EMOTIONAL EATING AND HEART RATE VARIABILITY: TESTING THE AFFECT REGULATION MODEL

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ABSTRACT

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Emotional eating, or overeating in response to a mood state, is related to various negative physical and mental health outcomes, including obesity and Binge Eating Disorder (BED). According to the affect regulation model of emotional eating, emotional eating behavior is conceptualized as a maladaptive strategy to regulate affect. However, inconsistent concurrent and discriminative validity of emotional eating self-report measures found in experimental and naturalistic studies call the affect regulation model into question. Psychophysiological measures shown to behaviorally indicate emotion dysregulation, such as trait level Heart Rate Variability (HRV), might confirm a decreased ability to regulate affect is related to emotional eating behavior. A secondary analysis of data from an experimental study of emotional eating examined relationships between different measures of emotion dysregulation and emotional eating. To validate the affect regulation model of emotional eating, lower trait levels of HRV were expected to be associated with higher scores on the Difficulties in Emotion Regulation Scale (DERS), higher food intake following a negative mood induction, and higher scores on the Emotional Eating Scale (EES). Hierarchical linear regression models did not find these relationships to be significant, though both trait level HRV and self-reported emotion dysregulation were associated with changes in the Positive and Negative Affect scale (PANAS). Results of the current study showed trait level HRV and the DERS subscales to be good indicators of an emotional response to the mood induction. Although it remains unclear whether affect regulation is truly central to emotional eating behavior, obstacles to resolving this question are revealed and discussed.

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INTRODUCTION

Emotional eating is a pattern of eating in response to negative and positive mood states and is associated with an increased risk of overweight and obesity (Péneau, Ménard, Méjean, Bellisle, & Hercberg, 2013) and difficulty losing weight (Koenders & van Strien, 2011). Approximately half of the general population (45%) and slightly more overweight and obese individuals (57.3%) identify as emotional eaters (Péneau et al., 2013). In addition to the negative impact on physical health, emotional eating is related to adverse psychological consequences, such as the presence and severity of binge episodes (Ricca et al., 2009), other disordered eating symptoms (Waller & Osman, 1998) and depression (Etkin, Bowker, & Scalco, 2016). Theories of emotional eating incorporate behavioral principles of reinforcement with conceptualizations of maladaptive strategies employed to regulate affect as precipitating factors of emotional eating. Emotional eaters report low distress tolerance (Kozak & Fought, 2011), increased reward sensitivity (Loxton & Tipman, 2016), poor coping expectancy, and the belief that eating can improve negative mood (Spence & Courbasson, 2012). Despite these correlates, self-report measures of emotional eating fail to consistently predict this eating behavior (Bongers & Jansen, 2016) or to differentiate it from overeating in general (Bongers, de Graaff, & Jansen, 2016). The challenges of identifying emotional eating raise the important question of whether emotion dysregulation is truly involved in this eating behavior pattern. The current study proposes to examine a measure of trait level Heart Rate Variability in addition to self-reported emotion dysregulation, to further understand the role of affect regulation in emotional eating.

Theories of Emotional Eating

Behavioral models. Emotional eating may be a learned behavior (Wing, Blair, Epstein, & McDermott, 1990). Classical conditioning explains how negative mood can increase the desire to eat, and eating is positively reinforced following the pleasurable experience of eating palatable food resulting in decreased negative mood (Booth, 1994; Wardle, 1990). After repeatedly pairing emotions with food consumption (unconditioned stimuli), emotions (conditioned stimuli) elicit increased salivation and gastric processes to prepare for ingestion and digestion (Jansen, Havermans, & Nederkoorn, 2011). Results from two experimental studies have supported behavioral models of emotional eating. For example, compared to drinking water and eating non-palatable chocolate, palatable chocolate consumption resulted in a greater improvement in mood (Macht & Mueller, 2007). Furthermore, mood improvement was greatest among emotional eaters (Macht & Mueller, 2007).

Affect regulation. Affect regulation models have also been used to explain emotional eating (Wiser & Telch, 1999). According to Heatherton and Baumeister (1991) overeating and the pleasure experienced from eating is an attempt to distract oneself from aversive self-awareness. In addition to the desire to escape a negative mood state, affect regulation models emphasize that emotional eating may not be directly caused by the presence of negative emotions, but by a lack of adaptive emotion regulation strategies. Laboratory studies have provided support for the role of affect regulation in emotional eating. For example, Additionally, experimentally manipulated emotion dysregulation (i.e., emotional suppression) predicted greater food intake, when compared to adaptive emotion regulation (i.e., emotional expression and reappraisal) (Evers, Marijn Stok, & de Ridder, 2010). Support for affect regulation models has also been demonstrated in cross-sectional studies. In women, low attention to emotion predicted self-reported emotional eating and a greater caloric intake compared to high attention to emotion (Moon & Berenbaum, 2009) and emotion regulation difficulties were independently associated with more frequent emotional eating among treatment seeking obese patients (Gianini, White, & Masheb, 2013). Furthermore, emotion-oriented coping and avoidance distraction were more closely related to emotional eating than a negative mood state alone (Spoor, Bekker, Van Strien, & van Heck, 2007). These findings suggest that emotional eating is not simply a behavioral response to negative mood, but rather a maladaptive strategy to cope with a negative emotional experience.

Self-report Assessment of Emotional Eating

The Dutch Eating Behavior Questionnaire (DEBQ; Van Strien et al., 1986), the Emotional Eating Scale (EES; Arnow et al., 1995), and the Three Factor Eating Questionnaire (Stunkard & Messick, 1985) are the three most commonly cited measures used to assess emotional eating (Frayn & Knäuper, 2017). In obese and non-obese sub-samples of men and women, the emotional eating subscale of the DEBQ (DEBQ-E) has shown strong reliability, internal consistency, and factorial validity (Van Strien et al., 1986). The two DEBQ-E subscales measure emotional eating in response to either specifically labeled emotions (e.g., "Do you have the desire to eat when you are feeling frightened?") or diffuse mood states (e.g., "Do you have a desire to eat when somebody lets you down?"), each of these dimensions showing strong reliability in multiple samples (Van Strien et al., 1986).

Unlike the DEBQ-E, The EES allows researchers to demonstrate relationships between specific negative mood states and the intensity of one's desire to eat. The EES does this by having participants to rate their desire to eat (ranging from no desire to an overwhelming urge) after experiencing a specific negative mood state (Arnow et al., 1995). Subscales of the EES each represent one specific negative mood state item, such as anger, sadness, or frustration, each showing strong internal consistency (Arnow et al., 1995). Changes in EES subscales correspond to treatment associated changes in reported binge eating among obese clinical samples (Arnow et al., 1995). The EES has also shown adequate construct validity in non-obese samples demonstrating that it can be employed in non-clinical settings (Waller & Osman, 1998).

The original Three Factor Eating Questionnaire (TFEQ) conceptualized emotional eating as a subset of disinhibited eating (i.e., emotional eaters struggle to control their compulsion to eat in response to food cues; Stunkard & Messick, 1985). The revised measure has a 6-item emotional eating subscale derived from the disinhibition factor (Ganley, 1988). This subscale consists of five true or false questions, such as "when I feel anxious I find myself eating" and an additional item asking participants to rate how often they binge eat when not hungry (ranging from never to at least once a week; Ganley, 1988). Despite showing good test-retest reliability, the internal structure of the disinhibition subscale was found to be weak. A second revision of the measure that includes the emotional eating subscale was developed to maximize convergent and discriminant validity (Karlsson, Persson, Sjöström, & Sullivan, 2000). Overall, studies measuring psychometric properties of emotional eating self-report measures show them to be valid in measuring this eating behavior in clinical and non-clinical populations.

Limitations of the affect regulation model. In other words, these self-report measures should both predict food intake during negative mood and differentiate emotional eating from external eating (overeating in response to food cues) and from restraint eating (overeating in response to caloric restriction). However, a series of naturalistic studies found no relationship between self-report of emotional eating and food intake following negative affect (Adriaanse, de Ridder, & Evers, 2011). Although extreme scores rather than continuous scores of the DEBQ-E better predict food intake following negative mood, they do not result in increased discriminative validity between external, restrained, and emotional eating (Jansen et al., 2010). Additionally, high scoring self-reported emotional eaters who ate the most following a sad mood condition, also ate the most in positive mood, food exposure, and control conditions compared to low scoring emotional eaters (Bongers et al., 2016). Furthermore, a moderate-to-strong association was found between emotional and external eating subscales of the DEBQ (Jansen et al., 2010), and both are moderately correlated with emotion dysregulation, EES, and boredom proneness (Crockett, Myhre, & Rokke, 2015). These studies not only show self-report measures to be problematic in identifying emotional eating, but question the notion that overeating is a result of emotion dysregulation or of a more intense experience of negative emotion in emotional eating.

Given all the challenges with self-report measures of emotional eating, incorporating multiple modes of measuring emotion dysregulation might help researchers better understand and identify emotional eating. As one piece of this effort, the current study will examine relationships between emotion dysregulation and emotional eating that are fundamental to supporting the affect regulation model. If emotional eating is a result of emotion dysregulation, then measures of this construct will correlate with self-reported emotional eating and with food intake during negative mood. Rather than measuring emotion dysregulation with self-report alone, the current study will also incorporate a physiological measure of this construct.

Detecting Emotional Responding with Heart Rate Variability

Physiology of HRV. Heart rate variability (HRV), or the variance in beat to beat intervals of heart rate, results from the interplay of the sympathetic and parasympathetic (vagal) outputs of the central autonomic network (CAN) at the sinoatrial node of the heart (Thayer & Lane, 2000). While at rest, the sympathetic and vagal branches of the autonomic nervous system regulate heart rate by influencing the "primary pacemaker of the heart" or the sinoatrial node (Appelhans & Luecken, 2006). The activation of sympathetic fibers produces an excitatory influence on the firing rate of the sinoatrial node and the vagal influences inhibit this process in order to decrease heart rate (Appelhans & Luecken, 2006). Sympathetic and vagal influences on the heart depend upon separate mechanisms that produce different effects at the sinoatrial node. The sympathetic influence depends upon the neurotransmission of norepinephrine, whereas the vagal influence relies on acetylcholine transmission. Of the two, the vagal influence has a more expedient effect on the firing rate at the sinoatrial node (Appelhans & Luecken, 2006). In other words, HRV reflects the autonomic control of heart rate by inhibiting sympathetic activation that is necessary to regulate physiological responses to changing situational demands.

Emotional responding. Because sympathetic and vagal influences determine the physiological responses to emotional experience, indices of HRV can be used to infer emotional experience in response to environmental factors. In the context of emotional responding, HRV is best understood within the neuroviceral integration model. This model conceptualizes the array of behavioral, cognitive, and physiological processes involved in emotion to each be self-organizing components of a broader integrated dynamic system (Thayer & Lane, 2000). Within this framework, the central autonomic network (CAN) directs these components into regulated emotional states (Appelhans & Luecken, 2006). For example, the CAN has been shown to inhibit sympathoexcitatory, allostatic, and inflammatory responses through reciprocal communication among system components, sensitivity to initial conditions of the system, and the presence of multiple pathways, all of which, are elements of a neuroviscerally integrated dynamic system (Appelhans & Luecken, 2006; Thayer & Sternberg, 2006). Because the CAN's ability to inhibit other potential responses is mediated synaptically in the brain and vagally in the periphery, HRV is a proxy for the CAN's ability to manage the timing and magnitude of an emotional reaction (Appelhans & Luecken, 2006). Although it is not a direct measure of mood state or emotional experience, HRV indicates the adaptive functioning of a broader system that governs emotional experience in response to the environment.

Support for HRV as an indicator of emotion regulation. Empirical evidence supports the link between HRV and emotion regulation. (Appelhans & Luecken, 2006; Thayer & Lane, 2009). For example, HRV measures have been associated with limited recovery to mental stressors (Messerli-Bürgy, Engesser, Lemmenmeier, Steptoe, & Laederach-Hofmann, 2010) and are indicative of a stronger reactivity to sadness and insecurity in bulimia nervosa and BED patients compared to healthy controls (Hilbert, Vögele, Tuschen-Caffier, & Hartmann, 2011). Furthermore, lower levels of HRV are related to anxiety, rumination, and difficulties in regulating everyday emotions (Williams et al., 2015), and changes in concomitant cerebral blood flow in areas associated with emotion regulation correspond to higher levels of resting HRV (Lane et al., 2009). Phasic changes in HRV have also shown to be an effective indicator of emotional suppression during a negative mood induction task (Appelhans & Luecken, 2006; Thayer, Ahs, Fredrikson, Sollers, & Wager, 2012). Because emotional eating is considered to result of emotion dysregulation, HRV indices might prove effective in confirming this relationship.

The trait level index of HRV. Although indices of HRV can be used to infer both a trait and state level of emotional responding, the current study will focus on trait HRV. Trait levels of HRV reflect observed changes in heart rate associated with respiratory sinus arrhythmia (RSA) and are measured while at rest. During RSA the vagal influence on heart rate is predominant and maintains this rate well below the intrinsic firing rate of the sinoatrial node (Appelhans & Luecken, 2006). When air is inhaled, the vagal influence on heart rate is gated resulting in increased heart rate; as air is exhaled the vagal influence is reinstated which decreases heart rate.

A higher resting HRV may facilitate more effective emotional regulation through both adaptive and functional top-down and bottom-up cognitive modulation of emotional stimuli, where lower resting HRV is associated with hypervigilant and maladaptive cognitive responses that may impede emotion regulation (Park & Thayer, 2014). For example, individuals with higher HRV levels show a better ability to recover from and make context appropriate responses to stressors (Thayer et al., 2012). Lower levels are associated with instability of positive affect (Koval et al., 2013) and greater difficulties in regulating emotions (Williams et al., 2015). Therefore, if emotional eaters truly have a decreased ability to regulate their emotions then they should show lower trait levels of HRV when compared to non-emotional eaters.

The Current Study

The purpose of the current study was to examine relationships between variables of emotion dysregulation and emotional eating that underpin the affect regulation model of emotional eating. The current study used a correlational design drawn from a secondary analysis of data gathered from an experiment on emotional eating. Emotion dysregulation was measured two ways, a validated self-report measure and trait level HRV. Emotional eating was also measured two ways, a self-report measure and food intake immediately following a negative mood induction.

Specifically, this research addressed the following questions pertaining to these relationships:

1. Are difficulties in emotion regulation negatively associated with trait level HRV?
2. Is food intake negatively associated with trait level HRV in the negative mood condition?
3. Is emotional eating negatively associated with trait level HRV?

METHOD

Participants and Procedure

The current study was a secondary analysis of The Emotional Eating Lab Study at Bowling Green State University. To the public and to all participants, the study was referred to as The Food Tasting Study. A list of the screening, informed consent, and study procedures in the order they were administered is provided in Appendix A. Eighty-two undergraduate students were recruited to participate in a study measuring the influence of memories on taste perception. Advertisements were delivered through flyers emailed to university students and through Sona, an online recruiting service that grants undergraduate psychology students class credit for participating in research studies. Interested students were emailed to schedule a phone appointment to screen for the following exclusion criteria: past or current heart conditions, significant medical conditions such as diabetes or a thyroid condition, psychotropic medication, currently pregnant or breast feeding, past or current diagnosis of Bulimia Nervosa or Anorexia Nervosa, and food allergies. After meeting eligibility criteria, participants were scheduled for an appointment with a research assistant from the Food Tasting Study and were instructed to not eat or drink any food or beverages other than water for the two hours leading up to their appointment time. Participants were provided with a food palatability form to complete before their appointment where they indicated their top six preferred snack foods (to control for confounds in measuring food intake among varying food preferences). Because emotional eating could be a confabulated reason to explain one's own overeating, participants were told that the study would examine the impact of memories on food preferences.

After informed consent was obtained, each participant was randomized to either negative (n= 42) or neutral mood induction condition (n= 40). Participants then completed a battery of self-report measures of demographic information and emotion dysregulation along with other measures and computer tasks pertaining to the primary study aims.

Next, graduate research assistants recorded participant heart rate during the mood induction procedure using a three-point lead electrocardiogram machine. Research assistants first recorded baseline heart rate where participants were instructed to sit quietly and still for five minutes while they were guided through a five-minute relaxation procedure. After the relaxation procedure, participants in the negative mood condition were asked to recall a recent memory associated with a negative emotion and were given examples of negative emotions to prime this memory. Participants in the neutral mood condition were asked to think of a recent memory of their walk to class. Once the participant indicated that they had the target memory in mind, they were instructed to close their eyes and were verbally guided through the mood induction procedure for five minutes. Participants were then asked to write as vividly as they could about the target memory for five-minutes. In order to measure changes in mood state and control for hunger level, brief rating scales of these variables were administered at the following time points: before baseline, after the relaxation exercise, after the mood induction, and after the writing exercise. Heart rate variability data were collected throughout the mood induction procedure.

Immediately after the mood induction procedure, electrocardiogram leads were disconnected from the participant and the undergraduate research assistant served the participant a tray containing previously weighed bowls of their top six preferred snack foods. The graduate research assistant oriented the participant to the food tasting worksheet where the participant was instructed eat a whole piece of each snack food and to indicate their rating of the overall taste of each snack food to the researcher. The purpose of this instruction was to lead the participant to believe that the researcher was interested in how they rated each snack food and to familiarize the participant with the food tasting activity. The graduate research assistant then instructed the participant to take their time in completing the rest of the form while tasting each food and encouraged them to have as much of the food as they would like. Furthermore, the research assistant casually mentioned that any food they did not eat would be thrown away because it cannot be reused. The participant was then told that the research assistant had to finish up some previous work in the room next door and would return when it was time to move on to the next task.

The participant was then left alone with the foods and taste test rating form for ten minutes. Immediately after the ten-minute food exposure, both research assistants returned to the room to remove the food tray and to orient the participant to the computer to complete the second survey. The second survey included self-reported emotional eating measures along with various other measures pertaining to the larger study. Self-reported measures of emotional eating and emotion dysregulation were administered after the bogus taste test and mood induction procedures in order to minimize retrospective bias or knowledge of the purpose of the current study. After the survey was completed, participant height and weight was measured in inches and kilograms respectively. At the end of the lab appointment, participants were thanked for their participation and provided with either class credit or a $10 gift card to Amazon.com.

Measures

All survey measures were administered using Qualtrics, a web-based software used to create, administer, and to collect survey data. Demographic information included age, gender identity, relationship status, education level, and race and ethnicity.

Emotion dysregulation. Emotion dysregulation was measured using the Difficulties in Emotion Regulation Scale as demonstrated in Appendix B (DERS; Gratz & Roemer, 2004). The DERS contains a total of 36 items where the participant indicates one of five options: “almost never”, “sometimes”, “about half the time”, “most of the time”, and “almost always”. The DERS contains subscales corresponding to six dimensions of emotion dysregulation, such as non-acceptance of emotional responses, difficulty in engaging in goal-directed behavior, impulse control difficulties, lack of emotional awareness, limited access to emotion regulation strategies, and lack of emotional clarity. Psychometric properties of the DERS report high internal consistency for the total mean score ($\alpha = .93$) and for each subscale ($\alpha \geq .80$; Gratz & Roemer, 2004). The DERS scales also show adequate construct validity with each subscale showing significant positive associations with experiential avoidance and negative associations with emotional expressivity (Gratz & Roemer, 2004). The DERS has also shown to be independently related to emotional eating and general eating pathology when controlling for negative affect and sex (Gianini et al., 2013). Each of these subscales and the total mean score of the measure will be included in the analyses.

Emotional eating. Self-reported emotional eating was measured using the Emotional Eating Scale as shown in Appendix C. The EES consists of 31 items associated with the following subscales: Anger / frustration, Anxiety, Depression (Arnow et al., 1995). Each item instructs the participant to rate to what extent a word describing a feeling leads them to feel an urge to eat with the following response options: “no desire to eat”, “a small desire to eat”, “a moderate desire to eat”, “a strong desire to eat”, and “an overwhelming urge to eat”. As mentioned earlier the EES and its subscales show strong internal consistency in non-clinical populations ($\alpha \geq .80$; Waller & Osman, 1998). Furthermore, changes in EES subscales are associated with treatment related changes in binge eating episodes in clinical populations (Arnow et al., 1995). In the general population the EES and its subscales are significantly related to increased weight and bulimic attitudes (Waller & Osman, 1998).

Food intake. Food intake was measured as the total calories eaten for all snack foods consumed during the food exposure task. During this task participant were provided with bowls containing their previously indicated top six snack foods and asked to try a single whole piece of each food before the food exposure. Calories consumed was calculated using nutritional information provided by the snack food packaging and the difference of pre and post weight for each snack food during. The total grams consumed for each snack food was then adjusted to account for the single piece of each snack food eaten that participants were asked to eat when oriented to the bogus taste test. The adjusted total calories eaten for each participant was calculated as the sum of the adjusted calories consumed of each snack food during the 10-minute food exposure.

Heart rate variability. The electrocardiogram (ECG) data used to infer heart rate variability (HRV) indexes were collected with the Biopac (MP160) using three leads on the torso. ECG data from the Biopac device was processed and collected with Acknowledge software (Version 5.0; Biopac Systems, 2011). ECG data, including the time point markers indicating the different stages of the mood induction procedure, were analyzed using Kubios HRV software package to record HRV indexes for each time point (version 3.0; Tarvainen, Niskanen, Lipponen, Ranta-aho, & Karjalainen, 2014). With this software, ECG data were cleaned to remove artifacts, such as irregular heart beat activity that might interfere with the software's ability to identify distances and times between R-waves from the ECG data. The time points indicating baseline, relaxation, mood induction, and writing mood induction are then imputed into the software where the following HRV indexes are then calculated for each time point. Kubios software then calculates HRV indexes used to infer emotion regulation and emotional responding for each of the designated time points. The root mean square of successive differences of R-R intervals in milliseconds (RMSSD) recorded during the relaxation exercise was chosen over the baseline recording because it best followed the procedures for measuring vagal tone, such as sitting still with eyes closed and with knees bent at a ninety degree angle (Laborde, Mosley, & Thayer, 2017). The natural log of this RMSSD index was then transformed in order to adjust for unequal variance, as suggested by Laborde, Mosely, and Thayer (2017).

Mood state and hunger level. In order to control for possible confounding variables in food intake, mood state, and hunger level were also assessed. Mood state was assessed throughout the mood induction procedure on paper with the Positive and Negative Affect Scale (PANAS; Watson, Clark, & Tellegen, 1988). The PANAS is a 20 item self-report measure that contains two subscales measuring positive and negative mood state. Each item presents a word indicating a mood state such as “interested” or “nervous” and participants rate to what extent they feel this way at the present moment: “slightly or not at all”, “a little”, “moderately”, “quite a bit”, and “extremely”. Hunger was measured directly after the PANAS using a visual analog scale. Participant indicated their current hunger by marking a line that showed a range of “not hungry” to “extremely hungry” at either ends. The Negative affect scale of the PANAS and the hunger rating score, both taken immediately before the food exposure were used for all subsequent analyses. Examples of the PANAS and hunger rating scale used in the current study can be found in Appendix D.

Body mass index. Body mass index (BMI) was calculated using the height and weight of each participant with the BMI calculator on the National Center of Disease Control’s website.

Height in inches were measured using a stadiometer which was later converted to meters. Participant weight was measured in kilograms using the TANITA scale.

Data Analysis

Descriptive statistics were calculated for demographic and key study variables of the entire study sample. Bivariate correlations were conducted between key study variables and relevant demographic variables to identify potential covariates relevant to the following models. Inferential statistics addressed the three research questions by examining the following analyses for significant parameters using multiple regression models. Questions 1 and 3 were tested using the entire sample, and question 2 was tested using only the subsample in the negative mood condition.

1. Are difficulties in emotion regulation negatively associated with trait level HRV?

   Multiple linear regression models were constructed to test for a significant negative association between self-reported emotion dysregulation and trait level HRV. In separate regressions, the DERS mean score and subscale scores were regressed on the RMSSD HRV index measured during the baseline relaxation exercise. No covariates were anticipated to influence the relationship between emotion dysregulation variables and trait level HRV. However, important covariates (e.g., demographic variables) that did emerge during the preliminary analyses, were entered into the regression model first.

2. Is trait level HRV negatively associated with food intake following negative mood induction?

   Using only the subsample in the negative mood condition ($n = 42$), a hierarchical multiple linear regression model was constructed to test for a significant negative association between adjusted total calories eaten and trait level HRV. Anticipated covariates such as gender, hunger rating, negative affect, and other potential covariates indicated by significant bivariate correlations were included in this model, regressing adjusted total calories eaten on the RMSSD HRV index. The first step of this model regressed demographic variables, the second step included hunger rating, BMI, and negative affect, and the third step included the RMSSD HRV index.

3. Are Emotional Eating Scales negatively associated with trait level HRV?

A hierarchical multiple linear regression model was constructed to test for significant negative associations between self-reported emotional eating and trait level HRV. This model regressed the EES subscales and total score on the RMSSD HRV index measured during the relaxation exercise. The first step of this model included demographic covariates indicated by significant bivariate correlations, the second step included hunger rating, BMI, and negative affect, and the third step included EES subscale and total scores.

RESULTS

Participant Characteristics

A majority of participants were female (*n*=63, 76.8%) and Caucasian (*n*=48, 58.5%). On average they were around 20 years of age (*M*= 20.39, *SD*= 2.997) and were marginally overweight according to BMI (*M*= 26.64, *SD*=6.77). Demographic information for the study sample is listed in Table 1 of Appendix E.

Preliminary Analyses

Chi-square and independent samples T-tests were conducted to test for significant differences in key study variables by demographic variables and mood condition. Race was dichotomized to Caucasian or not Caucasian and relationship status was dichotomized as in a relationship or not in a relationship. Chi-square analyses indicated that there were more Caucasian participants in the negative mood condition $\chi^2(1, N = 78) = 4.94$, $p = .026$, and no difference in relationship status by mood condition. Independent samples T-tests indicated no difference in emotional eating subscales by mood condition, gender, or whether participants identified as Caucasian. Independent samples T-tests indicated no significant differences in DERS subscale scores, trait level HRV, or food intake between negative and neutral mood conditions. No significant difference was found between males and females or between those identifying a Caucasian or not Caucasian in food intake. The DERS Goals subscale scores were higher among participants identifying as Caucasian $t(76) = 2.109$, $p = .031$, but no other differences in DERS subscales, EES scales, or trait level HRV between those identifying as Caucasian or not Caucasian. Descriptive statistics of key study variables by mood condition, such as trait level HRV, emotional eating, emotion dysregulation are listed in Table 2-5 of Appendix E.

Repeated measures ANOVAs were conducted to test for changes in the RMSSD HRV index, negative affect rating, and hunger ratings, by mood induction condition and sampling time point, such as during baseline, relaxation, mood induction, and writing portion of the mood induction procedure. Significant changes in the RMSSD index were observed by time point collected, $F(3,77) = 12.104$, $p < .0001$, but no significant interaction was found between time point of RMSSD index collected and mood condition. Changes in negative affect were significant by time point collected, $F(3,65) = 18.943$, $p < .0001$, and these changes resulted in a significant interaction between time point collected and mood condition, $F(3,65) = 12.793$, $p < .0001$. No significant differences in hunger ratings were found by time point collected and no interaction was found between the time point hunger ratings were collected or by mood condition.

Bivariate correlations among continuous demographic and key study variables were used to test for covariates to include in the regression models for the primary analyses. BMI showed a significant negative correlation with the DERS Goals subscale, $r(81)= -.28$, $p = .01$, and the DERS total score, $r(81)$ -.23, $p = .04$. Age was not significantly related to any key study variables. Hunger rating showed a significant negative correlation with the DERS Non-Acceptance of Emotions subscale, $r(79)$ -.24, $p = .03$, and positive correlations with Anger / Frustration, $r(79)$ .23, $p = .03$, and Anxiety subscale of the EES, $r(79)$ .25, $p = .03$. Change in positive affect was positively related to the DERS Non-Acceptance of Emotions subscale, $r(81)$ .39, $p < .01$, and change in negative affect was positively associated with the DERS Impulse control subscale, $r(74)$ .34, $p < .01$, the DERS Awareness of Emotions subscale, $r(74)$ .23, $p = .05$, the DERS Total score, $r(74)$ .26, $p = .02$. Change in negative affect was also negatively associated with trait level HRV, $r(73)$ -.26, $p = .02$.

Primary Analyses

Emotion dysregulation and HRV. A hierarchical multiple linear regression model was constructed to test for a negative association between emotion dysregulation and trait level heart rate variability (HRV). Separate models were used to regress each DERS subscale on trait level HRV. The first step of each of the regression models included variables that were significantly correlated with any DERS subscale or with trait level HRV. The first step of the model regressed gender, race, and BMI on trait level HRV, the second step included change in positive affect and change in negative affect, and the third step entered a single DERS subscale. None of the regression models in any step or with any DERS subscale was significant in predicting trait level HRV. However, change in negative affect remained a significant predictor of trait level HRV in the second and third step of all DERS regression models, $b = -.13$, $t(58) = -2.4$, $p < .05$. A summary table of these regression models are found in Table 6 of Appendix E.

Food intake and HRV. A hierarchical multiple linear regression model was constructed to test for a negative association between food intake and trait level HRV for participants in the negative mood condition. The first step of this model regressed gender, BMI, and race on food intake in the negative mood condition. The second step included hunger rating, change in positive affect, and change in negative affect. The third step included trait level HRV. The second step, $F(6,35) = 2.72$, $p < .05$, explaining 23% of the variance, and the third step, $F(7,35) = 2.4$, $p < .05$, explaining 22% of the variance, each significantly predicted food intake in the negative mood condition. In the second step of the model, race, $b = -.51$, $t(29) = -3.19$, $p < .01$, and hunger rating, $b = .43$, $t(29) = -2.7$, $p < .01$, were the only significant predictors of food intake. However, trait level HRV was not a significant predictor of food intake in these models. A summary of this regression model can be found in Table 7 of Appendix E.

Emotional eating and HRV. Hierarchical multiple linear regression models were constructed to test for a negative association between separate Emotional Eating subscales and trait level HRV for the entire study sample. Gender, race, and BMI were regressed on trait level HRV in the first step of the model. The second step included positive affect and change in negative affect with the same variables from the first step. The third step of the model included a single EES subscale included with all variables from the second step. Separate regression models were constructed for each EES subscale, all including the same covariates as previously mentioned. None of these models were significant in predicting trait level HRV. A Summary of the results of these regression models can be found in Table 8 of Appendix E.

DISCUSSION

The desire to escape a negative mood state and an overall difficulty with regulating negative emotions are thought to result in emotional eating in some individuals. The current study used a cross-sectional design to test for associations between emotional eating and emotion dysregulation that would be predicted by the affect regulation model of emotional eating. Emotional eating was measured behaviorally as food intake following a negative mood induction condition and by self-report with the Emotional Eating Scale (EES). Emotion dysregulation was measured by self-report with the Difficulties in Emotion Regulation Scale (DERS) and physiologically with trait level heart rate variability (HRV). Three relationships between these variables were hypothesized to occur in order to support the affect regulation model of emotional eating. Specifically, lower trait levels of HRV were expected to be associated with higher levels of self-reported emotion dysregulation, higher food intake following a negative mood induction, and higher self-reports of emotional eating. Hierarchical linear regression models did not find any of these relationships to be significant, and therefore could not confirm that trait level HRV was related to emotional eating or emotion dysregulation. On the other hand, both trait level HRV and self-reported emotion dysregulation were associated with change in positive or negative affect ratings following the mood manipulation in this study.

Emotional Responding and HRV

These results support an association between self-perceived difficulties in emotion regulation and less stable affect after recalling a negative memory. Increases in negative affect ratings from before to after the mood induction procedure were related to higher scores in DERS scales, such as difficulty with overall emotion regulation, awareness of emotions, and impulse control. In parallel, decreases in positive affect were significantly related to non-acceptance of emotions. Both of these findings are consistent with research showing difficulties in emotion regulation are related to both reduced positive affect and greater negative affect (Saritaş-Atalar, Genc¸Öz, & Özen, 2015) and confirms affect lability to be characteristic to emotion dysregulation.

Inconsistent with Williams et al. (2015), lower trait level HRV did not relate to difficulties in emotion regulation. However, individuals with lower trait level HRV did show greater increases in negative affect, supporting the notion that HRV is indicative of negative affective instability (Koval et al., 2013) and is related to regulated emotional responding (Appelhans & Luecken, 2006). A lower trait level HRV has been shown to be related to hypervigilance and increased cognitive responses to negative emotional stimuli, processes thought to be detrimental to emotion regulation (Park & Thayer, 2014). Therefore, low levels of trait HRV and higher DERS scores in the study sample could reflect subthreshold levels or factors of emotion dysregulation. On the other hand, the low levels of trait HRV could be a result of trait anxiety. Compared to healthy controls, low trait level HRV is characteristic of patients across a variety of clinically diagnosed anxiety disorders (Pittig, Arch, Lam, & Craske, 2013). Because low trait level HRV could also be a result of anxiety, stress, or poor physical health (Thayer et al., 2012) this measure might not always show associations with perceived difficulties with emotion regulation in the general population. Although it remains unclear whether a low trait level HRV is characteristic of difficulties with emotion regulation, both of these measures appear to be good indicators of affective instability and psychological distress.

Emotional Eating and Affect Regulation

On a broader level, this study failed to confirm the role affect regulation plays in emotional eating, suggesting that it might be worthwhile to reconsider or refine the understanding of this eating behavior. Trait eating behaviors such as emotional eating, restrained eating, and disinhibited eating have shown to be significant moderators of food intake following negative affect (Fay & Finlayson, 2011) and the EES has predicted greater food intake following a negative mood induction compared to a neutral mood induction (Schneider et al., 2012). However, emotional eating self-report measures have not consistently predicted emotional eating behavior. For example, Adriaanse et al. (2011) found that emotional eating measures did not predict snack consumption, but rather snack consumption was related to unhealthy snacking and restraint eating. Emotional eating scores were also associated with self-regulatory skills, monitoring of food habits, perceived control, and past snacking behavior (Adriaanse et al. 2011). When comparing food intake following a negative mood induction, neutral mood induction, or puzzle activity, self-reported emotional eaters ate more in all of these conditions compared to non-emotional eaters (Bongers et al., 2016). This finding shows that self-reported emotional eaters tend to eat more than non-emotional eaters regardless of whether they were experiencing a change in mood immediately before. Furthermore, emotional eaters randomized to a condition where they were told they overate during a food exposure retrospectively rated their mood to be more negative compared to those who were told they ate a normal amount despite controlling for affect ratings following the mood induction (Adriaanse, Prinsen, de Witt Huberts, de Ridder, & Evers, 2016). These studies clearly show that emotional eating self-report measures indicate a tendency to overeat, the belief that this overeating is caused by negative emotions, and distress about overeating. Although the EES scale has been shown to be related to self-reported difficulties in emotion dysregulation (Crockett et al., 2015), the current study did not find HRV to be related the EES or to food intake following the negative mood induction. Rather than using eating to escape or avoid a negative mood state, high scores on emotional eating self-report measures might better indicate distress about overeating and the tendency to attribute this to the experience of negative emotions.

Study Strengths and Limitations

This study has several strengths that allow us a degree of confidence that the lack of relationships between HRV and emotional eating and emotion dysregulation measures were not due to confounds related to study measures, sampling error, or study procedures used to induce mood or measure food intake. Procedures used to induce negative mood, measure food intake, and control for food palatability were modeled after studies which found EES subscales to predict food intake following negative mood (Schneider et al., 2012). Consistent with this, negative affect ratings indicated that the negative mood condition did induce a mild negative mood state compared to the neutral mood condition, which should have been sufficient to result in emotional eating. As expected, hunger ratings before the food exposure did predict food intake in the study sample, and for this reason, it was controlled for in the main analyses. Additionally, the mean and standard deviations of EES subscale scores were similar to Schneider et al. (2012) and trait level HRV and DERS subscale scores were similar to Williams et al. (2015) and all of these measures appeared to be normally distributed. Therefore, it can be assumed that scores from these measures are generalizable. In other words, there are several indications that the study sample, measures, and protocol were effective and consistent with other research in this area.

Nonetheless, limitations of the current study might account for the lack of significant relationships between emotional eating and trait level HRV. Based on power analyses, the current study had a sufficient sample size to detect a medium or large effect with trait level HRV (Quintana, Alvares, & Heathers, 2016). However, a sample size of 233 would be necessary to detect a small effect. It is possible that the relationship between trait level HRV and emotion dysregulation and emotional eating is small and could have been detected with a larger sample size. Furthermore, as previously mentioned, trait level HRV could be influenced by a variety of factors, anxiety, stress, and poor health. Consistent with both of these ideas, Williams et al. (2015) demonstrated small effects of trait level HRV and the Total score, Impulse Control, and Clarity scales of the DERS with a sample of 183 college students while controlling for rumination and trait anxiety. Finally, the current study followed the majority of the latest recommendations for reliably collecting and analyzing trait level HRV (Laborde et al., 2017). However, because these data were collected before the publication of those recommendations, some were not followed, such as screening participants for alcohol use, smoking, oral contraceptive use, waist to hip ratio, and caffeine intake (Laborde et al., 2017). It is possible that employing a larger sample size, controlling for additional covariates like anxiety and rumination, and screening out participants based on smoking, alcohol use, and other confounds in measuring HRV could have impacted the results.

Implications for Future Research

To our knowledge, only one study has found a relationship between the DERS and trait level HRV (Williams et al., 2015). Both of these measures appear to capture aspects of emotion dysregulation, such as affective lability and psychological distress. However, trait levels of HRV could be a reflection of not only emotion dysregulation, but also difficulties with regulating adaptive cognitive and physiological processes in response to the environment (Thayer et al., 2012). A recent literature review of 135 studies comparing emotion regulation and HRV show mixed results of whether these constructs are related, and these studies were found to have considerable variation in methods used to measure these constructs (Balzarotti, Biassoni, Colombo, & Ciceri, 2017). Therefore, measures of HRV cannot be assumed to be reliable indicators of emotion dysregulation. Future research should focus on establishing behavioral or physiological indicators of emotion dysregulation as a criterion for self-reported emotion dysregulation. Additionally, the role HRV measures can play in indicating emotion dysregulation in research should be clarified in reference to the intensity and valence of the experienced mood. Mood induction procedures that induce positive, negative, and neutral moods to varying intensities while measuring trait level HRV, self-reported mood state, and behaviorally observed changes in affect might shed light on the extent to which HRV is indicative of affect regulation. These procedures could also potentially be used as criteria in validating self-reported emotion dysregulation measures.

Additionally, the ability to express emotion, rather than emotion dysregulation might be a more relevant underpinning of emotional eating behavior. As discussed earlier, experimental conditions requiring the suppression, rather than expression or reappraisal of an experimentally elicited negative emotion resulted in greater food intake (Evers et al., 2010). A similar effect of suppression on food intake following mood induction was also found in a similar experiment conducted on binge eating disorder subjects (Dingemans, Martijn, Jansen, & van Furth, 2009). Alexithymia, or the inability to identify or describe one’s emotions might be an important risk factor for emotional eating to develop into BED. Alexithymia has been shown to predict emotional eating in binge eating disorder subjects where perceived stress and depression predicted emotional eating in non-BED subjects (Pinaquy et al., 2003). Therefore, alexithymia coupled with emotional eating might indicate an important distinction between a trait eating behavior and the development of disordered eating. Therefore, future research should work to clarify the relationship between how emotions are experienced and whether this relates to food intake in emotional eating.

CONCLUSION

Results of the current study show the affect regulation model of emotional eating has yet to be fully supported, and illuminate barriers to this endeavor. Primary analyses testing relationships that underpin the affect regulation model of emotional eating were not significant. Neither change in affect or trait level HRV were related to food intake following the negative mood induction. This result points to the need to clarify whether self-identified emotional eating better reflects distress about overeating rather than overeating specific to experiencing negative emotions. Individuals in our society face tremendous challenges associated with maintaining healthy eating habits in an environment replete with unhealthy energy-dense foods. Negative emotional experiences continue to be associated with a perceived ability to regulate eating behavior in the face of these circumstances. Given the physical and mental health consequences associated with overeating unhealthy foods, continued research to understand how to conceptualize, and reliably and validly assess, related constructs, such as emotional eating, has the potential to yield enormous benefits for individuals who struggle with undesired overeating.

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APPENDIX A

Order of administration of measures and procedures during the lab session for the current study.

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1. Eligibility Screening
    a. Food palatability rating
2. Informed consent
    a. Randomization to mood condition
3. Computerized measures
    a. Demographic survey
    b. Cognitive tasks
4. Mood induction procedure
    a. First affect and hunger rating
    b. Baseline HRV recording
    c. Relaxation HRV recording
    d. Second affect and hunger rating
    e. Mild negative or neutral mood induction
    f. Third affect and hunger rating
    g. Writing component mood induction HRV recording
    h. Fourth affect and hunger rating
5. Bogus taste test and food exposure
6. Computerized survey
    a. Emotion dysregulation measure
    b. Emotional eating measures
7. BMI measure and debrief

APPENDIX B

Difficulties in Emotion Regulation Scale

Please indicate how often the following statements apply to you by writing the appropriate number from the scale below on the line beside each item:

--1--------------------------	2----------------------	3------------------------	4--------------------	5--
almost never	sometimes	about half the time	most of the time	almost always
(0-10%)	(11-35%)	(36-65%)	(66-90%)	(91-100%)

_______1) I am clear about my feelings.

_______ 2) I pay attention to how I feel.

_______ 3) I experience my emotions as overwhelming and out of control.

_______ 4) I have no idea how I am feeling.

_______ 5) I have difficulty making sense out of my feelings.

_______ 6) I am attentive to my feelings.

_______ 7) I know exactly how I am feeling.

_______ 8) I care about what I am feeling.

_______ 9) I am confused about how I feel.

_______ 10) When I'm upset, I acknowledge my emotions.

_______ 11) When I'm upset, I become angry with myself for feeling that way.

_______ 12) When I'm upset, I become embarrassed for feeling that way.

_______ 13) When I'm upset, I have difficulty getting work done.

_______ 14) When I'm upset, I become out of control.

_______ 15) When I'm upset, I believe that I will remain that way for a long time.

_______ 16) When I'm upset, I believe that I'll end up feeling very depressed.

_______ 17) When I'm upset, I believe that my feelings are valid and important.

_______ 18) When I'm upset, I have difficulty focusing on other things.

_______ 19) When I'm upset, I feel out of control.

_______ 20) When I'm upset, I can still get things done.

_______ 21) When I'm upset, I feel ashamed with myself for feeling that way.

_______ 22) When I'm upset, I know that I can find a way to eventually feel better.

_______ 23) When I'm upset, I feel like I am weak.

_______ 24) When I'm upset, I feel like I can remain in control of my behaviors.

_______ 25) When I'm upset, I feel guilty for feeling that way.

_______ 26) When I'm upset, I have difficulty concentrating.

_______ 27) When I'm upset, I have difficulty controlling my behaviors.

_______ 28) When I'm upset, I believe that there is nothing I can do to make myself feel better.

_______ 29) When I'm upset, I become irritated with myself for feeling that way.

_______ 30) When I'm upset, I start to feel very bad about myself.

_______ 31) When I'm upset, I believe that wallowing in it is all I can do.

_______ 32) When I'm upset, I lose control over my behaviors.

_______ 33) When I'm upset, I have difficulty thinking about anything else.

_______ 34) When I'm upset, I take time to figure out what I'm really feeling.

_______ 35) When I'm upset, it takes me a long time to feel better.

_______ 36) When I'm upset, my emotions feel overwhelming.

APPENDIX C

Emotional Eating Scale

We all respond to different emotions in different ways. Some types of feelings lead people to experience an urge to eat. Please indicate the extent to which the following feelings lead you to feel an urge to eat by checking the appropriate box.

	No Desire to Eat	A Small Desire to Eat	A Moderate Desire to Eat	A Strong Urge to Eat	An Overwhelming Urge to Eat
Resentful					
Discouraged					
Shaky					
Worn Out					
Inadequate					
Excited					
Rebellious					
Blue					
Jittery					
Sad					
Uneasy					
Irritated					
Jealous					
Worried					
Frustrated					
Lonely					
Furious					
On edge					
Confused					
Nervous					
Angry					
Guilty					
Bored					
Helpless					
Upset					

APPENDIX D

Positive and Negative Affect Scale and Hunger Rating Scale

PANAS Instructions: This scale consists of a number of words that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. *Indicate to what extent you feel this way* ***right now****, that is, at* ***the present moment****.*

Use the following scale to record your answers:

1- very slightly or not at all 2- a little 3- moderately 4- quite a bit 5- extremely

	1	2	3	4	5
Interested					
Distressed					
Excited					
Upset					
Strong					
Guilty					
Scared					
Hostile					
Enthusiastic					
Proud					
Irritable					
Alert					
Ashamed					
Inspired					
Nervous					
Determined					
Attentive					
Jittery					
Active					
Afraid					

Hunger Rating

How hungry are you right now? Place a vertical mark on the line below to indicate your hunger.

Not at all Hungry ____ Extremely Hungry

APPENDIX E

Table 1. *Demographic information of study participants.*

	n	Percent
Gender		
Male	19	23.2
Female	63	76.8
Race/ Ethnicity		
Asian	4	4.9
Black	24	29.3
Hispanic	2	2.4
Caucasian	48	58.5
Other	3	3.7
RNS	1	1.2
Relationship		
Single	73	89
Divorced/ separated	1	1.2
Not married living together	5	6.1
RNS	3	3.7
Employment*		
Full time	1	1.2
Part time	38	46.3
Student	55	67.1
Unemployed	6	7.3
Retired	0	0
Homemaker	0	0
RNS	0	0
Education		
HS	17	20.7
Some college	54	65.9
Bachelors	7	8.5
Graduate	4	4.9

*participants check all that apply

Table 2. *RMSSD HRV index measures by mood condition and sampling period.*

	Baseline	**Relaxation**	**Mood induction**	**Writing**
Negative Mood				
Mean	61.54	66.93	63.5	56.16
n	41	41	41	41
SD	33.18	35.78	37.63	29.64
Min	18.55	16.01	16.25	14.41
Max	141.05	156.16	152.18	149.85
Neutral Mood				
Mean	55.23	58.85	54.9	48.59
n	40	40	40	40
SD	33.17	32.2	33.67	32.84
Min	12.51	11.17	13.18	16.92
Max	140.97	137.57	142.14	52.43
Total				
Mean	58.42	62.94	59.26	52.43
n	81	81	81	81
SD	33.12	34.09	35.78	31.3
Min	12.51	11.17	13.18	14.41
Max	141.05	156.16	152.18	162.1

Table 3. *Negative affect ratings by mood condition and sampling time point.*

	Pre-Baseline	Post Relaxation	Post Mood induction	Post Writing	Change*
Negative Mood					
Mean	11.69	11.25	17.25	16.16	4.47
N	32	32	32	32	32
SD	2.07	2.50	6.88	6.81	6.51
Min	10.00	10.00	10.00	10.00	-4.00
Max	19.00	23.00	40.00	36.00	24.00
Neutral Mood					
Mean	12.74	11.26	11.68	11.61	-1.13
N	31	31	31	31	31
Std. Deviation	3.03	2.08	2.93	2.40	2.68
Minimum	10.00	10.00	10.00	10.00	-6.00
Maximum	22.00	21.00	21.00	19.00	8.00
Total					
Mean	12.21	11.26	14.51	13.92	1.71
N	63	63	63	63	63
Std. Deviation	2.54	2.29	4.94	4.64	4.63
Minimum	10.00	10.00	10.00	10.00	-6.00
Maximum	22.00	23.00	40.00	36.00	24.00

*The difference found when subtracting pre-baseline from post-writing negative affect ratings.

Table 4. *DERS subscale scores and total scores by mood condition.*

	Goals	Impulse	Awareness	Strategies	Clarity	Non-Acceptance	Total
Negative Mood							
Mean	14.10	10.88	13.98	14.62	9.88	12.19	63.45
n	42	42	42	42	42	42	42
Std. Deviation	5.40	5.43	4.82	5.57	3.18	5.07	18.09
Minimum	5.00	6.00	6.00	8.00	5.00	6.00	31.00
Maximum	25.00	29.00	24.00	28.00	17.00	25.00	108.00
Neutral Mood							
Mean	13.35	10.80	13.38	15.50	9.90	11.75	62.93
n	40	40	40	40	40	40	40
Std. Deviation	4.60	4.54	3.78	5.92	2.92	4.56	16.80
Minimum	5.00	6.00	6.00	8.00	5.00	6.00	31.00
Maximum	25.00	29.00	22.00	39.00	17.00	24.00	124.00
Entire Sample							
Mean	13.73	10.84	13.68	15.04	9.89	11.98	63.20
n	82	82	82	82	82	82	82
Std. Deviation	5.00	4.99	4.33	5.73	3.03	4.80	17.36
Minimum	5.00	6.00	6.00	8.00	5.00	6.00	31.00
Maximum	25.00	29.00	24.00	39.00	17.00	25.00	124.00

Table 5. *EES subscales scores by mood condition.*

	Anger / Frustration	Anxiety	Depression	Boredom
Negative Mood				
Mean	19.86	18.19	13.31	15.19
n	42	42	42	42
SD	7.76	5.87	4.63	5.24
Minimum	11.00	9.00	5.00	8.00
Maximum	40.00	32.00	21.00	27.00
Neutral Mood				
Mean	19.63	17.40	12.58	13.98
n	40	40	40	40
SD	7.05	5.92	3.22	4.10
Min	11.00	9.00	7.00	6.00
Max	35.00	31.00	22.00	25.00
Total				
Mean	19.74	16.52	12.95	14.60
N	82	82	82	82
SD	7.38	5.87	4.00	4.73
Min	11.00	9.00	5.00	6.00
Max	40.00	32.00	22.00	27.00

Table 6. *Summary of separate hierarchical regression models of individual DERS subscales predicting trait level HRV.*

	Step 1					Step 2					Step 3				
		B	***SE B***	***β***	***t***		***B***	***SE B***	***β***	***t***		***B***	***SE B***	***β***	***t***
Gender[a]		-.02	.07	-.04	-.34		-.13	.16	-.043	-.34		-.12	.16	-.10	-.77
Race[a]		.02	.06	.04	.31		-.03	.14	-.04	.31		-.03	.15	-.03	-.22
BMI[a]		.01	.00	.02	.14		.00	.01	.02	.14		.00	.01	.03	.24
Positive affect change[a]							-.02	.01	-.20	-1.50		-.02	.01	-.19	-1.5
Negative affect change[a]							-.03	.01	-.31	-2.4*		-.03	.01	-.30	-2.40*
DERS Total[b]												.01	.06	.14	.89
DERS Goals[b]												.00	.01	-.03	-.20
DERS Impulse[b]												.00	.01	-.06	-.42
DERS Aware[b]												.00	.02	.04	.28
DERS Strategies[b]												.00	.01	.08	.67
DERS Clarity[b]												.03	.02	.15	1.20
DERS Non-Acceptance[b]												-.01	.02	-.09	-.66
<u>Model</u>															
Adj R^2	-.04					.03					.02				
F	.09					1.47					1.2 1				
N	68					68					68				

**Correlation coefficient or F is significant at the p < .05 level.*
a. Regression coefficients for these variables vary in the third step of each regression model, but significance remains constant.
b. Each DERS subscale was entered into the third step of separate regression models.

Table 7. *Hierarchical regression model of trait level HRV predicting food intake in the negative mood condition.*

	Step 1				Step 2				Step 3			
	B	***SE B***	***β***	***t***	***B***	***SE B***	***β***	***t***	***B***	***SE B***	***β***	***t***
Gender	-42.67	95.67	-.08	-.45	-33.03	90.45	-.06	-.37	-34.57	91.00	-.06	-.38
BMI	-1.50	6.98	-.04	-.22	-4.10	6.52	-.097	-.63	-4.83	6.61	-.11	-.73
Race	-216.95	94.96	-.39	-2.29*	-287.12	90.00	-.51	-3.19**	-294.19	90.94	-.53	-3.24**
Hunger					4.28	1.58	.43	2.71**	3.91	1.66	.40	2.40*
Positive affect change					-81.86	55.66	-.23	-1.47	-7.52	56.57	-.22	-1.33
Negative affect change					-93.01	60.53	-.24	-1.54	-6.95	67.38	-.18	-1.03
Trait level HRV									66.66	81.78	.14	.82
Model												
Adj R^2	.06				.23				.22			
F	1.80				2.72*				2.40*			
N	36				36				36			

**Coefficient or F ratio is significant at the 0.05 level (2-tailed).*
***Coefficient or F ratio is significant at the 0.01 level (2-tailed).*

Table 8. *Summary of separate hierarchical regression models regressing individual EES scales on trait level HRV.*

	Step 1					Step 2					Step 3				
		B	***SE B***	***β***	***t***		***B***	***SE B***	***β***	***t***		***B***	***SE B***	***β***	***t***
Gender[a]		-.06	.16	-.04	-.34		-.13	.16	-.10	-.78		-.13	.16	-.10	-.80
Race[a]		.05	.14	.04	.31		-.03	.14	-.03	-.19		-.03	.14	-.02	-.19
BMI		.00	.01	.02	.14		.00	.01	.04	.30		.00	.01	.03	.24
Positive affect change[a]							-.01	.01	-.20	-1.50		-.02	.01	-.20	-1.54
Negative affect change[a]							-.03	.01	-.31	-2.42*		-.03	.05	-.31	-2.44*
EES Anger / Frustration[b]												.02	.04	.05	.425
EES Anxiety[b]												.00	.01	.00	.02
EES Depression[b]												-.01	.02	-.04	-.34
EES Boredom[b]												-.01	.01	-.08	-.65
Model															
Adj R^2	-.04					.03					.03				
F	.09					1.47					1.29				
N	68					68					68				

**Coefficient or F ratio is significant at the 0.05 level (2-tailed).*
***Coefficient or F ratio is significant at the 0.01 level (2-tailed).*
a. Regression coefficients for these variables vary in the third step of each regression model, but significance remains constant.
b. Each EES subscale variable was entered into the third step of separate regression models.