Modifying Attention Away from Food Cues: The Utility of Attentional Bias Modification Training among Emotional Eaters

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Modifying Attention Away from Food Cues: The Utility of Attentional Bias Modification

Training among Emotional Eaters

by

Moet Aita

A Thesis Submitted in Partial Fulfillment of the Requirements for the

Degree of Master of Science in Experimental Psychology

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College of Liberal Arts

Rochester Institute of Technology

Rochester, NY

August 23, 2023
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Abstract

The current study (N=153) was designed to explore the relationships between emotional eating and emotion regulation, attentional biases, and food consumption. Emotional eating describes the tendency to eat in response to emotional experiences, especially negative emotions, and is associated with the consumption of high-fat, sugary foods. The present study explored whether food intake could be modified among a sample of emotional and non-emotional eaters by shifting attention away from high-calorie pictorial food stimuli using the attentional bias modification (ABM) training paradigm. Participants were randomly assigned to either the attentional-training group, placebo-training group, or control group. Following the training, participants underwent a negative emotion induction and were promptly given a bogus food taste test where high- and low-calorie foods were presented. Results indicated that emotional eating was not associated with greater attentional biases towards high-calorie food cues. Unlike previous research, the ABM training did not successfully modify attention away from high-calorie pictorial food stimuli nor influence food intake in the predicted direction. Emotional eating status, body mass index, food insecurity, nor difficulties with emotion regulation seemed to predict total food consumption during the taste test. Rather, gender seemed to best predict total food consumption, with self-reported men consuming the most. The failure to find an association between emotional eating and food intake following a negative emotion induction adds to the existing literature on the difficulties of capturing emotional eating in a laboratory setting. Limitations and future studies are addressed in the discussion.

Keywords: emotional eating, emotion regulation, attentional bias
Modifying Attention Away from Food Cues: The Utility of Attentional Bias Modification Training Among Emotional Eaters

Our current obesogenic environment surrounds us with inescapable food cues that make food salient and food intake convenient (Polivy et al., 2008). The way in which the brain processes food-related cues in the environment can compromise innate hunger regulation systems through the development of attentional biases towards food stimuli and hedonic hunger (Lambert 2018). Eating in the absence of physical hunger is evident among emotional eaters, who eat to cope with negative emotions (Goossens et al., 2009). Not only is eating a poor coping mechanism, but emotional eating is also linked to difficulties losing weight, higher caloric intake, higher body mass index, poorer psychological well-being, and a risk factor for psychopathological disorders (Schnepper et al., 2020; Villano et al., 2021; Gianini et al., 2013). The present study sought to merge dimensions related to eating behaviors by exploring how attentional biases towards food-related cues, difficulties regulating emotions, and consumption of high-calorie foods sustain emotional eating.

Theories of Emotional Eating

Emotional eating refers to the tendency to eat in response to emotions, in particular negative emotions (Koenders & van Strien et al., 2011). Emotional eating more specifically captures the attempt to regulate and reduce negative emotions thought eating (Goossens et al., 2009). However, the typical physiological fight-or-flight response to distress elicits gastric changes like that of satiety, thus making emotional eating a maladaptive learned behavior (Evers et al., 2009). Competing theories behind emotional eating emerged to understand why some people override physiological processes of distress. These theories are briefly summarized below.
Psychosomatic

Studies of anorexia and obesity laid the foundation for understanding the mental and emotional factors in eating (Bruch, 1964). Interest in the emotional factors of eating behaviors took off from the 1930s onward, after observations of sudden weight gain following a traumatic experience and in cases of severe mental shock following the First and Second World War (Mayer, 1953; Bruch, 1964). Given that the typical physiological response to distress is a reduction in appetite, Bruch (1964) theorized that both obese individuals and patients with anorexia must share an inability to correctly identify hunger and satiety signals from emotional reactions. Others theorized that overeating quells anxieties among obese individuals (Kaplan & Kaplan, 1957). While Bruch (1964) focused on how obese individuals react to distress, Schachter et al. (1968), focused on how normal-weight individuals react to distress, namely their reduction in eating. Unlike Bruch’s (1964) theory that obese individuals were not taught to identify bodily signals from emotional states, Schachter (1968) proposed that obese individuals mistake physiological cues for hunger signals. Psychosomatic accounts of obesity are largely disconfirmed as research suggests obesity status itself is not predictive of eating in response to emotions. Instead, related dimensions such as dieting status, stressful life events, and self-reported tendencies to emotionally overeat better explains emotional eating among overweight and obese individuals (Greeno & Wing, 1994; Baucom & Aiken, 1981; van Strien et al., 1986; Schlundt et al., 1991). Since related dimensions of body weight status may better explain tendencies to emotionally overeat, the present study focused on dimensions such as difficulties regulating emotions and restrained eating behavior, while also accounting for body mass index (BMI).
Restraint Hypothesis

The restraint hypothesis developed out of the set-point theory of obesity. The set-point theory posits that both normal-weight and obese individuals eat according to a biologically determined set-point, which is directly related to the number of fat cells in the body (Nisbett, 1972; Herman & Mack, 1975). Under this theory, obese individuals happen to be biologically prone to carry more fat cells and gain weight simply by meeting the demands of their fat cells (Nisbett, 1972). Since it is not possible to reduce the number of fat cells in the body, when individuals diet, they are depleting the fat cells and would need to overeat to replenish those cells (Nisbett, 1972). Individuals who chronically diet exemplify the restrained eating style, where an individual intentionally restricts food intake to control their body weight, either in the form of maintaining or losing weight (Herman & Polivy, 1975). The restraint hypothesis theorizes that negative affect depletes the cognitive resources that would otherwise help restrained eaters adhere to a strict diet (Greeno & Wing, 1994). Instead, restrained eaters overeat and fail to refrain from ‘forbidden’ foods, because the body demands that they replenish the depleted fat cells (Schnepper et al., 2020). In line with previous research suggesting that restrained eaters may be prone to emotional eating, the present study looked at restrained eating status as a covariate between emotional eating and consequent food intake.

Affect Regulation Model

The affect regulation model captures the concept of emotional eating, proposing that eating serves as a coping mechanism to regulate negative affect (Goossens et al., 2009). Under this model, emotional eating is addressed as a learned behavior from repeated pairings of negative emotions and the rewarding nature of food intake (Reichenberger et al., 2020). Research findings on Binge Eating Disorder (BED) suggest that negative affect serves as a proximal
antecedent to binge eating episodes (Haedt-Matt & Keel, 2011). Food science research also provides explanations for the rewarding properties of food that potentially elevate mood. For example, chocolate is one of the most commonly and frequently craved foods, often associated with comfort food during distress (Gibson 2011). The unique combination of caffeine and theobromine found in chocolate is associated with increases in positive mood and performance (Gibson 2011). Similarly, high-carbohydrate foods provide the amino acids necessary to produce serotonin, a neurotransmitter involved in stabilizing mood (Killgore & Yurgelun-Todd, 2006). Macht (2008) theorizes in his five-way model that restrained eaters show increased food intake in response to moderately arousing positive and negative emotions, while emotional eaters demonstrate enhanced consumption specifically of sweet and high-fat foods in response to negative emotions (Macht, 2008).

Both the affect regulation model and Macht’s five-way model were used to inform the current study hypotheses regarding the expected relationships between emotional eating and emotion (dys)regulation, and the tendency for emotional eaters to consume sweet, high-fat foods in response to negative emotions. In particular, the affect regulation model suggests that eating is a (maladaptive) coping mechanism used in response to emotional experiences, justifying the inclusion of measures of emotion regulation in this study. Furthermore, Macht’s five-way model suggests that moderately arousing emotions, such as sadness, is associated with emotional eating, hence the use of a sadness-inducing movie clip for the emotion induction procedure. The five-way model also suggests that emotional eating is associated with the consumption of sweet, high-fat foods, hence why the current study looked at the type of food consumed in addition to the amount of food consumed.
Summary

Theories on the relationship and mechanisms between emotional states and bodily signals of hunger and satiety stem from research on eating disorders and studies on obese populations (Bruch, 1964). Emotional eating broadly captures the tendency to eat in response to negative emotions, seen primarily among obese individuals and individuals with BED (Wiedemann et al., 2018; Stice et al., 2002), as well as in healthy, non-restrained individuals (Newman et al., 2007; Nguyen-Rodriguez et al., 2008; Macht, 2008). The affect regulation model is best suited for studies on emotional eating as it identifies negative affect as the trigger for consequent food intake and eating behavior as the coping mechanism to regulate emotions. Further, Macht’s (2008) observations that negative affect enhances the consumption of sweet and high-fat foods among emotional eaters provide support for the rewarding nature of such foods. The current study focused on the application of the Affect Regulation model as well as Macht’s (2008) five-way model to determine how negative affect influences food intake and food selection.

Studies on Emotional Eating

The relationship between emotions and overeating, and likewise, emotional eating and weight outcomes are apparent in cross-sectional and prospective studies. Koenders and van Strien (2011) found that emotional eating contributed to increases in body weight, above and beyond smoking habits, alcohol use, and the consumption of fruit or vegetables. Similarly, van Strien et al. (2012) found that emotional eating moderated the relationship between overeating and weight gain over the course of two years. Cross-sectional data from the NutriNet-Santé cohort study found that 45.4% of a total sample of 35,641 respondents reported high levels of emotional eating, with over half of the 45.4% falling within the overweight and obese range (Péneau et al., 2013). Similar endorsements of emotional eating were seen among primary care
patients with obesity, with 50% of the patients (N = 337) reporting high emotional eating (Chacko et al., 2015). Among women with eating disorders, Wiedemann et al. (2018) found that participants with BED reported greater frequency of emotional overeating compared to participants without BED, and most often emotionally overeat in response to feelings of loneliness. Further, Stice et al. (2002) identified emotional eating as a predictor of future binge eating among adolescent females. Cross-sectional data suggest that emotional eating is related to overeating and increased body weight over time (Koenders & Van Strien, 2011; Van Strien et al., 2012), however experimental studies on emotional eating have struggled to establish a conclusive causal relationship.

When it comes to translating cross-sectional and longitudinal findings in the laboratory setting, the findings are inconsistent as to whether emotional eating status predicts increased food consumption after a negative mood induction. Experimental research on emotional eating typically involves a mood induction procedure, followed by a bogus food taste test, to determine if emotional eaters will predictably eat more food compared to healthy controls. Van Strien et al. (2012) utilized a sad movie (Study 1) and a social stressor task (Study 2) and found that high emotional eaters tended to increase food intake while low emotional eaters tended to decrease food intake after the negative mood induction. Additionally, the anticipation of a psychosocial stressor led to greater food consumption among female emotional eaters compared to non-emotional eaters (Raspopow et al., 2014).

However, many studies yield null findings, generating criticisms about the validity of self-reported emotional eating. A repeated concern about measures of emotional eating is the ‘triple recall bias,’ a term coined by Evers et al. (2009). The triple recall bias describes the three points in which recall bias may occur: (1) recalling the negative emotion; (2) recalling the eating
behavior; and (3) recalling the association between the negative emotion and eating behavior (Evers et al., 2009). Evers and colleagues (2009) conducted a series of experiments with different emotion induction procedures to determine whether self-described emotional eaters showed increases in food intake after emotional encounters compared to the control conditions, as well as to self-described non-emotional eaters. Their findings suggested that self-reported emotional eating was not predictive of increased food intake in the laboratory after mood induction (Evers et al., 2009).

In addition to criticisms about the validity of self-reported emotional eating, concerns about the ecological validity of laboratory measures of food intake exist. Researchers utilize a bogus food taste test to unobtrusively measure food consumption, though ecological momentary assessments (EMA) would provide higher ecological validity. However, EMA does not allow for causal conclusions, for example, that food intake was caused by negative emotions (Berg et al., 2015). While laboratory measures of food intake lack ecological validity, it allows for causal interpretations. Further, they provide an objective examination of food intake and allow for the standardization of internal and external food cues. Additionally, bogus taste tests attempt to disguise the intention of measuring food intake by presenting the task as a taste test. Robinson and colleagues (2017) assessed the validity of bogus taste tests and found that taste tests were sensitive to experimental manipulations of hypothesized changes in food intake. The bogus food taste test was utilized in the current study to allow for causal interpretations. While experimental research on emotional eating and increased food intake remains inconclusive, the current study attempted to improve upon the existing literature by incorporating additional variables and measures that warrant closer consideration, which are explained below.
Returning to Macht’s (2008) five-way model, the model suggests that self-reported emotional eating is less predictive of overall increased food intake, but more closely related to the type of food consumed. Barak et al. (2021) found in a United States national survey that emotional eating was associated with frequent fast-food consumption and obesity. Further, Oliver et al. (2000) found that highly stressed emotional eaters ate more sweet, high-fat foods compared to unstressed and non-emotional eaters. In another study, emotional eaters ate significantly more sweet food following a sad mood induction compared to emotional eaters in the joy mood condition (van Strien et al., 2013).

Other research finds that the existing emotional eating scales have poor predictive validity (Bongers & Jansen, 2016), demonstrating the need for alternative assessments of emotional eating. The development of the Salzburg Emotional Eating Scale (SEES) stemmed from this need, broadening the range of emotions being measured to include positive and negative emotions (Muele et al., 2018). Additionally, the SEES includes differentiation between increases and decreases in food intake in response to specific emotional states rather than simply measuring increases in food intake like in the widely used Dutch Eating Behavior Questionnaire (DEBQ; van Strien et al., 1986). This study chose to assess self-reported emotional eating with the SEES given that it could provide a more comprehensive measure of emotional eating, with the inclusion of both positive and negative emotional states along with specific changes in food intake.

A possible reason for inconsistencies on whether emotional eating is predictive of consequent food intake in the laboratory could relate to differences in liking of the food offered. Robinson et al. (2017) found that the extent to which participants liked the foods provided in the taste test was predictive of food intake. Van Strien and colleagues (2019) found that the tastiness
of food mediated the relationship between food intake and mood improvement in high-emotional eaters. Similarly, Macht and Mueller (2007) found that eating palatable chocolate elevated mood in high, more so than low, emotional eaters. Given that emotional eating is a learned response, such findings suggest that emotional eaters do not indiscriminately eat in response to a negative mood but choose tasty foods to alleviate their negative mood. If this is the case, then laboratory studies examining whether a mood induction predicts increased food intake in emotional eaters should consider individual differences in the perceived tastiness of the taste-test foods being offered. Therefore, participants in the current study were asked to rank their preferences for the available foods at the start of the study and could indicate whether they disliked the foods offered at the end of the study.

Summary

Cross-sectional studies provide support for the relationship between emotional eating and increased food consumption, yet this relationship is less pronounced in experimental studies that utilize a mood induction procedure and bogus food taste test (Koenders & van Strien, 2011; van Strien et al., 2012; Evers et al., 2009). The difficulties in translating cross-sectional results into a laboratory setting may stem from the poor predictive validity of existing emotional eating scales (Bongers & Jansen, 2016), failure to account for the liking for the food provided in the bogus taste test (Robinson et al., 2017), or perhaps a need to look at food intake of energy-dense, sweet foods rather than solely focusing on overall food intake (Macht, 2008). The current study took into account the existing criticisms surrounding experimental research on emotional eating and sought to improve upon the research by using the SEES (Muele et al., 2018), a more comprehensive measure of emotional eating, considering food preferences in the bogus taste test and looking at food intake of sweet, high-calorie foods in addition to overall food intake.
Studies on Emotion Regulation

As the Affect Regulation Model described, eating serves as a coping mechanism to regulate negative affect among emotional eaters (Goossens et al., 2009). Likewise, maladaptive eating behaviors like emotional eating, are strongly maintained by emotion dysregulation and can be external regulations of emotions (Jurascio et al., 2020). Research on emotional eating and emotion regulation suggests that difficulties regulating emotions are an important risk factor in the development and maintenance of eating disorders (Harrison et al., 2010). Emotion regulation refers to the process in which we shape our emotional experiences and expressions (Gross, 1998). Gross’ (1998) process model of emotion regulation predicts how different emotion regulation strategies will influence how a person feels, thinks, and acts. According to the process model, emotions can be regulated at different points in the emotion-generation process: selection of the situation; modification of the situation; deployment of attention; changes of cognitions; and modulation of experiential, behavioral, or physiological responses (Gross, 2002). Situation selection, situation modification, attentional deployment, and cognitive change represent antecedent-focused emotion regulation strategies (Gross & John, 2003). Meanwhile, response modulation represents response-focused strategies (Gross & John, 2003). Cognitive reappraisal represents an adaptive, antecedent-focused emotion regulation strategy while expressive suppression represents a maladaptive, response-focused strategy linked to various negative outcomes (Gross & John, 2003).

Maladaptive emotion regulation strategies may provide context for the tendency to eat in response to negative emotions. Some research suggests that among emotional eaters, poor emotion regulation skills may be predictive of food intake in response to negative emotions, more so than the actual emotion (Evers et al., 2010; Gianini et al., 2013; Jones & Herr, 2018).
For example, participants reporting frequent use of expressive suppression consumed more food after a negative mood induction compared to participants who reported minimal use of suppression (Evers et al., 2010). Further, participants who were instructed to suppress their emotions ate more comfort food compared to participants who were either instructed to reappraise emotions or to express emotions freely (Evers et al., 2010). In addition, Jones and Herr (2018) found that individuals with less differentiation of negative emotions and individuals with more emotion regulation difficulties consumed more calories during the taste test, in both negative and positive mood conditions. Similarly, Gianini et al. (2013) found that difficulties with emotion regulation accounted for unique variance in emotional overeating over and above negative affect. Individual differences in difficulties with emotion regulation may help contextualize those who are prone to rely on eating as a coping mechanism compared to those who do not. Therefore, two measures of emotion dysregulation were included and explored in this study.

**Heart Rate Variability**

In addition to self-report measures of emotion regulation, physiological measures derived from heart rate recordings may supplement the understanding of emotion regulation. Heart rate variability (HRV) describes the change in the time intervals between both instantaneous heart rate and successive R waves, also called RR intervals (Malik et al., 1996). The autonomic nervous system (ANS) is a primary determinant of heart rate with the parasympathetic release of acetylcholine by the vagus nerve and the sympathetic release of epinephrine and norepinephrine, both influencing heart rate (The Task Force, 1996). Resting HRV is dependent on vagal tone, with higher resting HRV and higher cardiac vagal tone reflecting flexible and dynamic regulation of autonomic activity (The Task Force, 1996; Thayer and Lane, 2000). The cardiac vagal tone
provides a quantifiable index for self-regulating abilities such as context-appropriate physiological response selection and appropriate recovery response after the stressor has ended (Thayer & Lane, 2000; Thayer et al., 2012). On the other hand, low resting HRV is correlated with delayed recovery from psychological stressors compared to higher resting HRV, and with disease and mortality thus serving as a marker for disease (Thayer et al., 2012).

For short-term recordings of two to five minutes, heart rhythm oscillations can be broken down into three components: high-frequency (HF), low-frequency (LF), and very-low-frequency (VLF) (The Task Force, 1996). The current study will focus on the HF band, otherwise known as the respiratory band, which ranges from 0.15 Hz to 0.4 Hz reflecting the rhythms with periods that occur between 2.5 and 7 seconds (McCraty & Schaffer, 2015). The HF band reflects the parasympathetic activity and has been linked to emotion regulation ability (Thayer et al., 2012). Although HF HRV is linked to the ability to regulate emotions, Juarascio and colleagues (2020) found that higher HF HRV was associated with an increased risk of experiencing an emotional eating episode, with acceptable accuracy. Heart rate changes in the HF power band were observed 15-20 minutes prior to an emotional eating episode and 0-5 minutes prior to an emotional eating episode (Juarascio et al., 2020). It is possible that the high fluctuations between the LF HRV and HF HRV observed during the entire 30-minute period preceding an emotional eating episode may be more informative as the 30-minute period preceding a control episode (non-emotional eating episode) was more stable (Juarascio et al., 2020). To expand on the limited literature on HRV and emotional eating, the current study supplemented self-reported difficulties with emotion regulation with a psychophysiological measure in hopes to identify a more concrete relationship between emotion regulation and emotional eating.
Summary

Research on emotion regulation strategies helps broaden the understanding of how difficulties with emotion regulation maintain maladaptive eating behaviors such as emotional eating. When adaptive emotion regulation strategies are utilized, such as reappraisal and attentional deployment, subjects appear more resilient to the effects of a negative mood induction (Evers et al., 2010; Luerssen & Ayduk, 2014). However, when translating self-report measures of emotion regulation to psychophysiological measures through HRV, the relationship to emotional eating is less clear. While HF HRV provides a measure of parasympathetic flexibility to the presence and conclusion of stressors, Juarascio et al. (2020) found fluctuations in the HF power band to be associated with emotional eating episodes. Therefore, the current study examined how self-reported emotion regulation, HRV, and emotional eating might be interconnected as well as whether HR HRV would be negatively correlated with emotional eating.

Food Insecurity and Socioeconomic Status

Evidence supporting the relationship between emotional eating and emotion regulation strategies is seen in research examining the influence of socioeconomic status (SES) (Spinosa et al., 2019). Spinosa and colleagues (2019) found that lower SES was associated with higher levels of psychological distress and higher psychological distress was associated with higher emotional eating. Yet higher SES was also associated with higher emotional eating, independent of psychological distress (Spinosa et al., 2019). Taken together, it suggests that specifically for those of lower SES, emotional eating may act as a maladaptive coping mechanism to combat psychological distress (Spinosa et al., 2019). Other research found similar relationships, such that food insecurity was associated with high emotional eating among Latinxs, and this association was fully mediated by perceived stress (Lopez-Cepero et al., 2020). Likewise, Rosengvist and
colleagues (2022) also found that emotional eating was associated with higher experienced financial strain, though only among women. There is some conflicting findings such as with Kowalkowska and Poinhos (2021) who failed to find any significant associations between emotional eating and SES among university students. Pigeyre et al. (2016) also failed to find any association between SES and emotional eating in a case-controlled study of obese and non-obese people. As it appears that emotional eating is not unique to those of lower or higher SES, the present study used SES and food insecurity as exploratory variables without posing any particular hypothesis.

Social Desirability

Self-report of eating behaviors may be influenced by social desirability (Latkin et al., 2018). Social desirability can bias reporting towards overestimating one’s positive traits, such as healthy eating behaviors, and underestimating one’s negative traits, such as unhealthy eating behaviors (Latkin et al., 2018). Evidence of a negative relationship between social desirability and emotional eating is seen, with higher social desirability associated with lower reports of uncontrolled eating and emotional eating (Allison & Heshka, 2007; Kowalkowska & Poinhos, 2021; Freitas we al., 2017). Furthermore, in a study among university students, Kowalkowska and Poinhos (2021) found that social desirability had the largest effect on self-reported eating behavior. The current study measured social desirability as an exploratory variable to determine whether social desirability was associated with self-reported emotional eating, however, did not pose any particular hypotheses.
Attentional Bias Towards Food Cues

Attention is a limited cognitive resource that allows the brain to prioritize evolutionary salient stimuli to ensure survival (Oberauer, 2019). Attending to threatening stimuli and appetitive stimuli both facilitate survival; however, prioritization of food-related stimuli is no longer beneficial in our obesogenic environment (Berthoud, 2007). Instead, attentional biases toward appetitive stimuli in a food-abundant environment may increase food consumption and the chances of overeating in the absence of hunger (Hofmann & Van Dillen, 2012; Tiggemann & Kemps, 2005; Werthermann et al., 2013). Elevated attentional biases towards food cues are often observed in overweight and obese sample populations as well as individuals with eating disorders (Werthermann et al., 2013; Renwick et al., 2013).

Attentional biases are captured through paradigms such as the modified Stroop task, spatial attention tasks, and the current gold standard: the dot-probe task (Pineda & Leland, 2011). The dot-probe task is a modified version of the Posner paradigm in which subjects sit in front of a computer screen and stare at a fixation cross (MacLeod et al., 1986). Then, a pair of stimuli (one neutral, one symptom-relevant) is presented. Following the presentation of the stimuli, a dot probe appears on either side of the screen. Subjects must indicate the location in which the probe appears as quickly as possible using a response pad. By presenting a stimulus pair, rather than a single stimulus, the subject has to process two distinct stimuli and direct their attention towards/away from one of the stimuli. In this way, once the probe appears, the speed at which a subject responds to the probe can determine where their attention was directed (Starzomska, 2017).

When the dot probe appears on the same side as the symptom-relevant stimuli, it is considered a congruent trial; when the dot probe appears on the opposite side, it is considered an
incongruent trial. Attentional biases are determined by the differences in reaction times when the dot probe replaces the neutral stimuli and symptom-relevant stimuli in congruent and incongruent trials (Starzomska, 2017). When the probe appears in the same spatial location as the symptom-relevant stimuli, faster reaction times indicate that the subject was already attending to that location (Starzomska, 2017). When the probe appears on the opposite spatial location as the symptom-relevant stimuli, slower reaction times indicate that the subject had to shift their attention from one side of the screen to the other (Starzomska, 2017).

Using a visual probe task, Nijs et al., (2010) found that overweight and obese individuals demonstrated greater initial orientation toward food-related stimuli when food-deprived, compared to normal-weight controls. Likewise, among dieters, a modified Stroop task revealed that dieters displayed greater attentional bias to food cues compared to non-dieters (Bazzaz et al., 2017). Overweight and obese samples also displayed elevated attentional biases for food cues compared to healthy weight controls (Werthemann et al., 2011).

**Attentional Bias Modification**

Attentional bias modification (ABM) training was developed by MacLeod and colleagues (2002) through a modified dot probe task. The primary goal of ABM is to train attention away from the symptom-relevant stimuli (e.g., high-calorie food, alcohol, snakes) thereby reducing the attentional bias for that stimulus. Utilizing the dot-probe task mentioned earlier, the ABM training is divided into three phases: (1) pre-training, (2) training, and (3) post-training. During phase 1, the participant completes a version of the dot-probe task, mentioned earlier, aimed at measuring baseline attentional biases to the study-relevant stimuli (e.g., high-calorie foods). Phase 1 follows a 50/50 contingency, where the dot probe appears on either side of the stimulus pair, an equal number of times. During the training phase, the participant completes a version of
the dot-probe task in which the location of the probe is designed to train attention away from the study-relevant stimuli by appearing on the same side as the neutral stimuli in at least 90% of the trials. Finally, during phase 3, the participant repeats the same dot probe task from phase 1 to determine whether the training was successful in modifying attention.

Successful modification of attentional biases using the ABM training procedure is evident in the food domain. Kemps and colleagues (2014, Experiment 1) used a single session of the ABM training procedure to modify attention towards and away from chocolate cues among female undergraduate students. One group had their attention trained toward chocolate cues and consequently demonstrated increases in attentional bias for chocolate (Kemps et al., 2014). The other group had their attention trained away from the chocolate stimuli and consequently demonstrated decreases in attentional bias for chocolate cues (Kemps et al., 2014). During the taste test, participants in the ‘avoid’ group consumed less of the chocolate muffin compared to participants in the ‘attend’ group, indicating that the modification of attention influenced food consumption as intended. Kemps and colleagues (2016) replicated their findings in a later study to test the longevity of ABM training in overweight and obese female samples. The researchers again demonstrated that attentional bias could be modified through the ABM training. Further, they demonstrated that attentional bias for chocolate cues were sustained 24 hours, and one week after training among those receiving five weekly training sessions (Kemps et al., 2016).

To generalize Kemps and colleagues’ (2014) findings, broader ‘unhealthy’ and ‘healthy’ food groups, Kakoschke et al. (2014) utilized healthy and unhealthy pictorial food stimuli to explore whether the ABM training could encourage healthy eating in a sample of female undergraduate students. Using a single session, the ‘attend healthy’ group demonstrated successful modification of attention towards the positive cues (i.e., healthy food pictures) which
led to increased relative consumption of healthy snack foods (Kakoschke et al., 2014). The other group (‘attend unhealthy’) had their attention trained towards unhealthy food cues however, the training effects did not reach significance, which the researchers suggest may result from existing tendencies to attend towards unhealthy food cues (Kakoschke et al., 2014).

More recently, Smith et al. (2018) utilized the ABM training procedure using high-calorie food cues and low-calorie food cues on a sample of overweight/obese female participants. The participants were randomly assigned to either the attentional-training group, placebo-training group, or control group and shown word stimuli. Results demonstrated that participants in the attentional-training group ate less food overall when compared to the placebo group, and specifically, ate less high-fat biscuits and high-fat foods (Smith et al., 2018). Closer inspection demonstrates that the control group consumed less than the placebo group, perhaps suggesting that the placebo group experiences an exposure effect during the sham training (Smith et al., 2018). Rather than using word stimuli, Zhang et al. (2018) used high- and low-calorie food images. The researchers found that attention was successfully modified by the ABM training among high-calorie food-craving women and resulted in higher consumption of low-calorie foods and lower consumption of high-calorie foods when compared to the control group (Zhang et al., 2018). As the current study sought to look at the type of food consumed during the bogus food taste test, the ABM training procedure from Zhang and colleagues’ (2018) study was used to examine the impact of the ABM training on consequent high- and low-calorie food intake. The current study modeled the ABM training procedure from Zhang et al. (2018) to determine whether their results could be replicated among a sample of undergraduate students.
Summary

Applications of the ABM training procedure in the food domain demonstrate that not only can attentional biases be modified, but the impact of the training is also evident in consequent food intake. Studies using food-related stimuli modify attentional biases and food consumption in the predicted way in both overweight/obese and healthy weight populations. To my knowledge, the impact of the ABM training procedure has not been explored in a sample of emotional eaters, therefore the current study is the first to do so.

Current Study

The present study took a multifaceted approach to emotional eating by considering the roles of emotion regulation, attentional biases, sociodemographic characteristics, food insecurity, and food preferences. One of the goals of this study was to better understand how difficulties with emotion regulation relate to emotional eating. Additionally, this study aimed at determining the impact of the attentional bias modification (ABM) training paradigm in reducing biases towards high-calorie pictorial food stimuli and consequently influencing food intake of high- and low-calorie foods. Further, the ABM training paradigm was tested against a negative emotion induction to examine whether it shifted food consumption among emotional eaters.

The present study aimed to add to prior literature on emotional eating by addressing limitations brought forth by previous research. This study used the SEES, a newer, more comprehensive measure of emotional eating, considered food preferences in the bogus taste test, and looked at the total amount of food consumed along with the consumption of sweet, high-calorie foods. Additionally, although most of the research on emotional eating limits its sample to
females, this study broadened the sample to all eligible undergraduate students to generalize the findings beyond only females.

**Hypotheses**

**Hypothesis 1.** Based on prior research that indicates emotional eating is associated with increased consumption of energy-dense foods (van Strien et al., 2013; Barak et al., 2021), it is hypothesized that higher emotional eating will be associated with a greater attentional bias for high-calorie pictorial food images, compared to lower emotional eating at baseline (Phase 1).

**Hypothesis 2.** To the extent that the ABM training is successful, participants in the attention modification training group will demonstrate lower attentional bias for high-calorie pictorial food stimuli after training, compared to the placebo training and control groups.

**Hypothesis 3.** Overall, participants who score higher on emotional eating will eat more during the bogus taste test compared to participants who score lower on emotional eating, regardless of training conditions.

**Hypothesis 3a.** To the extent that ABM training impacts food intake after the negative emotion task, it is hypothesized that individuals in the attentional-training group (trained away from high-calorie pictorial food stimuli) will consume fewer calories from high-calorie food snacks compared to low-calorie food snacks.

**Hypothesis 3b.** To the extent that ABM training impacts food intake after the negative emotion task, it is hypothesized that emotional eaters in the attentional-training group will eat fewer calories from high-calorie sweet snacks compared to emotional eaters in the placebo-training and control conditions.
Hypothesis 4. Based on prior findings that maladaptive eating behaviors are strongly maintained by emotion dysregulation (Juarascio et al., 2020), it is hypothesized that emotional eaters will demonstrate greater difficulties with emotion regulation as reflected by higher ratings on the DERS and lower levels of baseline HF-HRV, compared to non-emotional eaters.

Method

Participants

Participants were 172 undergraduate students from the Rochester Institute of Technology, recruited through the university’s SONA research pool in exchange for five SONA credits during the 2022-23 academic year. The experiment was advertised as a study looking at the correlates of taste perception such as attention, emotions, and a taste test. Of the 172 participants, eight were excluded due to hearing status and two were excluded for incomplete data, pre-determined as > 30% of survey completion following previous research (e.g., Shen et al., 2021). Additionally, due to the low number of participants self-reporting as non-binary/third gender, 9 participants were removed as there would be insufficient power to see gender differences between the three self-reported gender groups. The final sample consisted of 153 participants.

For a complete table of sociodemographic data, see Table 1. The sample was between 18-41 years of age ($M = 19.35, SD = 2.22$), with a relatively even sex distribution (54.2% male). Participants self-described as men (54.2%) and women (45.8%). The majority of the sample was White (62.1%), while the remaining were Asian (18.3%), African American (9.8%), or other (9.8%). Additionally, 16.3% of the sample identified as Latinx/Hispanic origin. A little over half the sample (52.3%) had a body mass index (BMI) in the healthy range ($18.5 < \text{BMI} < 25, M = 25.67, SD = 5.59, \text{range} = 18.11-43.19$), as defined by the World Health Organization (World
Health Organization, 2021). The remainder of the sample were overweight (29.4%), obese (16.3%), or underweight (2%).

Exclusionary criteria included: being below the age of 18, having a known food allergy/food sensitivity, or having dietary restrictions, hearing impairments, self-described third gender/non-binary, and eating within two hours of the study start time. The study was approved by the university’s Institutional Review Board.

Materials and Tasks

Sociodemographic Measures

Information on age, sex at birth, gender, racial/ethnic identity, annual family income, and food insecurity was collected (see Appendix A). Food insecurity was measured using the 2-item Adult Food Insecurity Screening Questions which showed high sensitivity and specificity (Radandt et al., 2018). Food insecurity was determined by the endorsement of “often” or “sometimes” to either question regarding their food situation in the last 12 months.

Fasting Time

Participants were instructed to refrain from eating 2 hours prior to the study start time to approximate similar levels of hunger and craving across participants. Compliance with these instructions was determined by asking, “When was the last time you ate?”

Visual Analog Scale for Hunger and Craving

Subjective state hunger and craving were measured through a visual analog scale (VAS) at the beginning of the study to account for any group differences at baseline. The VAS for hunger asked, “How hungry are you feeling right now?” with the horizontal sliding scale
beginning from 0 (not hungry) to 10 (very hungry). The VAS for craving asked, “How strong is your craving for food right now?” with a horizontal sliding scale beginning from 0 (not strong) to 10 (very strong). The VAS as a measure of hunger and craving is shown to be a reliable and valid measure of subjective states of hunger and craving (Flint et al., 2000) and is often used in studies testing attentional bias modification training on consequent food intake (e.g., Smith et al., 2018; Werthmann et al., 2014).

Self-Assessment Manikin for Valence and Arousal

Subjective measures of affective valence and arousal were measured using the Self-Assessment Manikin (SAM) at three separate time points: (1) upon arrival, (2) immediately after the mood induction, and (3) immediately after food intake. The SAM provides a non-verbal pictorial assessment of valence with figures that range in the depiction of frowns to smiles, with the figure on the far left expressing extreme sadness and the figure on the far right expressing extreme happiness. The SAM for arousal ranges from a relaxed figure with its eyes closed on the far left to a wide-eyed figure depicting extreme arousal/activation on the far right. The SAM provides a quick, easy, and effective method to assess a person’s emotional experience of an event (Bradley & Lang, 1994).

Body Mass Index (BMI)

Body mass index was calculated by dividing the weight (kg) by the height (m²) of each participant. Participants’ height (in.) and weight (lbs.) were obtained using a physician scale in the laboratory.
Emotional Eating

The Salzburg Emotional Eating Scale (SEES; Meule et al., 2018) was used to measure emotional eating. The SEES is a 20-item self-report questionnaire that measures emotional eating during specific emotional states and differentiates between decreases and increases in food intake in response to the specific emotion (e.g., “When I feel lonely,” and “When I feel confident”). Items produce four subscales: happiness, sadness, anger, and anxiety. Higher averaged scores indicate greater emotional eating tendencies while lower scores indicate less emotional eating tendencies. In this sample, the overall scale demonstrated an acceptable level of internal consistency (α = 0.77). The subscale reliability in the current sample was low (α = 0.48), even though preliminary validation of the scale by Meule and colleagues (2008) demonstrated acceptable internal consistencies for each subscale (α > 0.70).

Emotion Regulation

The Difficulties in Emotion Regulation Scale (DERS; Gratz & Roemer, 2004) was used to measure self-reported emotion regulation. The DERS is a 36-item self-report measure of six dimensions of emotion regulation: (1) awareness and understanding of emotions; (2) acceptance of emotions; (3) the ability to engage in goal-directed behavior; (4) lack of emotional clarity; (5) impulse control difficulties, and (6) access to emotion regulation strategies perceived as effective. In this sample, the overall scale demonstrated high internal consistency (α = 0.85). The DERS generates a total score as well as scores for each of the subscales. The present study only focused on the overall score, with higher scores indicating greater difficulties with emotion regulation.
Eating Disorder Symptomology

The Eating Disorder Examination Questionnaire short-form (EDE-Q-13; Lev-Ari et al., 2021) was used as a brief measure of eating disorder (ED) symptomology. The EDE-Q-13 is a 13-item self-report measure that captures the following ED subscales: (1) eating restraint; (2) body dissatisfaction; (3) shape and weight over-evaluation; (4) bingeing; and (5) purging. The EDE-Q-13 scores are shown to have strong positive correlations to the original EDE-Q scores ($r = .92, p < .001$). The internal consistency of the EDE-Q-13 in this sample was high ($\alpha = 0.86$) as well as for the restraint subscale ($\alpha = 0.82$). The total score and subscale scores are calculated by the sum of the items, with higher scores indicating greater symptom severity. The present study only focused on the total score and the restraint subscale.

Food Insecurity

A 2-item Adult Food Insecurity Screening questionnaire was used as a brief measure of food insecurity. The two items asked about the household food situation within the last 12 months and have been shown to be a reliable and valid way of measuring food insecurity (U.S. Household Food Security Survey). Response of “often true” or “sometimes true” to either statement indicates food insecurity.

Social Desirability

The six-item Social Desirability Measure (Kemper et al., 2012) was used as a brief measure of social desirability, should higher scores influence the amount of food consumed or self-reported eating behaviors. The Social Desirability Measure produces two scales, the underestimation of negative qualities and the overestimation of positive qualities. The internal consistency for the underestimation of negative qualities subscale ($\alpha = 0.39$) and overestimation
of positive qualities ($\alpha = 0.46$) were lower compared to those produced by Kemper and colleagues (2012), respectively ($\alpha = 0.70$, $\alpha = 0.69$).

**Stimuli**

Pictorial stimuli for the dot-probe task came from the Food-Pics_Extended image database for experimental research on eating and appetite (Blechert et al., 2019). The control pairs consisted of non-food images that were matched by color, size, and shape. The critical pairs consisted of low- and high-calorie food image pairs that were matched by color, size, and shape. See Appendix B for examples of matched stimuli pairs.

**Attentional Bias Modification (ABM) Training Paradigm**

The ABM training followed the standard procedure with three phases: (1) pre-training assessment, (2) training, and (3) post-training assessment (MacLeod et al., 2002). The visual dot probe task for each phase modeled Zhang and colleagues’ (2018) study as they also utilized high-calorie and low-calorie picture pairs. Each trial began with a fixation cross displayed at the center of the computer screen for 500ms. Following the fixation cross, the picture pair (high-calorie food image and low-calorie food image or two non-food image pairs) was presented for 500ms. Each picture was presented 20mm from the fixation cross and sized at 120mm (Zhang et al., 2011; Kemps et al., 2014). After the images disappeared, a probe stimulus (‘E’ or ‘F’) appeared in the location of one of the pictures (left or right) and remained on the screen until the participant responded using the response pad. See Appendix C.

**Phase 1: Pre-training Assessment.** The pre-training assessment consisted of 144 trials composed of 18 critical pairs (high- and low-calorie food images) and 18 control pairs (non-food images). Each image appeared four times, with the location of the pictures and probes
counterbalanced in a pseudo-random order following a 50/50 contingency. The pre-training assessment provided a baseline attentional bias for high-calorie food stimuli in contrast to low-calorie food stimuli.

**Phase 2: Training.** The training phase included 288 trials where each of the 18 critical pairs appeared 16 times (eight times on each side of the screen) in a pseudo-random order. Rather than replace the low-calorie food image in 100% of the trials, as seen in other studies (e.g., Smith et al., 2018), the training phase followed a 90/10 contingency like Zhang and colleagues (2018). The probe replaced the low-calorie food image in 90% of the trials and replaced the high-calorie food image in 10% of the trials. The 90/10 contingency is shown to effectively manipulate attentional bias (Schoenmakers et al., 2007; Kakoschke et al., 2014; Zhang et al., 2018).

**Phase 3: Post-training assessment.** The post-training assessment was identical to Phase 1, with 144 trials consisting of 18 critical pairs and 18 control pairs in a pseudo-random order.

**Emotion Induction**

The emotion induction procedure utilized a two-minute and 51-second movie clip from The Champ, in which a little son finds his father severely injured from a boxing match and unresponsive. According to Macht’s (2008) five-way model of emotion-induced changes in eating, with emotional eating, negative emotions moderate in arousal or intensity may increase food intake, specifically that of sweet, high-fat foods. The Champ movie met the criteria of eliciting a negative emotion (sadness) or moderate intensity (Hewig et al., 2005). Using a film clip for emotion induction differed from the typical autobiographical recall procedures used in studies on emotional eating (Werthmann et al., 2014; van Strien et al., 2013; Evers et al., 2009).
However, the use of film clips for emotion induction allows for standardization and high ecological validity, while autobiographical recall suffers from individual variability based on willingness/ability to imagine a scenario (Hewig et al., 2005; Devilly & Donohue, 2021).

**Bogus Food Taste Test**

Participants were first asked to rank two lists of food items from (1) most favorite to (4) least favorite. The first list included the following higher-calorie food options: plain potato chips (Lays), snack cake with cream filling and icing (Zebra cakes), Frito-Lays flavored chips (Doritos), and chocolate chip cookies (Chips Ahoy). The second list included lower-calorie food options: freeze-dried strawberries, popcorn with sea salt, Jell-o (gelatinized fruit juice), and veggie sticks (potato-based sticks with potato, spinach, and tomato variety). The top two rankings from each list were included in the bogus food taste test.

**Psychophysiological Measures**

**Electrocardiogram (EKG)**

Heart rate was measured using the electrical signal recorded using two electrodes, one taped on the right collarbone and another taped on the left abdomen. EKG signals were recorded using the Biopac MP150 System (Biopac, Inc., Goleta, CA) and consequently analyzed using the Acqknowledge 4.0 software (Biopac Inc., Goleta, CA). The BIOPAC amplifiers were set with a low pass filter at 35 Hz and a high pass filter at 0.05 Hz. The gain was set at 1000. Heart rate (HR) was used as a manipulation check for the negative emotion task, namely, to observe decreases in heart rate while watching a sad film clip. HR data was extracted 30 seconds prior to the emotion induction video starting, during the first 30 seconds of the video, and 30 seconds after the video ended. HR data was analyzed on Acqknowledge 4.0 by taking the mean beats per
minute for the three-time points. To determine high-frequency heart rate variability (HF HRV) as a physiological marker of emotion regulation, five minutes of baseline HR data was extracted and analyzed on Kubios HRV Premium 4.0 (Kubios Oy, Kuopio, Finland).

**Skin Conductance Levels (SCL)**

SCL was used as a secondary manipulation check for the negative emotion task. SCL was measured through the resulting electrodermal activity (0-35 Hz) between two electrodes taped on the palm of the non-dominant hand. SCL signals were recorded using the Biopac MP150 System (Biopac, Inc., Goleta, CA) and consequently analyzed using the Acqknowledge 4.0 software (Biopac Inc., Goleta, CA). The gain was set at x2000 with a threshold set to 0.03µS.

Prior to analyzing the SCL, the following settings were applied: a smoothing baseline removal was added, the baseline estimation window width was set to one second, the threshold level was set to zero umho, and SCL under 10% was rejected. The waveforms were resampled at a rate of 62.500 samples/second with a median smoothing factor of 63 samples. Additionally, a low-pass digital filter was applied with a frequency cut-off fixed at 1.00 Hz. Each electrodermal activity “event” (SCL peak) was counted for 30 seconds windows at three-time points for comparison: (1) right before starting the emotion induction video; (2) when the video began; and (3) right after the video ended.

**Procedure**

See Figure 1 for an overview of the procedures. Participants self-selected a timeslot to participate in the study through the online SONA participant management system. The day before the selected time slot, participants were emailed instructions to refrain from consuming food at least two hours prior to the start of the study session. Upon arriving at the laboratory,
written informed consent was obtained, and verbal confirmation of no known food allergies, food sensitivities, or dietary restrictions was obtained. Participants were also asked to report the last time they consumed food. If their last food intake was less than two hours prior to the study session, participants were rescheduled.

Participants were taken into a smaller, dimly lit room where they were asked to fill out a short questionnaire on Qualtrics using the tablet provided in the laboratory. The questionnaire asked them to indicate their hunger and craving levels using the visual analog scale, their valence and arousal levels, and to rank their preference for the four high-calorie foods and four low-calorie foods available. Participants were then hooked up to the electrodes measuring their heart rate and skin conductance responses and instructed to sit quietly for five minutes while the researcher collected a five-minute baseline of heart rate to inform heart rate variability.

Based on their participant number, participants were randomly assigned to either the (1) attentional-training group, (2) placebo-training group or (3) control group. All groups completed Phase 1 (pre-training assessment) to get a baseline measure of attentional bias toward high-calorie pictorial food stimuli. The control group finished after Phase 1, finishing approximately 10 minutes earlier than the other two groups. The attentional-training group and placebo-training group moved on to Phase 2, the training phase. The attentional-training group had their attention trained away from high-calorie food images and toward low-calorie food images, with the probe appearing on the same side as the low-calorie food image for 90% of the trials. The placebo-training group did not have their attention modified in either direction, and the probe appeared on the same side as the low-calorie food image as often as it appeared on the high-calorie food image, following a 50/50 contingency. Phase 3 mirrored Phase 1 as a post-training assessment to
determine whether the ABM training was successful. Participants were given the opportunity to take a break between each phase.

The negative mood induction followed the ABM paradigm. Skin conductance and heart rate data were recorded for 30 seconds prior to the start of the film clip, the entire duration of the film clip, and 30 seconds after the film clip. Participants were instructed to watch the approximately three minute film clip from the movie The Champ on the tablet and then asked to report their affect ratings on the valence and arousal SAM.

Upon indicating completion of the valence and arousal SAM, the researcher brought in four, pre-weighed bowls of food for the bogus food taste test. Participants were told to eat as little or as much as they liked and were given five minutes to make ratings on the sweetness and saltiness of each food. After five minutes, the researcher came back and told the participant that all the food would be placed in Zip-lock bags so that they could take it home. Before placing them in plastic bags, the researcher weighed each food bowl to determine how much food (g) was consumed. In the meantime, participants rated their affect using the valence and arousal SAM and completed the remaining questionnaires on Qualtrics which included: sociodemographic measures, the Social Desirability Measure, the Difficulties with Emotion Regulation Scale, the Salzburg Emotional Eating Scale, and the Eating Disorder Examination-13 Questionnaire.

Finally, the researcher took the participant’s height and weight in a separate room. Participants were verbally asked (1) if they disliked any of the foods in the taste test, (2) if they noticed any patterns in the attention tasks, and (3) to guess what the study was measuring. Participants were then fully debriefed, thanked, and given SONA credits.
Results

Statistical Analysis

Data were analyzed using the IBM SPSS Statistics for Windows, version 28. Descriptive statistics are presented as means and standard deviations for continuous variables and compared using independent samples t-tests. For categorical variables, frequencies are presented and compared using Chi-squared tests. An alpha level of .05 was used to determine significant p-values. Partial eta\(^2\) (\(\eta^2_p\)) was used for effect size measures for ANOVAs with .01 representing a small effect, .06 representing a medium effect, and .14 representing a large effect.

Attentional Bias Scores

Attentional bias index scores were calculated by subtracting the mean reaction time to the trials in which the dot probe replaced the high-calorie food stimuli from the mean reaction time to the trials in which the dot probe replaced the low-calorie food stimuli. Positive scores indicate attentional biases toward low-calorie food images and negative scores indicate attentional biases toward high-calorie food images. In line with previous studies, incorrect responses were removed (Nijs et al., 2010; Kakoschke et al., 2014), response times greater than 2.5 SDs above or below the mean were removed as outliers (Kemps et al., 2014), and reaction times less than 150ms and greater than 1500ms were removed as it potentially suggests response due to anticipation or lapse in concentration, respectively (Kemps et al., 2014; Kemps & Tiggemann, 2009). Overall, 4.97% of trial response times were removed due to incorrect responses, less than 0.01% were removed due to anticipation, and 0.18% were removed due to a lapse in concentration. Response times for one participant were completely removed as over 50% of the trial responses were incorrect,
suggesting that the participant was randomly responding to the trials. Finally, three participants were removed as outliers.

For the attentional-training and placebo-training groups, attentional bias scores were calculated for the pre-training phase and post-training phase. For the control group, only the attentional bias scores for Phase 1 (pre-training phase) were available.

**Food Intake**

The amount of food a participant consumed during the bogus food taste test was calculated by the change in weight (g) of each of the four-food bowls prior to the taste test and after the taste test. The change in weight (g) was then calculated into calories by multiplying the change in weight by the number of calories per gram for each food option. Calorie information was computed for: the total food intake, sweet food intake, salty food intake, high-calorie food intake, low-calorie food intake, and high-calorie, sweet food intake.

**Missing Data**

As per the exclusionary criteria, two participants were removed by listwise deletion since they had less than 30% of the measures completed. On baseline measures, three participants were missing data on the hunger scale and six participants were missing on the craving scale. Though participants were instructed to move the slider to input a response regardless of the default placement of the slider, it is unclear whether participants understood these instructions. On the arousal SAM, one participant was missing at time 1, and another participant was missing at time 3. On sociodemographic measures, three participants were missing on age and three participants were missing on annual family income. All three participants who were missing on annual family income verbally indicated not knowing their family income and were instructed to leave it blank.
by the researcher. On primary variables, one participant was missing on the SEES, one participant was missing on the DERS, and two were missing on EDE-Q-13. For psychophysiological data, missing data were due to improper signals, 33 (21.6%) were missing on SCL, 20 (13.1%) were missing on heart rate, and 16 (10.5%) were missing on HRV.

Preliminary Analyses

The normal distribution of variables was assessed through visual inspection of Q-Q plots along with indices of skewness and kurtosis, with non-normality determined by skewness of ±2 and kurtosis of ±7 (West et al., 1995). Extreme outliers identified through the box plot were first removed. Two extreme outliers were found on the happiness subscale of the SEES. For psychophysiological data on heart rate (HR) during the emotion induction procedure, four extreme outliers were found at time 1, one at time 2, and three at time 3, all of which were removed. Skewness was found on the happiness subscale of the SEES, with a skewness index of 5.10. Given that neither the logarithmic transformation nor square-root transformation was able to normalize the distribution, a reciprocal transformation was used, and the skewness index was reduced to -0.75. The anger subscale of the SEES was negatively skewed, with a skewness index of -2.49. The variable was reflected, then transformed using a square-root transformation, resulting in a skewness index of 0.33. The EDE-Q-13 had a skewness index of 3.96 which was reduced to 0.36 through log transformations. The negative qualities subscale of the SDM had a skewness of -3.64 which was reflected and log-transformed to .28, and the positive qualities subscale of the SDM had a skewness of 2.33, which was log-transformed to -1.2. BMI had a skewness index of 6.71 and was transformed using the reciprocal to -1.52. On psychophysiological data, HRV had a skewness of 18.57, which was log-transformed to -1.19. All variables measuring total food consumed were log-transformed, except for the measures of
high-calorie and high-calorie sweet foods which were transformed using a square-root transformation. Preliminary and descriptive statistics are presented using the original variables however, all other statistical analyses were performed using transformed variables. Where appropriate, reported means were back-transformed by using the opposite mathematical function (e.g., raising 10 to the power of a log-transformed mean) and reported with the back-transformed 95% confidence intervals (CI).

**Descriptive Statistics**

The SEES scores can range from 1 – 5. The mean SEES total score was 2.82 ± 0.38 (range: 1.85 – 4.30). The scores for the subscales were as follows: happiness subscale: 3.18 ± 0.37 (range: 2.40 - 4.40); sadness subscale: 2.99 ± 0.67 (range 1.40 – 4.80); anger subscale: 2.63 ± 0.55 (range: 1.00 – 4.20); and anxiety subscale: 2.48 ± 0.75 (range: 1.00 – 4.80). Medium scores (~3) represent unchanged food intake in response to emotional cues, which most participants fell under, both overall and within the subscales. Lower scores (< 3) represent decreased food intake and higher scores (> 3) represent increased food intake, with higher scores representing greater emotional eating.

The DERS scores can range from 36 – 180 with higher scores indicating greater emotion regulation difficulties. The clinical range varies from 80 – 127 but is considered mild if it is less than 90, moderate if it is between 91 – 105, and severe when scores are greater than 105. The current sample mean was 86.12 ± 20.35 (range: 39.00 – 133.00), indicating that the majority of participants show mild emotion regulation difficulties.
With EDE-Q-13 scores, the range spans from 13 – 91, with higher scores indicating a greater presence of eating disorder symptoms. The current sample mean was 30.94 ± 13.85 (range: 13.00 – 78.00) indicating lower to moderate presence of eating disorder symptoms.

**Baseline Group Differences Check**

For a complete table of means and standard deviations for baseline characteristics per ABM group, see Table 2. Preliminary analyses found no significant differences between the AT, PC, and control groups in terms of age ($F(2,147) = 1.93, p = .149$), sex ($\chi^2 (2, N = 153) = 1.16, p = .561$), gender ($\chi^2 (2, N = 153) = 1.16, p = .561$), hunger ($F(2,147) = .55, p = .884$), cravings ($F(2,144) = .36, p = .698$), valence ($F(2,150) = 1.31, p = .274$), arousal ($F(2,149) = 1.35, p = .262$), and total fasting time ($F(2,150) = 2.38, p = .096$). However, there were significant group differences in BMI ($F(2,150) = 3.79, p = .025$) and eating disorder symptomology ($F(2,148) = 5.75, p = .004$), though not on the restraint subscale ($F(2,150) = 1.75, p = .178$). Comparison of group means revealed that the BMI among the attentional training group (24.03 ± 3.72) was significantly lower than the placebo training group (24.03 ± 3.72), ($t(85.74) = -2.95, p = .004$) but not between the control group (25.40 ± 5.81), ($t(89.46) = -1.43, p = .157$). Comparison of the groups on the EDE-Q-13 revealed that the attentional training group (25.23 ± 10.95) demonstrated significantly lower scores compared to the placebo group (33.14 ± 13.14), ($t(94.17) = -3.24, p = .002$), and compared to the control group (33.00 ± 15.08), ($t(94.69) = -2.98, p = .004$). Both BMI and eating disorder symptomology were used as covariates in the analyses comparing the ABM group effects.
Emotion Induction Manipulation Check

A series of repeated measures ANOVAs were conducted to compare the effect of the emotion induction video on SAM ratings for valence and arousal over three-time points: (1) before the emotion induction, (2) after the emotion induction, and (3) after food intake. Since sphericity was violated for both analyses of valence and arousal, the Greenhouse-Geisser correction was used. There was a statistically significant difference between SAM ratings for valence across time \( F(1.81, 274.40) = 207.04, p < .001, \eta^2_p = .58 \), with pairwise comparisons (p’s < .001) indicating a quadratic relationship with a decrease in valence from time 1 \( M = 6.09, SD = 1.03 \) to time 2 \( M = 4.31, SD = 1.33 \), and an increase at time 2 to time 3 \( M = 6.46, SD = 1.09 \), as well as from time 1 to time 3. There were no statistically significant differences between SAM ratings for arousal across time \( F(1.93, 289.72) = 1.27, p = .475, \eta^2_p = .01 \). See Figure 2.

Psychophysiological data for skin conductance levels (SCL) indicated a statistically significant increase in arousal over time \( F(1,119) = 7.02, p = .009, \eta^2_p = .06 \). Pairwise comparisons indicated an increase in SCL from time 1 \( M = 4.23, SD = 2.11 \) to time 3 \( M = 4.88, SD = 1.88, p = .027 \), however, not from time 1 to time 2 \( M = 4.69, SD = 2.18, p = .180 \) or from time 2 to time 3 \( p = 1.00 \). Given that time 1 represents the 30 seconds prior to the emotion induction video starts, and time 3 represents the 30 seconds after the video ends, the results indicate that the emotion induction in its entirety was physiologically arousing. However, to note, SCL data comes from a subset of the sample \( n = 120 \) due to missing data.

Psychophysiological data for heart rate (HR) indicated a statistically significant quadratic relationship \( F(1,126) = 39.70, p < .001, \eta^2_p = .24 \). HR decreased from time 1 \( M = 80.79, SD=12.12 \) to time 2 \( M = 76.14, SD = 11.01, p < .001 \), increased from time 2 to time 3 \( M =
ATTENTIONAL BIAS MODIFICATION AMONG EMOTIONAL EATERS

79.06, \( SD = 11.03, p = <.001 \), and decreased from time 1 to time 3 (\( p = .033 \)). See Figures 3 and 4.

Main Analyses

To test hypothesis 1, that higher emotional eating would be associated with a greater attentional bias for high-calorie pictorial food stimuli, two linear regressions were performed. The first regression analyzed the association between emotional eating and high-calorie attentional biases. The second analysis was a hierarchical regression that looked at the association between emotional eating and attentional bias while covarying for gender and BMI. Results from the first regression analysis on the influence of emotional eating (\( \beta = .12, t = 1.42, p = .159 \)) and pre-training attentional bias for high-calorie pictorial food stimuli revealed no significant main effect of emotional eating (\( F(1,148) = 2.01, p = .159, R^2 = .01 \)). In the second regression, the covariates (gender and BMI) were added in the first step (\( F(2,147) = .87, p = .422, R^2 = .01 \)). Emotional eating was added in the second step, with pre-training attentional bias scores as the dependent variable. The results demonstrate emotional eating (\( \beta = .13, t = 1.62, p = .108 \)) was not significantly associated with attentional bias scores when gender (\( \beta = .11, t = 1.38, p = .171 \)) and BMI (\( \beta = -.05, t = -.62, p = .536 \)) were added as covariates (\( \Delta F(1,146) = 2.61, p = .108, \Delta R^2 = .03 \)). None of the individual subscales of emotional eating were significantly associated with high-calorie pictorial food bias, with and without covarying for BMI and gender.

To test hypothesis 2, the successful reduction in attentional bias for high-calorie pictorial food stimuli in the attentional training group, a mixed-model ANOVA was analyzed. Pre-training attentional bias scores were compared to post-training scores, with ABM training condition (attentional training, placebo training) as the between-subjects factor and attentional bias index scores (pre- and post-training) as the within-subjects factor. The attentional bias to high-calorie...
food cues was the dependent variable. Attentional bias index scores by condition and across time are provided in Figure 5. The analysis revealed a small but significant main effect of time ($F(1,94) = 6.96, p = .010, \eta^2_p = .07$), indicating a decrease in attentional bias within subjects after the training. However, the interaction between training condition and time was not statistically significant ($F(1,94) = .01, p = .946, \eta^2_p = .00$), indicating that the actual training paradigm was not the cause of the change in bias scores. Pairwise comparisons indicate that in both groups, the attentional bias scores decreased from the pre-training phase ($M = .04, p = .010$) to the post-training phase ($M = .03$) which suggests that the ABM training reduced biases towards low-calorie food cues, rather than training attention away from high-calorie food cues as predicted. This decrease suggests that over time, participants got better at the dot-probe task itself, and over time, skill was trained rather than attention.

To test hypothesis 3, that higher scores on emotional eating would be associated with greater food intake compared to lower scores on emotional eating regardless of training condition, a hierarchical regression was conducted. In the first step, the ABM training group was added as the covariate ($F(1,151) = 1.91, p = .169, R^2 = .01$). In the second step, emotional eating was added, with total calories consumed as the dependent variable. The results indicate that emotional eating ($\beta = .00, t = .05, p = .962$) was not significantly associated with food intake ($F(2,150) = .95, p = .389, R^2 = .01$), after covarying for the ABM group ($\beta = -.11, t = -1.38, p = .171$). No statistically significant association between emotional eating and total food intake was found ($F(1,151) = .01, p = .920, R^2 = .00$) when analyzed without the covariate. Analysis using BMI ($\beta = -.01, t = -.15, p = .881$) and EDE scores ($\beta = -.01, t = -.11, p = .914$) as covariates also yielded non-significant results ($F(3,147) = .01, p = .998, R^2 = .00$). Analyses looking at the four individual subscales of the SEES did not yield significant results.
To test hypothesis 3a, that the attentional-training group would consume fewer calories from high-calorie snacks, a one-way ANOVA was conducted looking at the total amount of calories consumed from high-calorie snacks between the three ABM groups. There were no significant differences \( (F(2,150) = 1.03, p = .359) \) between the number of high calories consumed between the attentional training group \( (M = 165.37, 95\% \text{ CI} [141.08, 193.84]) \), placebo training group \( (M = 153.89, 95\% \text{ CI} [134.81, 175.67]) \), and control group \( (M = 143.90, 95\% \text{ CI} [123.44, 167.76]) \). This is not surprising given that the ABM training did not successfully modify attention away from high-calorie food cues. Additionally, a one-way ANOVA was conducted to compare the differences between participants indicating no dislikes, dislikes for a high-calorie food item, and dislikes for a low-calorie food item presented during the bogus food taste test on the amount of food they consumed. No significant differences \( (F(2,126) = .88, p = .416) \) between the groups on how much food they consumed. Instead, it appeared that gender \( (\beta = -.17, t = -2.12, p = .035) \) better predicted the amount of calories consumed during the bogus food taste test \( (F(1,151) = 4.50, p = .035) \). Specifically, men consumed more \( (M = 166.96, 95\% \text{ CI} [147.71, 188.71]) \) than women \( (M = 139.51, 95\% \text{ CI} [124.71, 156.01]) \).

To test hypothesis 3b, that emotional eaters in the attentional-training group would consume fewer high-calorie sweet snacks compared to emotional eaters in the placebo-training and control groups, a hierarchical regression analysis was conducted with emotional eating as the independent variable, caloric intake from high-calorie sweet snacks as the dependent variable, and ABM group as the moderator. Emotional eating scores were first mean-centered before computing an interaction term to avoid multicollinearity and increase interpretability (Aiken & West, 1991). The interaction term between emotional eating scores and the ABM group was
calculated by multiplying those two variables. In the first step of the model, emotional eating scores were entered. Results indicate that emotional eating ($\beta = -.01$, $t = -.17$, $p = .863$) was not significantly associated with total consumption of high-calorie sweet foods. In the second step, the moderator was added, and the results indicated that ABM group was not significantly associated with total high-calorie sweet food consumption ($\beta = -.11$, $t = -1.36$, $p = .175$). In the final step, the interaction term between emotional eating and the ABM group was added but it was also non-significant ($\beta = .22$, $t = .86$, $p = .392$). The results indicate that the ABM group did not moderate the relationship between emotional eating and high-calorie food consumption ($F(3,149) = .87$, $p = .457$). Additionally, the overall regression was not significant even when the interaction term was removed ($F(2,150) = .94$, $p = .392$). Self-reported emotional eating is not associated with the total consumption of high-calorie sweet snacks and the ABM group condition did not moderate the effects.

To test hypothesis 4, that emotional eating would be associated with difficulties with emotion regulation reflected by higher scores on the DERS and lower levels of baseline high-frequency HRV, a multiple regression was conducted. Since the scores on the DERS were not significantly correlated with the high-frequency HRV ($r = -.165$, $p = .055$), both the self-report and physiological measures of emotion (dys)regulation were added as independent variables, with emotional eating as the dependent variable. The regression results indicate that neither the HF HRV ($\beta = -.02$, $t = -.24$, $p = .808$) nor the scores on the DERS ($\beta = .04$, $t = .50$, $p = .630$) were significantly associated with emotional eating ($F(2,133) = .18$, $p = .837$, $R^2 = .00$). Therefore, it appears that emotion regulation is not associated with self-reports of emotional eating.
**Exploratory Analyses**

*Food Insecurity and Annual Family Income*

The correlations between food insecurity, lower annual family income, and eating behaviors were explored. Food insecurity and annual family income were significantly negatively correlated ($r = -.26, p = .002$), indicating that greater annual family income is correlated with less food insecurity. While SEES was not correlated with annual food income nor food insecurity, the sadness subscale was correlated with annual family income ($r = .17, p = .039$), which may suggest that higher socioeconomic status may increase the ability to afford to alleviate negative emotions through food. In addition, though neither food insecurity nor annual family income was significantly correlated with the total amount of food consumed, annual family income was correlated with the consumption of sweet snacks ($r = .21, p = .009$) and high-calorie sweet snacks ($r = .21, p = .011$). A regression looking at the association between the sadness subscale of the SEES ($\beta = -.02, t = -.235, p = .815$) and consumption of sweet foods was explored, with annual family income as the covariate ($\beta = .22, t = 2.66, p = .009$). This yielded significant results ($F(2,147) = 3.55, p = .031$) however, annual family income seemed to carry the significance rather than emotional eating.

*Social Desirability*

In this study, social desirability responding was measured through two subscales: the understatement of negative qualities and the overstatement of positive qualities in case social desirability influenced food consumption. Neither the understatement of negative qualities ($r = -.13, p = .099$) nor overstatement of positive qualities ($r = .07, p = .375$) were significantly correlated with emotional eating, or with any of the SEES subscales. The social desirability
scales were not correlated with any of the measures in the study however, the internal consistencies of the subscales were low (α’s < 0.50), indicating that the instrument used may not accurately capture social desirability bias responding.

**Eating Disorder Symptomology**

Eating disorder symptomology, and the restraint subscale specifically, was used to account for the potential of high endorsement of an eating disorder which may influence food intake after a negative emotion induction. Correlations between the eating disorder questionnaire (EDE-Q-13) and the consequent restraint subscales were explored. ED symptomology was significantly positively correlated with BMI ($r = .41, p < .001$) and food insecurity ($r = .36, p < .001$). It is possible that individuals who have a higher BMI demonstrate greater attempts to control their weight hence the correlation with the EDE-Q-13 survey, and with the restraint subscale ($r = .27, p < .001$). Additionally, the correlation between the EDE-Q-13 and the restraint subscale with food insecurity may suggest a necessity to control food consumption. Lastly, the EDE-Q-13 was significantly positively correlated with the DERS ($r = .29, p < .001$) indicating that greater eating disorder symptomology is correlated with greater emotion dysregulation.

**Discussion**

The present study examined the roles of emotional eating and emotion regulation in food intake after a negative emotion induction, and how the attentional bias modification (ABM) training paradigm might shift attention away from high-calorie food cues and consequently influence food intake. The results from Hypothesis 1 indicated that emotional eaters do not show greater attentional bias for high-calorie pictorial food cues, as indicated by pre-training attentional bias scores. Adding gender and BMI as covariates in the analyses did not produce any
significant relationships either. It was hypothesized that emotional eaters would demonstrate biases towards high-calorie food cues since previous research found associations between emotional eating and greater consumption of high-calorie foods (van Strien et al., 2013; Barak et al., 2021). In the present study, attentional bias scores were measured prior to the emotion induction procedure and bogus food taste test. However, when the negative mood induction occurred prior to measuring attentional bias, Hepworth and colleagues (2010) found that the mood induction led to an increased bias towards food cues and subjective appetite among a sample of young females. Therefore, emotional eaters might not demonstrate biases toward high-calorie food cues until after experiencing negative affect.

The results from Hypothesis 2 demonstrated that the ABM training paradigm did not successfully modify attention away from high-calorie food cues. Comparisons of this study to previous studies utilizing ABM within the food domain suggest that sample characteristics may largely influence who the ABM training is most effective for. Previous studies had inclusionary criteria for overweight/obese females (Kemps et al., 2015; Smith et al., 2018), high-calorie food-craving women (Zhang et al., 2018), and female undergraduate students (Kemps et al., 2014; Kakoschke et al., 2014). While it is common for researchers to restrict their samples to only women when exploring maladaptive eating behaviors, this study sought a more representative sample of undergraduate students. However, the utility of the ABM training may be limited to populations who demonstrate strong biases towards food, such as high-calorie food-craving women (Zhang et al., 2018).

The third hypothesis was not supported as greater emotional eating was not associated with greater food intake during the bogus food taste test, compared to lower emotional eating, regardless of training condition. The association remained insignificant even after accounting for
BMI and endorsement of eating disorder symptoms. In the current study, the majority of the sample indicated that their eating does not change in response to emotions, making it difficult to see whether self-reported emotional eating is associated with greater food intake after a negative emotion induction. However, researchers such as Evers and colleagues (2009) suggest that self-reported emotional eating is not predictive of increased food intake in the laboratory after a mood induction overall. While the SEES is a newer self-report measure aimed at capturing increases and decreases in emotional eating in response to positive and negative emotions, the current study sample showed a low level of internal consistency among the emotion subscales ($\alpha = 0.48$). Although preliminary validation of the scale by Meule and colleagues (2008) demonstrated acceptable internal consistencies for each subscale ($\alpha > 0.70$), this difference may stem from differences in sample characteristics. The majority of their study sample were women (>74%) compared to the current study sample where less than half (45.8%) were self-reported women. It is possible that men and women interpret the same constructs in the SEES differently from one another. For example, Limbers and colleagues (2016) found that adolescent males and females interpreted eating in response to worry and boredom differently from one another on the Emotional Eating Scale developed by Arnow and colleagues (1995). Therefore, while emotional eating may be more prevalent in women (van Strien et al., 2012), gender differences in the interpretation of emotions may bias the awareness of the frequency at which emotional eating occurs.

When looking into the type of food consumed (i.e., high- vs. low-calorie), the results failed to find support for Hypothesis 3a and 3b. While it was predicted in Hypothesis 3a that the attentional-training group would consume fewer calories from high-calorie snacks compared to the placebo group and control group, the results indicated no difference between the groups. It is
likely that the failure to find any differences in high and low-calorie food intake between the groups is because the ABM training did not successfully modify attention away from high-calorie food cues in the attentional-training group. Prior studies that resulted in a failure to modify attentional bias through ABM training also failed to influence the outcome variable such as anxious disposition or emotional vulnerability (MacLeod & Clarke, 2015; Carlbring et al., 2012). Likewise, this study failed to modify attention away from high-calorie food cues and failed to reduce high-calorie food consumption. Clarke and colleagues (2014) interpret results such as these as providing a theoretical basis that the ABM is sound. Instead, more research on the conditions in which ABM is most effective is needed. Therefore, the ABM training paradigm to modify food-related biases may be most effective in a sample of overweight women.

Given that the ABM training did not produce significant differences in attentional bias scores or in consequent total food intake between the three ABM groups, it is not surprising that ABM group assignment did not moderate the association between emotional eating and high-calorie sweet snack intake. However, it is surprising that emotional eating was not significantly associated with the total consumption of high-calorie sweet snacks. Oliver et al. (2000) found that highly stressed emotional eaters consumed more high-fat, sweet foods compared to unstressed and non-emotional eaters. Likewise, van Strien et al. (2013) used the same video clip from The Champ and found that emotional eaters consumed more sweet food after a sad mood induction compared to those in the joy mood condition. Although the current study did not include both positive and negative mood conditions for comparison, the sample was mostly non-emotional eaters. In van Strien and colleagues’ (2013) study, low-emotional eaters consumed more in the sad mood condition than low-emotional eaters in the joy mood condition, despite the expected reduction in food consumption in response to negative emotions. It is possible that non-
emotional eaters are less reactive to emotion induction procedures, or better at buffering the effects of a sad emotion procedure. In the current sample, though self-reported SAM valence ratings decreased after the movie clip, the ratings decreased from a mean rating of 6.09 \( (SD = 1.03) \) to a mean rating of 4.31 \( (SD = 1.33) \), suggesting that the emotion induction video decreased positive emotions, but only towards the neutral zone. Perhaps one way to avoid this in future studies is to utilize a separate VAS scale for happiness and sadness, as van Strien and colleagues (2013) did in their study.

Finally, the results from Hypothesis 4 suggest that emotional eating was not associated with difficulties with emotion regulation, reflected by higher scores on the DERS and lower levels of baseline high-frequency HRV. According to the Affect Regulation Model, emotional eating is reflective of poor emotion regulation ability (Goossens et al., 2009). However, the current study failed to find support for the model. Barnhart and colleagues (2021) studied the relationships between emotion regulation, emotional eating, and disordered eating, finding that emotion regulation difficulties strengthened the relationship between negative emotional eating and disordered eating, but not positive emotional eating. Based on the findings from Barnhart et al. (2021), difficulties with emotion regulation itself might not explain tendencies to emotionally overeat but rather exacerbate eating disorder symptoms. Exploratory analyses revealed that the EDE-Q-13 was significantly positively correlated with the DERS, suggesting that more clinical representations of disordered eating behaviors may better reflect emotion dysregulation than emotional eating. As Barnhart et al. (2021) pointed out, self-regulation and emotion-regulation skills are different constructs, thus emotional eating might reflect difficulties with self-regulatory behaviors than emotion regulation. However, it is also possible that the null findings were driven
by the amount of missing data on the HF-HRV (10.5%) due to difficulties maintaining a clean
signal for five minutes.

Exploratory analyses of food insecurity and annual family income demonstrated that
annual family income was significantly positively correlated with the consumption of sweet
snacks and high-calorie sweet snacks. According to the National Health and Nutrition
Examination Survey, American adults from middle and high family income groups consumed
more sweet foods compared to those of lower income groups (Sebastian et al., 2020). It is often
perceived that those of lower-income households maintain an unhealthier diet and consume more
fast food than those of higher-income households however, annual family income does not seem
to play a large role in fast-food consumption (Zagorsky & Smith, 2017). It is likely that food
intake patterns observed during a bogus food taste test may not translate to day-to-day
environments however, the current study findings support national sweet food consumption
trends among adults.

**Limitations and Future Directions**

There are several limitations in the present study. To begin, the study sample was
comprised of undergraduate students drawn from a Western, Educated, Industrialized, Rich, and
Democratic (WEIRD) society (Henrich et al., 2010), making it difficult to generalize any
findings or patterns to the larger population. A major limitation may stem from the bogus food
taste test itself. In this study, the taste test was reduced from 10 minutes to five minutes, which
contrasts with what other researchers have done (e.g., Zhang et al., 2018; Kakoschke et al., 2014;
Smith et al., 2018). The taste test duration was reduced to five minutes to reduce the overall
study duration and the probability of eating out of boredom. While five minutes gave the
participants sufficient time to eat and make their ratings, it may not be sufficient in capturing the
different consumption behaviors of emotional eaters and non-emotional eaters. Future studies should maintain the 10-minute bogus taste test to maintain standardization across studies and probe whether participants continued to eat out of boredom during the debriefing. Additionally, “Veggie Straws” was chosen as a low-calorie food option to include in the bogus food taste test. While veggie straws may be perceived as the ‘healthier’ option, it is not in fact a low-calorie snack. However, analyzing the data with and without the participants who consumed veggie straws did not result in any significant differences. While snacks with longer shelf lives are more affordable and easier to store in the lab, it would be beneficial to determine whether the inclusion of fresh fruits and vegetables during the bogus taste test demonstrates more meaningful differences in food choice and food intake.

The present study also used a video clip as a fast and efficient way to induce a negative emotion. While the video clip was successful in inducing a negative emotion, it might not mimic the emotional experiences that lead to eating. Perhaps alternative negative emotion induction methods such as autobiographical recall or ego-threatening stressors have stronger effects on the tendency to eat to regulate emotions. For example, Wallis & Hetherington (2004) found that emotional eaters exposed to ego-threatening stressors showed greater food intake, compared to the control. Oliver and colleagues (2000) also showed that when emotional eaters were stressed with the anticipation of public speaking, they consumed more high-calorie, sweet foods compared to controls. In patients with binge-eating disorder, Wiedemann and colleagues (2018) found that patients tended to emotionally overeat specifically in response to feelings of loneliness. Moving forward, studies looking at emotional eating should utilize an ego-threatening stressor to induce negative emotion, as it might better parallel daily stressors that lead to emotional overeating.
Additionally, this study may have missed other moderators such as perceived stress or self-regulatory behaviors such as sleep. Shen et al. (2020) found that emotional eating mediated the associations between perceived stress and food choice motives. Likewise, Chen et al. (2022) found that sleep quality moderated the relationship between stress and BMI indirectly through emotional eating among females. Furthermore, future research may benefit by looking beyond the endorsement of emotional eating to include alternative maladaptive coping mechanisms such as alcohol or substance use (Nolen-Hoeksema, 2012).

Conclusion

The current study aimed at looking at the relationships between emotional eating and related domains including emotion regulation, attentional biases, eating disorder symptomology, and food consumption, along with sociodemographic characteristics such as gender and BMI. Further, the study explored the utility of the ABM training paradigm on a sample of emotional and non-emotional eaters to determine whether the ABM training could: (a) modify attention away from high-calorie food cues; (b) influence food consumption and food choice, and (c) withstand the effects of a negative emotion induction among emotional eaters. The findings failed to show support for the utility of the ABM training paradigm for any of the conditions listed above. Further, the study failed to find support for the affect regulation model based on the lack of significant results for the associations between emotional eating and difficulties with emotion regulation. Instead, it appeared that the endorsement of greater eating disorder symptoms better captured maladaptive eating behaviors and emotion dysregulation than emotional eating itself suggesting that disordered eating behaviors are more reflective of emotion dysregulation. The results of this study also failed to find support for Macht’s (2008) five-way model that suggests emotional eaters consume more high-fat, sweet foods in response to negative
emotions. Instead, annual family income appeared to relate to the consumption of sweet foods, in line with U.S. survey data, with higher levels of family income associated with greater consumption of sweet foods (Sebastian et al., 2020). Additionally, gender played a significant role in the number of calories consumed during the taste test with males consuming the greatest number of calories. The present study is another study that failed to capture emotional eating within a laboratory setting, despite using a different emotional eating scale and accounting for food preferences. Future studies should experiment with other negative emotion-inducing paradigms, such as ones that are ego-threatening. Additionally, research on maladaptive eating behaviors should include community samples to improve generalizability and gain a better understanding of the influence of factors such as food insecurity on eating.
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Figure 1

Outline of Current Study Procedures
Figure 2

Valence and Arousal Ratings Before and After Emotion Induction, and After Food Intake

Note: SAM = Self-Assessment Manikin. Time 1 = before emotion induction; Time 2 = after emotion induction; Time 3 = after food intake. Valence ratings across time was statistically significant ($p < .001$) but not for arousal ratings. Error bars are represented by 95% confidence intervals.
Figure 3

*Skin Conductance Levels (SCL) Before, During, and After Emotion Inducing Movie Clip*

Note: Time 1 = 30 seconds before movie clip started; Time 2 = 30 seconds during movie clip; Time 3 = 30 seconds after movie clip ended. The number of SCL peaks significantly increased from time 1 to time 3 ($p = .010$). Error bars are represented by 95% confidence intervals.
Figure 4

*Heart Rate (HR) Before, During, and After Emotion Inducing Movie Clip*

Note: Time 1 = 30 seconds before movie clip started; Time 2 = 30 seconds during movie clip; Time 3 = 30 seconds after movie clip ended. Heart rate significantly decreased over time ($p = .033$). Error bars are represented by 95% confidence intervals.
**Figure 5**

*Phase 1 (Pre-training) and Phase 3 (Post-training) Attentional Bias Scores Across Groups*

Note: AT = attentional training, PT = placebo training. Attentional bias scores are calculated by subtracting the mean reaction time (seconds) to the trials in which the probe replaced the high-calorie food stimuli from the mean reaction time (seconds) to the trials in which the probe replaced the low-calorie food stimuli. Positive mean reaction times indicate attentional bias towards low-calorie food cues. Negative mean reaction times would indicate attentional bias towards high-calorie food cues. Error bars are represented by 95% confidence intervals.
Table 1

Sociodemographic Information of Participants (N=153)

<table>
<thead>
<tr>
<th>Variables</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (M, SD)</td>
<td>(19.35, 2.22)</td>
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<tr>
<td>Sex</td>
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<td>83 (54.2%)</td>
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<tr>
<td>Female</td>
<td>70 (45.8%)</td>
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<td>83 (54.2%)</td>
</tr>
<tr>
<td>Woman</td>
<td>70 (45.8%)</td>
</tr>
<tr>
<td>Race/Ethnicity</td>
<td></td>
</tr>
<tr>
<td>White or Caucasian</td>
<td>95 (62.1%)</td>
</tr>
<tr>
<td>Black or African American</td>
<td>15 (9.8%)</td>
</tr>
<tr>
<td>Asian</td>
<td>28 (18.3%)</td>
</tr>
<tr>
<td>Other</td>
<td>15 (9.8%)</td>
</tr>
<tr>
<td>Latinx/Hispanic</td>
<td>25 (16.3%)</td>
</tr>
<tr>
<td>Annual Family Income</td>
<td></td>
</tr>
<tr>
<td>Less than $10,000</td>
<td>9 (6.0%)</td>
</tr>
<tr>
<td>$10,000 - $19,999</td>
<td>7 (4.7%)</td>
</tr>
<tr>
<td>$20,000 - $29,999</td>
<td>10 (6.7%)</td>
</tr>
<tr>
<td>$30,000 - $39,999</td>
<td>11 (7.3%)</td>
</tr>
<tr>
<td>$40,000 - $49,999</td>
<td>9 (6.0%)</td>
</tr>
<tr>
<td>$50,000 - $59,999</td>
<td>15 (10.0%)</td>
</tr>
<tr>
<td>$60,000 - $69,999</td>
<td>14 (9.3%)</td>
</tr>
<tr>
<td>$70,000 - $79,999</td>
<td>7 (4.7%)</td>
</tr>
<tr>
<td>$80,000 - $89,999</td>
<td>10 (6.7%)</td>
</tr>
<tr>
<td>$90,000 - $99,999</td>
<td>8 (5.3%)</td>
</tr>
<tr>
<td>$100,000 - $149,999</td>
<td>32 (21.3%)</td>
</tr>
<tr>
<td>More than $150,000</td>
<td>18 (12.0%)</td>
</tr>
<tr>
<td>Food Insecurity</td>
<td>26 (17.0%)</td>
</tr>
<tr>
<td>Body Mass Index</td>
<td></td>
</tr>
<tr>
<td>Underweight</td>
<td>3 (2%)</td>
</tr>
<tr>
<td>Healthy</td>
<td>80 (52.3%)</td>
</tr>
<tr>
<td>Overweight</td>
<td>45 (29.4%)</td>
</tr>
<tr>
<td>Obese</td>
<td>25 (16.3%)</td>
</tr>
</tbody>
</table>
Table 2

*Means (Standard Deviations) for Baseline Characteristics Across Groups.*

<table>
<thead>
<tr>
<th>Variable</th>
<th>AT</th>
<th>PT</th>
<th>Control</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>19.04 (1.03) n=46</td>
<td>19.84 (3.46) n=51</td>
<td>19.15 (1.18) n=53</td>
<td>p = .149</td>
</tr>
<tr>
<td>Sex</td>
<td>1.40 (.50) n=52</td>
<td>1.51 (.50) n=57</td>
<td>1.47 (.50) n=53</td>
<td>p = .55</td>
</tr>
<tr>
<td>Gender</td>
<td>1.52 (.64) n=52</td>
<td>1.63 (.65) n=57</td>
<td>1.47 (.50) n=53</td>
<td>p = .36</td>
</tr>
<tr>
<td>Hunger</td>
<td>4.23 (2.20) n=46</td>
<td>4.27 (2.10) n=51</td>
<td>4.42 (2.04) n=53</td>
<td>p = .884</td>
</tr>
<tr>
<td>Cravings</td>
<td>3.59 (2.19) n=46</td>
<td>3.64 (2.12) n=49</td>
<td>3.94 (2.47) n=52</td>
<td>p = .698</td>
</tr>
<tr>
<td>Valence</td>
<td>6.28 (.96) n=48</td>
<td>5.97 (1.03) n=52</td>
<td>6.05 (1.09) n=53</td>
<td>p = .274</td>
</tr>
<tr>
<td>Arousal</td>
<td>3.82 (1.64) n=48</td>
<td>4.21 (1.62) n=52</td>
<td>3.75 (1.37) n=52</td>
<td>p = .262</td>
</tr>
<tr>
<td>Total fasting time</td>
<td>5.99 (5.71) n=48</td>
<td>7.39 (5.82) n=52</td>
<td>5.06 (4.94) n=53</td>
<td>p = .096</td>
</tr>
<tr>
<td>Body mass index</td>
<td>24.03 (3.72) n=48</td>
<td>26.97 (6.05) n=52</td>
<td>25.40 (5.81) n=53</td>
<td>p = .025*</td>
</tr>
<tr>
<td>EDE-Q-13</td>
<td>25.23 (10.95) n=48</td>
<td>33.14 (13.14) n=50</td>
<td>33.00 (15.08) n=53</td>
<td>p = .004*</td>
</tr>
</tbody>
</table>

Note: AT=attentional training, PT=placebo training
Table 3

*Means (Standard Deviations) for Food Consumption in Calories Across Groups*

<table>
<thead>
<tr>
<th>Food intake (calories)</th>
<th>Attentional training</th>
<th>Placebo training</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total food intake</td>
<td>189.72 (96.01)</td>
<td>171.08 (80.36)</td>
<td>165.49 (85.99)</td>
</tr>
<tr>
<td>High-calorie food intake</td>
<td>150.18 (76.87)</td>
<td>132.66 (64.90)</td>
<td>131.02 (74.03)</td>
</tr>
<tr>
<td>Low-calorie food intake</td>
<td>39.54 (34.64)</td>
<td>38.41 (31.68)</td>
<td>34.46 (29.11)</td>
</tr>
<tr>
<td>Sweet food intake</td>
<td>132.04 (78.68)</td>
<td>113.60 (67.64)</td>
<td>109.17 (60.40)</td>
</tr>
<tr>
<td>Salty food intake</td>
<td>57.69 (38.56)</td>
<td>57.48 (40.69)</td>
<td>56.32 (45.08)</td>
</tr>
<tr>
<td>High-calorie sweet food intake</td>
<td>104.25 (61.66)</td>
<td>89.33 (53.03)</td>
<td>89.36 (53.08)</td>
</tr>
</tbody>
</table>

Note: Means and standard deviations are reported from the original, untransformed, variables.
Table 4

Correlations Between Variables for Exploratory Analyses

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>1.</th>
<th>2.</th>
<th>3.</th>
<th>4.</th>
<th>5.</th>
<th>6.</th>
<th>7.</th>
<th>8.</th>
<th>9.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. SEES</td>
<td>153</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. EDE-Q-13</td>
<td>151</td>
<td>.054</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Restraint</td>
<td>153</td>
<td>-.080</td>
<td>.739**</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. BMI</td>
<td>153</td>
<td>-.056</td>
<td>.409**</td>
<td>.270**</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Food Insecurity</td>
<td>153</td>
<td>.033</td>
<td>.360**</td>
<td>.303**</td>
<td>.072</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Annual Family Income</td>
<td>150</td>
<td>.165*</td>
<td>-.125</td>
<td>-.158</td>
<td>-.084</td>
<td>-.255**</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. High-Calorie Sweet Intake</td>
<td>153</td>
<td>.015</td>
<td>-.030</td>
<td>-.014</td>
<td>.032</td>
<td>-.114</td>
<td>.216*</td>
<td>--</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. DERS</td>
<td>152</td>
<td>.063</td>
<td>.288**</td>
<td>.108</td>
<td>.068</td>
<td>.121</td>
<td>-.182*</td>
<td>-.005</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>9. SDM (negative)</td>
<td>153</td>
<td>-.134</td>
<td>.062</td>
<td>.158</td>
<td>.017</td>
<td>.058</td>
<td>-.093</td>
<td>-.076</td>
<td>-.123</td>
<td>--</td>
</tr>
</tbody>
</table>

Note: * = Correlation is significant at the 0.05 level; ** = Correlation is significant at the 0.01 level. SEES = Salzburg Emotional Eating Scale; EDE-Q-13 = Eating Disorder Examination Questionnaire-13; Restraint = restraint subscale of EDE-Q-13; BMI = body mass index; Food Insecurity = coded as 0 not experiencing food insecurity and 1 experiencing food insecurity; Annual Family Income = ranges from 1-12; DERS = Difficulties with Emotion Regulation; SDM (negative) = understate ment of negative qualities subscale of the Social Desirability Measure.
Appendix A

Sociodemographic Questionnaire

What is your age in years?

What sex were you assigned at birth, on your original birth certificate?

   Male

   Female

To which gender do you identify the most?

   Male

   Female

   Non-binary/third gender

   Prefer not to say

   Prefer to self-describe:

Please specify your ethnicity

   White

   Black or African American

   American Indian or Alaska Native

   Asian

   Native Hawaiian or Pacific Islander
Other

Do you identify as Hispanic/Latinx?

No

Yes

Please indicate your household income.

Less than $10,000
$10,000 - $19,999
$20,000 - $29,999
$30,000 - $39,999
$40,000 - $49,999
$50,000 - $59,999
$60,000 - $69,999
$70,000 - $79,999
$80,000 - $89,999
$90,000 - $99,999
$100,000 - $149,999
More than $150,000

Food Insecurity: For each statement, please indicate whether the statement is: often true, sometimes true, or never true for your household in the last 12 months.

I was worried whether our food would run out before we got money to buy more.

Often true     Sometimes true     Never true

The food we bought just didn't last, and we didn't have money to get more.

Often true     Sometimes true     Never true
Appendix B

Examples of high- and low-calorie pictorial food stimuli pairs. Images were matched by size and color. Numbers correspond with image file names from the Food-Pics Extended Database (Blechert et al., 2019).
Appendix C

Diagram of the dot-probe task procedure.

Participants are first presented with a fixation cross for 500ms and asked to focus on the cross.

Next, a stimulus pair will be presented for 500ms.

The letter "E" or "F" will appear on either side of the screen. The participant must respond as quickly as possible, using a response pad, indicating which letter appeared.

A new trial begins with a fixation cross.