myself after eating chocolate.	1	2	3	4	5	6	7	8	9
11.	I was thinking about chocolate a lot of the	1	2	3	4	5	6	7	8	9

time.

12.	After eating chocolate I often wished I hadn't.	1	2	3	4	5	6	7	8	9
13.	I usually found myself wanting chocolate in the afternoons.	1	2	3	4	5	6	7	8	9
14.	I felt unattractive after eating chocolate.	1	2	3	4	5	6	7	8	9

15. In the LAST MONTH, how often did you eat chocolate? Please tick (✓) only one box:

Never.	☐
Once or twice	☐
Once a week	☐
Twice a week	☐
3-5 times a week	☐
Almost every day	☐
Every day	☐

Appendix M

Local Counselling Resources

1. Lakehead University Student Health and Counselling Centre (located across from Security, near the Agora and University Centre Theatre). Personal counselling for students covering a wide variety of issues. – 343-8361

2. Family Services Thunder Bay. A not-for-profit organization providing confidential counselling, advocacy, education, and support for individuals and families in Thunder Bay. Counsellors provide comprehensive help for a wide variety of issues such as grief and coping, substance use, credit and financial problems, anger, anxiety, depression, and past experiences of violence. Fees are based upon individual circumstances and no person will be denied service due to an inability to pay. – 684-1880

3. Eating Disorder Program (St. Joseph's Care Group). A multidisciplinary team, which provides assessment and treatment to individuals with Anorexia Nervosa, Bulimia Nervosa, and Eating Disorder Not Otherwise Specified. A physician's referral is required for admission to the program. – 343-2400

4. Personal Development Centre (St. Joseph's Care Group). An adult out-patient program which offers and innovative, multi-disciplinary approach to treating a variety of mental health issues such as anxiety, depression, stress related problems, self-esteem issues, and compromised coping strategies. A physician's referral is required for admission to the program. – 343-2400

Appendix N

Example of an Alpha Wave Recording at Each Electrode Placement Site