DIMENSIONAL ANALYSIS OF EMOTIONAL TRAJECTORIES BEFORE AND AFTER DISORDERED EATING BEHAVIORS IN A SAMPLE OF WOMEN WITH BULIMIA NERVOSA

By

KENDRA D. BECKER

(Under the Direction of Joshua D. Miller)

ABSTRACT

Binge eating and purging are typically triggered by increases in negative affect. However, negative affect is a broad term encompassing a variety of negative moods. Furthermore, each mood state consists of three separate dimensions of emotional experience: valence, arousal, and approach/withdrawal. The manner in which these specific dimensions of emotional experience combine to prompt binge eating, purging and combined binge eating and purging is unclear. This study consisted of secondary analyses of a previously collected dataset using ecological momentary assessment in 133 women with bulimia nervosa. In the parent study, participants were asked to rate themselves on their experience of discrete emotions (e.g. happiness, sadness, hostility) and to report episodes of disordered eating behaviors six times a day. In order to examine the effects of the unique dimensional components of emotion on these behaviors, we organized the discrete emotions within the 3-dimensional space characterized by emotional valence, emotional arousal, and approach vs. avoidance motivations. Multilevel modeling was used to examine the trajectories of emotions (organized and grouped according to the three dimensions) prior and subsequent to each behavior. We also examined levels of

emotions between days that included disordered eating behaviors and days that did not. While no differences in linear slopes were observed between emotion groups either before or after behaviors, results indicated that avoidance motivations more strongly prompt disordered eating behaviors than approach motivations. Furthermore, disordered eating behaviors appear to be positively reinforced by return of positive valence irrespective of reductions in arousal levels. Between-day analyses revealed that negatively valenced emotions defined by both high arousal levels and avoidance motivations are the most elevated on days with bulimic events.
INDEX WORDS: bulimia, valence, arousal, avoidance, self-harm, purging, binge eating

DIMENSIONAL ANALYSIS OF EMOTIONAL TRAJECTORIES BEFORE AND AFTER DISORDERED EATING BEHAVIORS IN A SAMPLE OF WOMEN WITH BULIMIA NERVOSA

By

KENDRA D. BECKER

B.A., Purdue University, 2007

M.S., University of Georgia, 2013

A Dissertation Submitted to the Graduate Faculty of The University of Georgia in Partial Fulfillment of the Requirements for the Degree

DOCTOR OF PHILOSOPHY

ATHENS, GEORGIA

2016

DIMENSIONAL ANALYSIS OF EMOTIONAL TRAJECTORIES BEFORE AND AFTER DISORDERED EATING BEHAVIORS IN A SAMPLE OF WOMEN WITH BULIMIA NERVOSA

by

KENDRA D. BECKER

Major Professor: Joshua D. Miller

Committee: Sarah Fischer
Anne Shaffer

Electronic Version Approved:

Suzanne Barbour
Dean of the Graduate School
The University of Georgia
August 2016

## DEDICATION

As is common knowledge, any project is the result of collaboration and extensive support. This dissertation manuscript is no exception. I have been expertly guided by my advisors and continuously encouraged by my loving family, husband, and friends. Specifically, I want to dedicate this manuscript and project to Dr. Sarah Fischer who was instrumental in its design and management from conceptualization to manuscript preparation. I also want to recognize the innumerable contributions of my major professor, Dr. Joshua D. Miller, who's suggestions and advice ensured the success of this project. Further, this study would have been impossible without Dr. Ross Crosby, who graciously provided his time and expertise concerning statistical management of EMA data. He shared not only his time and knowledge, but also his love of statistics and research, making this project fun. My colleges and lab mates have helpfully discussed ideas and, thankfully, edited the many versions of this manuscript. In addition to scholastic support and assistance, I am grateful for the many wonderful friends and family members that have verbally encouraged me along this process and made it easier for me tackle this challenge. Thus, I would also like to dedicate this work to my parents, who always answer my anxious late-night phone calls with reassurance, and my husband, who's care and support have given me the fortitude to complete this study and this degree.

## TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

Chapter 1

# INTRODUCTION

## Overview

Bulimia nervosa (BN) is characterized by binge eating (i.e., consumption of large amounts of food in a relatively short time period), associated compensatory behaviors such as self-induced vomiting, misuse of laxatives, extreme dietary restriction, and excessive exercise, and distorted thoughts about the importance of weight and shape (American Psychiatric Association: APA, 2013). Binge and purge behaviors must occur once per week, on average, for a period of three months to meet diagnostic criteria (APA, 2013). Lifetime prevalence rates of BN based on DSM-5 criteria are 2.3% in a national sample and 2.6% in a community sample of women in their late teens and mid- twenties (Keski-Rahkonen, et al. 2009; Stice, Marti, & Rhode, 2013).

## Relationship between negative affect and BN

The affect regulation model of BN suggests that binge eating and purging represent coping methods for negative mood states resulting from deficits in adaptive emotion regulation strategies (Agras & Telch, 1998; Heatherton & Baumeister, 1991). Studies utilizing a variety of methods have produced results that are consistent with this hypothesis. For example, bulimic pathology is robustly associated with mood disturbances (e.g., Haedt-Matt & Keel, 2011; Smyth et al., 2007; Stice, 2002) and major depression is the most common comorbid disorder in individuals with eating pathology (e.g., Herzog, Keller, Sacks, Yeh, & Lavori, 1992; O'Brien, & Vincent, 2003). Furthermore, most individuals with BN or binge eating seek treatment for emotional difficulties rather than for disordered eating (Hudson, Hiripi, Pope, & Kessler, 2007). Negative affect is considered both a risk and maintenance factor for loss of control eating (LOC), body dissatisfaction, subjective cravings, and increased caloric intake (Hepworth, Mogg, Brignell, & Bradley, 2010; Macht, 2008; Stice, 2002). Evidence suggests that, even after treatment, individuals with BN continue to experience negative moods more frequently than healthy women (Kaye et al., 1998; Keski-Rahkonen et al., 2009). Studies utilizing ecological momentary assessment (EMA) demonstrate increases in negative affect and decreases in positive affect prior to binge eating and purging (e.g., Berg et al., 2012; Haedt-Matt & Keel, 2011; Hetherington et al., 1994; Smyth et al., 2007). Following bulimic behaviors, negative affect appears to decrease with a concurrent increase in positive affect (e.g., Berg et al. 2012; Smyth et al., 2007). These findings suggest that binge eating and purging are reinforced through short-term relief of, or escape from, distress (Ferriter & Ray, 2011; Smyth et al., 2007)

However, decreases in negative affect following bulimic behaviors, and specifically post-binge eating, are not universally reported (Haedt-Matt & Keel, 2011). This may be due, in part, to the use of different statistical techniques to examine changes in affect (i.e., trajectory analyses versus point analyses; Berg et al., 2012; Engel et al., 2013). Time point analyses examine a single rating of mood immediately pre-and post- relevant behaviors while trajectory analyses allow for examination of all data leading up to and following a behavior, generating a trajectory of mood as it changes over time (Engel et al., 2013). In a recent study using a sample of women with anorexia, trajectory analyses indicated increases in negative affect prior to engagement in LOC eating, purging, and combined LOC eating and purging, and decreases in negative moods following these behaviors. In contrast, time point analyses suggested that negative affect continually increased directly following LOC eating, purging, combined LOC eating and purging, and weighing behaviors (Engel et al., 2013). Clearly, the analytic approach influences findings and subsequent conclusions. However, the broad term 'negative affect' also is an imprecise term encompassing multiple, discrete, moods (Macht, 2008). Lumping all negative moods together does not capture the unique aspects of various negative emotional states, such as arousal levels and approach or withdrawal motivations. Thus, the various emotions that make up the broad term 'negative affect' may impact bulimic behaviors in a more nuanced manner. A more precise examination of specific features of negative affective states may help further elucidate inconsistent results regarding the affect regulation model of BN.

**Discrete versus dimensional measurement of emotional experience**

Ekman's theory of basic emotions (Ekman, 1992a; 1992b) suggests that discrete emotions have unique autonomic response patterns and that neural systems have developed to specifically prepare an organism for an action behavior (e.g., "flight or flight"; Stephens, Christie, & Friedman, 2010). Evidence supporting discriminate physiological activity for each emotion is equivocal, as some studies characterize unique emotional experiences with specific cardiovascular measurements (e.g., blood pressure), skin conductance, and respiratory changes, and other studies fail to find support for unique autonomic activity for individual emotions (Kolodyazhniv, Kreibig, Gross, Roth, & Wilhelm, 2011; Neuman & Waldstein, 2001; Posner, Russell, & Peterson, 2005; Stephens et al., 2010). Furthermore, individuals differ in their ability to label distinct emotional states because emotional awareness requires insight and emotional states appear to be partially determined by cognitive appraisals (Feldman, 1995; Posner et al., 2005). Therefore, emotions may be expressed and labeled differently by different individuals (Murugappan, Ramachandran, & Sazali, 2010; Posner et al., 2009).

Due to these challenges, some research suggests that dimensional models best represent emotional experiences by accounting for ambiguous and overlapping physiological sensations (Posner et al., 2005; Russell, Weiss, & Mendelsohn, 1989). The most widely used dimensional model consists of two factors: emotional valence and emotional arousal (Morgan & Heise, 1988; Russell et al., 1989). The valence dimension represents the degree to which an affective state is considered pleasant or unpleasant, while the arousal dimension captures the extent to which an individual reports feeling awake and alert or lethargic and drowsy (Posner et al., 2005; Russell, et al., 1989). Multiple studies have found that discrete emotions can be reliably mapped onto dimensional states (e.g., Posner et al., 2009; Posner et al., 2005; Russell et al., 1989).

In addition to self-report studies, the two-dimensional model of emotional experience has gained support from neurobiological studies in which specific peripheral physiological responses correspond to self-reported valence and arousal levels (Posner et al., 2005, Posner et al., 2009). For example, skin conductance and heart rate have been shown to vary in accordance with subjective reports of arousal while certain facial and eye movements are more closely associated with subjective ratings of positive or negative moods state (Posner et al., 2005, Posner et al., 2009).

Findings from electroencephalographic (EEG), and functional magnetic resonance imaging (fMRI) studies also suggest that there may be distinctive neural pathways for the processing of pleasant/unpleasant stimuli and arousing stimuli (Kensinger & Schacter, 2006; Posner et al., 2005; Posner et al., 2009). Previous findings have repeatedly indicated that the amygdala responds to highly arousing stimuli irrespective of valence and across a range of stimuli (e.g., pictures, words; Kensinger & Schacter, 2006; Posner et al., 2005). Some evidence also suggests that glutamate (the primary excitatory neurotransmitter) is released in the neural connections between the amygdala, the reticular formation, and the thalamus when individuals are reporting high arousal levels (Posner et al., 2005). Furthermore, some results show that lesions to the reticular formation (i.e., hypoactivity) are associated with low arousal states while hyperactivity in the reticular formation and the amygdala correspond to states of high arousal (e.g., panic and mania; Posner et al., 2005). Other structures also appear to be associated with increased arousal such as the dorsal anterior cingulate cortex, the left parahippocampus, and the left dorsolateral pre-frontal cortex (Posner et al., 2009). Regions implicated in the processing of positively and negatively valenced stimuli include the mesolimbic dopamine system (processing of reward and pleasure), the left insular cortex (processing of positively valenced stimuli), and the right dorsolateral prefrontal cortex (processing of negatively valenced stimuli; Posner et al., 2009). Thus, the arousal and valence dimensions each demonstrate physiological changes and neurological pathways that are distinctive, highlighting each dimension's significance in emotional experience (e.g., Kensinger, & Schacter, 2006; Posner et al., 2005; Stephens et al., 2010; Witvliet & Vrana, 1995).

Despite data highlighting the distinction between arousal and valence, the valence dimension is usually the only dimension considered in empirical investigations of the affect regulation model of BN. However, arousal levels may potentially be more predictive of dysregulated behaviors in that higher arousal may be indicative of greater distress and less ability to regulate emotional experiences (Chapman, Gratz, & Brown, 2006). Additionally, evidence suggests that arousal levels may be more varied across individuals in similar situations than valence levels (Chanel, Kronegg, Granjean, & Pun, 2006). The distinction between arousal and valence in the prediction of behavior has been studied in other fields, and has contributed to our understanding of risk for other maladaptive behaviors. For example, affect regulation models are used to conceptualize risk for NSSI (e.g., Klonsky, 2007). Many individuals report increases in physiological arousal and list high arousal emotions as precursors to nonsuicidal self-injury (Chapman et al., 2006; Claes, Klonsky, Muehlenkamp, Kuppens, & Vandereycken, 2010; Klonsky, 2009; Klonsky & Muehlenkamp, 2007; Nock, Prinstein, & Sterba, 2009). Perhaps most relevant are findings demonstrating that highly arousing negative moods are most reduced following nonsuicidal self-injury (Claes et al., 2010; Klonsky, 2007). This suggests that it may be useful to investigate changes in both arousal as well as valence prior to and following binge and purge episodes.

Importantly, some authors have argued that the two-dimensional emotional theory is not sufficient to adequately map and distinguish all emotions (e.g., Morgan & Heise, 1988). This research suggests that a "potency" or "approach/withdraw" dimension of emotional experience is particularly relevant in discriminating negative emotions, such as anger and fear (both high in arousal and negatively valenced) from each other and is important in understanding how emotions motivate certain behaviors (Carver &Harmon-Jones, 2009; Harmon-Jones, E. & Harmon-Jones, C., 2010; Morgan & Heise, 1988). Opposite motivational systems (i.e., somatic responses) are engaged during approach (e.g., positive moods, anger) and withdrawal (e.g., sadness, anxiety) mood states. These motivational systems influence behaviors and decisions in differentiated ways such that individuals are either more likely to interact with or avoid environmental stimuli (Carver & Harmon-Jones, 2009). Therefore, maladaptive behaviors such as binge eating and purging may specifically function as a way to escape or withdraw from unpleasant environmental circumstances and relieve distress associated with high arousal levels (Chapman et al., 2006; Davis & Fischer, 2012; Gratz, 2003; Nock et al., 2009).

Emotional experience can therefore be conceptualized as occurring along these three dimensions: arousal, valence, and approach/avoidance (Morgan & Heise, 1988; Posner et al., 2009). It is possible that engagement in negatively reinforcing behaviors may be driven by more than the valence dimension of emotional experiences. As the physiological variations associated with highly arousing negative moods may be intensely aversive and certain highly arousing negative moods promote withdrawal behaviors while others encourage approach behaviors, it seems important to consider all of three dimensions in understanding the trajectory of emotions pre- and post- maladaptive eating behaviors.

**Emotional arousal may have a unique influence on disordered eating**

Broad measurement of negative affect may not detect unique emotional trajectories or variations of emotional experiences at specific time points surrounding bulimic behaviors. In fact, evidence suggests that differences in valence and arousal may help explain unique influences certain emotions exert over eating behaviors (Macht, 2008). This underlines the importance of considering different components of emotions in motivational theories. The 'trade-off' theory purports that disordered eating behaviors function to uniquely regulate highly aversive and arousing negative emotions such as anxiety, anger, and guilt (Haedt-Matt & Keel, 2011; Kenardy, Arnow, Agras, 1996). According to this model, binge eating and purging specifically lower arousal levels, rather than negative valence. Therefore, levels of negative valence would not decrease following binge episodes, as negative emotions are purely altered from highly arousing to low arousing mood states (Haedt-Matt & Keel, 2011; Kenardy et al. 1996). Thus, an overall persistence of negative affect despite engagement in disordered eating is consistent with the trade-off theory because negative valence is not hypothesized to be reduced via behavior engagement (Claes et al., 2010; Haedt-Matt & Keel, 2011).

Several previous studies demonstrate preliminary support for the trade-off theory, even though these investigations were not designed to test this hypothesis. For example, anxiety, anger, and guilt are considered high arousal emotions (Chapman et al., 2006; Morgan & Heise, 1988) and high trait and state levels of these emotions are positively associated with binge eating and endorsement of disordered eating attitudes and beliefs in prospective and cross-sectional studies (e.g., Berg et al., 2012; Davis & Fischer, 2012; Elmore & de Castro, 1990; Hetherington, Altemus, Nelson, Bernat, & Gold, 1994; Kenardy et al., 1996). Evidence from EMA studies demonstrate that emotions classified as high arousal emotions such as guilt, anger, hostility, self-anger, anxiety, and frustration rise before binge eating and purging, and may reach higher magnitudes preceding these behaviors than low arousal emotions (Berg, et al., 2012; Smyth et al., 2007). Emotions such as shame and anger-at-self continue to show significant trajectories prior to and following bulimic events, even when controlling for other negative moods (Berg et al., 2012). Consistent with the trade-off theory, some research also suggests that consequent to maladaptive eating behaviors, high arousal emotions (specifically anxiety and guilt) show the most precipitous and greatest declines (Heaterington et al., 1994; Kaye, Gwirtsman, Weiss, & Jimmerson, 1986), perhaps because of intense aversion likely associated with negative moods high in physiological arousal (Chapman et al., 2006; Klonsky & Muehlenkamp, 2007; Klonsky, Oltmanns, & Turkheimer, 2003).

To date, two studies have examined the effects of both arousal and valence as precipitants to eating behavior in a laboratory study. In these two studies, arousal level following a mood induction, but not valence of mood, was associated with food consumption in the lab setting (Davis-Becker, Fischer, & Miller, in submission; Cools, Schotte, & McNally, 1992). Additionally, Cools et al. (1992) reported that negative valence may not be required to disrupt cognitive control over eating in individuals with higher levels of dietary restraint. This suggests that arousal may, as opposed to valence, motivate the selection of palatable foods over healthier options. Similarly, findings indicate that symptoms of posttraumatic stress disorder and, in particular, heighted physiological arousal, mediate the relationship between the experience of a traumatic event and the development of disordered eating (Holzer, Uppala, Wonderlich, Crosby, & Simonich, 2008). Thus, further examination of the components of negative mood states following and proceeding disordered eating behaviors may help clarify the motivating components of negative affect. Additionally, although two experimental studies have examined the influence of high arousal (e.g., stress) versus low arousal (e.g., depression) mood states on food consumption, investigations of arousal levels *following* food consumption have not been conducted in the eating disorders field (Macht, 2008). Thus, it is unclear whether or not reduction of arousal itself reinforces disordered eating behavior, as suggested by the trade-off theory.

**Avoidance or withdrawal motives may specifically motivate disordered eating.**

Escape theory suggests that maladaptive behaviors, such as binge eating and purging, function as distractions from negative moods (Heatherton & Baumeister, 1991). EMA studies demonstrating that negative emotions precede binge eating and purging, self-report studies indicating that individuals who engage in these behaviors endorse more avoidant coping methods in general, and experimental studies showing that acute negative moods prompt LOC eating all provide support for the conclusion that these behaviors manifest as avoidant coping (Chapman et al., 2006; Ferriter & Ray, 2011) and that emotional eating is distinctly related to a particular form of emotion-focused coping, i.e., avoidance of distress via distraction (Spoor, Bekker, Van Strien, & van Heck, 2007). Thus, emotions that promote avoidance behaviors (e.g., escaping from distressing environmental stimuli) and are highly arousing may be particularly aversive. High arousal, negatively valenced emotions that promote avoidance may increase the likelihood of maladaptive extreme behaviors in those who have difficulty regulating mood states and rely on emotion-focused (versus problem-focused) coping strategies.

**Persistence of low arousal negative moods**

Despite evidence that binge eating and purging appear to produce reductions in acute emotional distress, long-term levels of negative affect are not improved after these behaviors (e.g., Haedt-Matt & Keel, 2011). The overall propensity to engage in these behaviors is associated with increased levels of negative affect (e.g., Haedt-Matt & Keel, 2011) and individuals report higher levels of various negative mood states (e.g., depression, anger, guilt), on days that include binge eating and purging (Smyth, et al., 2007; Wegner, Smyth, Crosby, Wittrock, Wonderlich, & Mitchell, 2002). Additionally, binge eating may increase certain emotional states like depression (Hetherington et al., 1994; Haedt-Matt & Keel, 2011). Findings which suggest that binge eating and purging behaviors particularly target certain highly arousing and avoidant mood states may help explain discrepant reports regarding reductions in negative affect following these behaviors and high levels of residual negative affect afterwards (Haedt-Matt & Keel, 2011). Continued experience, or increased intensity, of certain low-arousal negative moods (e.g., sadness, loneliness) may explain the observed elevated vulnerability to engage in these behaviors for individuals who have comorbid mood disorders. Taken together, these findings further emphasize the value of examining the dimensions of arousal and approach/avoidance, in addition to valence, when investigating emotional antecedents and consequences of behaviors.

**Evidence for positive reinforcement of maladaptive behaviors**

Although changes in positive mood states have not been extensively studied in relation to disordered eating behaviors (Haedt-Matt & Keel 2011), there is support for concluding that positively valenced moods increase following binge eating or loss of control eating and purging (e.g., Smyth et al., 2007; Engel et al., 2013). Positive emotions may increase during binge episodes due to ingestion of highly palatable foods that act on the dopamine reward pathway in the brain (Small, Jones-Gotman, & Dagher, 2003). Additionally, self-reported contentment has been shown to increase during and post binge episodes and satisfaction ratings continued to increase up to an hour after binge eating (Hetherington et al., 1994). Purging behaviors also may be reinforced by increases in positive affect, as self-induced vomiting has been shown to reduce aversive somatic sensations (e.g., nausea) and body dissatisfaction while increasing relaxation (Hetherington et al., 1994; Keel, Wolfe, Liddle De Young, & Jimerson, 2007). It is, therefore, important to investigate trajectories of both high and low arousing positive emotions in conjunction with negative moods to better understand emotional motivation for engagement in maladaptive behaviors.

**Current study**

To summarize, emotions may be characterized on dimensions of arousal, valence, and approach/avoidance (approach/avoidance). Previous studies using EMA to examine antecedents to and consequents of binge and purge behaviors have generally examined negative and positive affect as broad constructs or examined discrete emotions, without considering how different dimensions of emotion may impact behavior. Additionally, there is some debate regarding whether or not binge eating specifically reduces negative affect, despite agreement that acute negative affect precedes this behavior. The purpose of this study was to examine trajectories of emotions based on dimensions of arousal, valence, and approach/avoidance both prior to and following binge-only episodes, purge-only episodes, and combined binge and purge episodes. This study utilized EMA data from a sample of 133 women with BN who recorded their mood and eating behaviors over a period of two weeks using palmtop computers. Participants entered recordings using a palmtop computer at various signaled semi-random time points during the day, whenever they engaged in a behavior, and at the end of each day.

**Hypotheses.** This study had four primary goals. The first was to examine how the three dimensions of emotional experience (emotional arousal, emotional valence, and avoidance/approach) change prior to and following binge eating episodes. The second goal was to examine how these dimensions change prior to and following purging behaviors. As a third goal, we explored the antecedent and consequent trajectories for combined binge eating and purging. Finally, we examined levels of emotions grouped according to the three dimensions of emotional experience on days with and without bulimic behaviors.

The following are specific hypotheses regarding trajectories of mood states categorized by arousal, valence, and approach vs. avoidance prior to, and after, binge episodes, purge episodes, and combined binge and purge episodes. The different groups of emotions will henceforth be referred to as follows: high arousal negative moods that promote avoidance are HNAV, high arousal negative moods that promote approach are HNAP, low arousal negative moods that promote avoidance are LNAV, high arousal positive moods that promote approach are HPAP, and low arousal positive moods that promote approach are LPAP (see Appendix A).

For each mood group we used generalized estimating equation (GEE) models to examine a linear coefficient, a quadratic coefficient, and a cubic coefficient preceding and following each of the three behaviors in order to determine the trajectories of the mood groups as they change over time in relation to eating disordered behaviors (i.e., binge-only, purge-only, and combined binge and purge events). Within the same model, the linear, quadratic, and cubic components will be estimated separately for the pre-behavior and post-behavior portions of each curve. The linear coefficient (i.e., time before behaviors, time following behaviors) indicates the nature (increasing, decreasing, or flat) of the initial slope of the trajectory immediately before or after a behavior and can be considered to reflect the rate of change in affect prior to, and following, each behavior. The quadratic coefficient (i.e., the square of time before behaviors, the square of time following behaviors) for the curve indicates whether the initial slope, from the linear component, deflects up or down and can be described as representing the acceleration in rate of affect change before and after each behavior. Finally, the cubic coefficient (i.e., the cube of time before behaviors, the cube of time after behaviors) indicates whether the initial deflection from the quadratic component is intensified (i.e., the same direction or sign as the quadratic coefficient) or diminished (i.e., the opposite direction or sign from the quadratic coefficient) and represents whether the rate is further accelerated or dampened (Berg et al., 2012; Engel et al., 2013).

We predicted that overall negative affect would increase linearly prior to engagement in all of these behaviors and that positive affect would decrease prior to each behavior. However, we expected that HNAV (e.g., anxiety, guilt), LNAV (e.g., sadness), and HNAP (e.g., anger) emotions would follow different trajectories both before and after each behavior. Finally, we expected that HPAP (e.g., energetic) and LPAP (e.g., calm) would show unique trajectories following engagement in these behaviors. More specific hypotheses for each behavior are delineated below.

We expected that all negative emotions (low arousal and high arousal and approach and avoidance promoting emotions) would show significant linear coefficients prior to each behavior, although, we further anticipated that the slopes would be significantly different. Thus, we hypothesized that analyses would reveal significant differences between the slopes of negative emotion mood groups (i.e., HNAV, HNAP, LNAV) prior to each behavior. We hypothesized that the trajectories of HNAV emotions would differ in relation to the trajectories of HNAP and LNAV emotions in that we expected only HNAV emotions to demonstrate significant and positive quadratic and cubic estimates prior to each behavior. Furthermore, we predicted that HNAV emotions would reach significantly higher intercepts (i.e., magnitudes) than LNAV and HNAP emotions prior to engagement in behaviors. We also hypothesized that all positive emotions (both high and low arousal) would decrease at similar rates (i.e., linear coefficients would be significant but would not differ significantly) and show similar trajectories (i.e., no differences in the significance of quadratic and cubic coefficients) preceding binge-only, purge-only, and binge/purge events.

We further anticipated that HNAV and HNAP would have different trajectories following binge-only events and combined binge and purge events than LNAV emotions. Specifically, we hypothesized that HNAV and HNAP emotions would show a significant negative linear estimate subsequent to behaviors, while we anticipated that LNAV emotions would rise significantly following binge-only and combined binge and purge events (i.e., significant and positive linear estimate). We did not expect that HNAV and HNAP would differ in post-behavior quadratic or cubic trajectories. Furthermore, we expected that LPAP emotions would increase at a steeper slope than LNAV emotions (i.e., a significantly greater linear estimate) following binge-only and combined binge and purge events and would show significant quadratic and cubic estimates. We expected there to be no change (i.e., a "flat" trajectory/non-significant linear estimate) in HPAP emotions following binge only and binge and purge events.

Following purge-only events, we hypothesized that there would be differences in trajectories between HNAV and HNAP emotions and LNAV emotions such that all negative moods would decrease (i.e., show significant negative linear estimates) but HNAV and HNAP emotions would decrease more rapidly (i.e., significantly greater linear estimates) than LNAV emotions and show significant quadratic and cubic estimates. We further hypothesized that LPAP emotions would increase following purge behaviors (i.e., positive significant linear estimate) and would show significant quadratic and cubic coefficients. However, we expected that HPAP emotions would show a flat trajectory following purge behaviors (i.e., none of the coefficients would be significant).

Finally, we hypothesized that there would be higher overall levels of HNAV emotions on days that include binge-only, purge-only, and binge and purge events than on days that do not include these behaviors. However, we expected that overall levels of LNAV emotions would not differ between event and non-event days. We also hypothesized that levels of both HPAP and LPAP emotions would be significantly lower on days that include bulimic events compared to days that did not.

## Chapter 2

## METHODS

### Participants

Data from a previous study utilizing ecological momentary assessment to examine the relationship of affect to binge eating and purging was used for the current study. The following describes the recruitment procedures, participants, and EMA data collection from the parent study (Smyth et al., 2007). Female participants were recruited from the community and the University of North Dakota campus to participate via advertisements in clinical, community, and campus settings and via clinical referrals. One hundred and fifty-four women were initially selected to participate in the study based on their responses to a phone screen. These participants were then asked to undergo further assessment with doctoral-level interviewers administering the Structured Clinical Interview for DSM-IV Axis I Disorders (SCID-IP; First, Spitzer, Gibbon, & Williams, 1995). In order to participate in the study, participants had to be female, at least 18 years of age, literate, not suffering from a current psychotic disorder, and meet criteria for BN according to the Diagnostic and Statistical Manual of Mental Disorders ($4^{th}$ ed., DSM-IV; APA, 1994). Eleven of the original 154 women were excluded because they did not meet the stated inclusionary criteria and a total of 143 women began the Ecological Momentary Assessment (EMA) protocol. Seven women dropped out of the study before completing at least seven days of the EMA protocol and three provided incomplete data (i.e., compliance rates were less than 50%). Thus, 133 women completed the EMA protocol and were included in the current study analyses (Smyth et al., 2007).

The average age of participants was 25.3 years (*SD* = 7.6, range =18-55) and most were single/never married (*n* = 85, 63.9%). A majority were Caucasian (*n* = 127, 95.5%), full-time students (*n* = 74, 55.6%), currently employed (*n* = 96, 73.3%) and all but one had completed high school (*n* = 132, 99.2%). The mean body mass index (BMI) was 23.9 (*SD* = 5.2, range = 17.1- 47.6) and all were at least at 85% of their ideal body weight. Some (*n* = 35, 26.3%) participants reported having received inpatient treatment for psychological problems and 80 participants (60.2%) had outpatient treatment for psychological difficulties during their lifetime. A mood disorder diagnosis was common, with 115 (85.5%) participants reporting a lifetime diagnosis and 71 (53.4%) meeting criteria for a mood disorder at the time of the assessment. Substance use also was relatively common in the sample, as 49 participants (36.8%) reported a lifetime diagnosis of substance dependence or abuse and 21 participants (15.8%) met criteria during the month of the assessment. Most women (*n* = 78, 58.6%) met criteria for a lifetime diagnosis of an anxiety disorder and 67 (50.4%) met criteria at the time of the assessment (Crosby et al., 2009; Smyth et al., 2007).

Attrition analyses indicated that there were no differences between participants who completed the full study and those who either did not complete the EMA protocol or did not complete additional questionnaires, with the exception that non-completers were slightly less likely to meet criteria for co-occurring mood disorders (*p* = .052; Smyth et al., 2007).

**Measures**

**EMA assessments.** Several assessments were completed daily on palmtop computers including questions concerning mood, affect, stress, and behaviors. Each time data were collected, the date, time started, and ending time were recorded in addition to the participant's questionnaire responses. Additional measures were collected on the palmtop computer for each participant, but are not relevant for this study and are therefore not described (Smyth et al., 2007).

***Profile of Mood States (POMS: Lorr & McNair, 1971).*** The POMS consists of 65 items that are assessed using a 5-point likert scale ("not at all" to "extremely") and measure transient discrete mood states. The measure was specifically designed to assess mood state fluctuation and, as such, can be re-administered frequently and given to assess momentary mood change (McNair, Douglas, Lorr, & Dropplmena, 1989). Six subscales have been identified via factor analysis including: Tension/Anxiety, Depression-Dejection, Anger-Hostility, Fatigue-Inertia, Vigor-Activity, and Confusion-Bewilderment (McNair, Douglas, Lorr, & Dropplmena, 1989). The Anger/Hostility subscale of the POMS has four items and was used to assess momentary anger and hostility. In this sample the coefficient alpha was .89 (Smyth et al., 2007).

***Positive and Negative Affect Scale (PANAS: Watson, Clark, & Tellegen, 1988).*** The PANAS consists of 60 words that represent the dimensions of positive and negative affect. The words chosen for the scale demonstrated high factor loadings on only one factor (either positive or negative; Watson et al., 1988). Both factors have shown acceptable test/retest reliability irrespective of the time frame between testings (e.g., momentary, days, weeks, years, or overall; Watson & Clark, 1994). The factor structure of the PANAS has been replicated across multiple populations and over various lengths of time (e.g., "moment," "past few days," "past year;" Watson & Clark, 1994). Alpha coefficients from various samples (e.g., college students, adults, clinical populations) have also demonstrated that the PANAS has acceptable internal consistency (Watson & Clark, 1994). On the basis of clinical relevance to BN, eleven terms were chosen to represent momentary negative affect (i.e., afraid, lonely, irritable, ashamed, angry, disgusted, nervous, dissatisfied with self, jittery, sad, and angry with self) and thirteen terms represented momentary positive affect (i.e., calm, happy, proud, relaxed, cheerful, confident, energetic, alert, determined, attentive). Participants were asked to rate how much they were experiencing each emotion in the moment using a 5-point Likert scale ranging from 1 ("not at all") to 5 ("extremely"). The coefficient alpha for the NA scale in this sample was .92 and the internal consistency of the PA scale in this sample was .91, both of which are consistent with the internal consistency of the full NA and PA scales when assessed at the momentary level (Smyth et al., 2007).

***The Eating Disorder and Self-Destructive Behavior Checklist (Smyth et al., 2007).*** This 19-item checklist represents an amalgamation of items from other measures of disordered eating and self-harm behaviors. Items included impulsive behaviors (not used in this analysis), eating items such as "I binge ate," and "I vomited," and NSSI items such as "I hit myself," and "I cut myself." Participants were trained before data collection began in identifying binge episodes during a palm pilot training session. Participants were told that a binge is defined as "an amount of food that you consider excessive or an amount of food that other people would consider excessive with an associated loss of control or the feeling of being driven or compelled to keep eating." During training, discussions clarified the size of an objectively large amount of food and personalized examples were generated given each participant's reported eating habits during the clinical interview (Smyth et al., 2007).

Participants were asked to record engagement in binge eating, self-induced vomiting, diuretic misuse, and laxative misuse, either immediately after the behavior or at the next scheduled recording. Participants were instructed not to complete the EMA assessment ratings during the behaviors (Smyth et al., 2007).

***Structured Clinical Interview for DSM-IV Axis I Disorders (SCID-IP; First, Spitzer, Gibbon, & Williams, 1995).*** The SCID-IP is a structured clinical interview for diagnosing DSM-IV Axis I conditions and is the most widely used diagnostic assessment for psychological disorders (Kashubeck-West, Mintz, & Saunders, 2001; Spitzer, R. L., Gibbon, M., & Williams, J. B. (1997). Assessors determine if criteria are met for each disorder by assigning one of three options to each symptom (i.e., inadequate information, below threshold or absent, and at a threshold; Spitzer et al., 1997). The Eating Disorder Module of the SCID-IP was given to assess eating pathology and diagnose BN nervosa (inclusionary criteria for the study) and other current and lifetime conditions according to the DSM-IV criteria. Community and clinical samples have indicated that the test-retest reliability of the SCID ranges from .82 to .90 (Kashubeck-West et al., 2001; Pike, Loeb, & Walsh, 1995; Segal, Hersen, & Van Hasselt, 1994). A randomly selected subset of the taped interviews (18.8%) were rated by another doctoral level psychologist on the research team in order to determine inter-rater reliability. The resulting kappa coefficient for the diagnosis of DSM-IV BN nervosa was 1.0 (Smyth et al., 2007).

**Procedure**

All data was collected at the Neuropsychiatric Research Institute of North Dakota. Interested participants underwent a phone screen to determine whether they met inclusion criteria and those who were eligible were invited to attend an informational meeting about the study. During this initial visit, participants also signed consent forms and provided a blood sample to screen for electrolyte imbalances and ensure medical stability. Following this meeting, participants attended two, 3-4 hour, assessment visits during which doctoral-level psychologists conducted structured clinical interviews of personality, comorbid lifetime and current conditions, and eating pathology. Only the measures relevant to the current study have been described (Smyth et al., 2007).

Eligible participants were trained to use the palmtop computers during the assessment visits. Participants were informed about what to expect during data collection, how to manage questions or difficulties with the palmtop computers, and were reminded about the goals of the overall study. Importantly, participants were instructed not to complete palmtop assessments when they were unable to respond (e.g., driving). If they were prompted to complete an entry when it was impossible for them to do so, they were instructed to "snooze" the palmtop computer and respond as quickly as possible. Participants carried and responded to the palmtop computer signals for two practice days, after which, they returned to complete their second assessment day and their two-day data was examined. The data from the practice sessions were not used in these analyses. Participants were given feedback about their compliance with the palmtop computer prompts. Upon leaving the second assessment day, participants were given the palmtop computer again along with self-report questionnaires to complete during the following two weeks. If possible, participants were scheduled for a return visit during the two-week period in order to download data (reduce data lost if a technical problem arose) and to provide additional feedback about compliance. After finishing the protocol, all participants were compensated and were given treatment referrals. Participants received $200 for completing the two-week EMA protocol and were given an additional $50 bonus if they complied with at least 85% of the daily assessments (Smyth et al., 2007).

**EMA assessment schedule.** Three types of self-report methods were used for the EMA assessment: Signal-contingent, event-contingent, and end-of-day (i.e., interval-contingent) ratings. Signal-contingent entries entailed reporting on experiences at various semi-random times throughout the day in response to a signal from the palmtop computer. Participants were signaled six times throughout the day and were asked to provide their mood, stress, disordered eating behaviors, and NSSI behaviors. The signals were randomly selected around anchor points that subdivided each day into six time-blocks (8:30 a.m., 11:10 a.m., 1:50 p.m., 4:30 p.m., 7:10 p.m., and 9:50 p.m.). Signal times were randomly dispersed around these time points using a normal distribution such that 0 minutes represented the anchor point and the standard deviation equaled 30 minutes. Every time participants were signaled, they were instructed to provide their mood and any behaviors they had not already logged. Event-contingent reporting requires participants to complete assessments in response to specific behaviors. Participants were asked to rate their mood and stress level following engagement in a disordered eating. Participants completed end-of-day ratings (i.e., interval ratings) to summarize the experiences of the full day (Smyth et al., 2007).

## Data Analytic Strategy

**Grouping of emotions.** Emotion words were taken from the EMA assessment data (i.e., POMS anger/hostility subscale and selected words from the PANAS) and grouped into one of the five categories: high arousal negative moods that promote avoidance (HNAV) high arousal negative moods that promote approach (HNAP), low arousal negative moods that promote avoidance (LNAV), low arousal positive moods that promote approach (LPAP) and high arousal positive moods that promote approach (HPAP; see Appendix A). The identification of words in terms of arousal (high and low) and valence (positive and negative) was modeled after Klonsky (2009) examination of dimensional emotional antecedents and consequences of NSSI behaviors. In Klonsky's (2009) study, 40 emotional states were independently rated on the dimensions of valence and arousal by two experts in emotion research (Dr. J.A. Coan and Dr. G. Hajack).

Emotions words from the current study were matched to those rated in the Klonsky (2009) manuscript. Because moral emotions (e.g., guilt, shame) have been assigned discrepant arousal ratings in the literature (e.g., Klonsky, 2009), we consulted an expert in moral emotions (Dr. J. Tangney) who classified both “guilt” and “ashamed” as a high arousal and negatively valenced emotions. Additionally, a previous confirmatory factor analysis, in this data set, replicated the grouping of “ashamed,” “angry at self,” and “dissatisfied with self” as elements of a lower-order negative affect factor representing “Guilt,” suggesting that these items should remain clustered together in our analysis (Berg et al., 2012). Emotion words were then rated on the approach/avoidance dimension according to Morgan & Heise (1988). From these sources of information, Dr. Fischer and the author each independently rated the emotion words used in the EMA assessment protocol. Our classification of each word was identical and the resultant groups can be found in Appendix A.

**Statistical models.** Multilevel modeling was used to examine the trajectories of the five emotion groups (determined by ratings of arousal valence, and approach/withdrawal) before and after binge-only, purge-only, and combined binge and purge events. Multilevel modeling is appropriate for our analyses because momentary data (i.e., each signal-, event/behavior-, and interval-contingent recording) are nested within a day and every day is nested within each subject (i.e., first level = momentary data, second level = day, third level = subject). In organizing our data, each momentary rating is represented by a separate row and is labeled as occurring on a particular day and being completed by a specific subject. Thus, all data recordings by a single participant are labeled with the same ID number and each recording is identified as occurring on one of 14 days within the two-week study period.

**Accounting for time and choosing an intercept.** All longitudinal data is ordered in time such that values of a dependent variable (i.e., emotion ratings) at one time point always follow values taken at a previous time point and precede values for the next time point (Bolger & Laurenceau, 2013). Thus, the passage of time is embedded in the data (Bolger & Laurenceau, 2013). In our analyses, we were interested in the influence of time as a direct predictor on emotion ratings surrounding disordered eating events (i.e., changes in emotion groups before and after binge-only, purge-only, and combined binge and purge events). We created a dummy-coded variable to recode time based on the occurrence of a behavior such that all time points before engagement in a behavior (for each day) were coded 0 and all times points afterwards (in the same day) were coded as 1. When grouped together for analyses, all ratings (across days and subjects) preceding a behavior have negative time values and all ratings following a behavior (across days and subjects) have positive time values. Therefore, the occurrence of a behavior occurs at time = 0 (i.e., the zero point or intercept). Recoding time zero as the occurrence of a behavior allows for ease of interpretability across subjects (i.e., all behaviors for every subject occur at time zero) and the generation of trajectory graphs. Forcing a common intercept between the pre- and post-behavior portions of the graphs also makes the affect line appear continuous. Graphs with separate intercepts for the pre-and post-behavior sections could appear to show a precipitous rise or fall in emotion groups immediately at the time of the behavior (i.e., the line appears to "jump"). However, it is unlikely that a large enough number of ratings exist around a behavior to support an apparent rise or drop (Engel, 2013).

If more than one behavior was reported during a day, the first reported behavior was used in analyses to avoid any confusion between antecedent emotional trajectories and consequent emotional trajectories. Additionally, if multiple behaviors occurred within a 4-hour time frame following the first reported behavior, than only mood states reported after the first behavior and before any subsequent behavior were included in the post-behavior analyses (Berg et al., 2012; Smyth et al., 2007).

**Within-day analyses**. We modeled the pre-behavior and post-behavior trajectories of each emotion group (i.e., HNAV, HNAP, LNAV, LPAP, and HPAPA) separately using piecewise linear, quadratic, and cubic functions centered on the time at which either binge-only, purge-only, or combined binge and purge events occurred. Multilevel models included linear functions, quadratic functions and cubic functions. The linear component of the trajectory curve indicated if the slope of the line immediately before (for the pre-behavior portion of the trajectory curve) or after (for the post-behavior portion of the trajectory curve) was increasing, decreasing, or flat and, therefore, reflected the slope or rate of change for each of the emotion groups before and after each behavior. The quadratic component indicated if the initial slope of the linear component deflected upward or downward and, thus, represented the acceleration in rate of affect change prior and subsequent to the behaviors. The cubic component indicated if the initial deflection from the quadratic component was intensified (i.e., if the cubic and quadratic coefficient were the same sign) or diminished (i.e., if the cubic coefficient was opposite in sign to the quadratic coefficient) demonstrating either further acceleration or dampened acceleration in the rate of affect change (Berg et al., 2012; Engel et al., 2013).

We ran 15 within-day GEE models using SPSS, version 22 (IBM, 2013); one model for each of the emotion groups for each behavior. The purging outcome variable was generated by combining all purging behaviors (self-induced vomiting, laxative use, and diuretic use). Variables representing time in hours before and after each behavior (linear components) were created and these variables were squared and cubed to generate the antecedent quadratic and cubic components of each model (i.e., three time variables – linear, quadratic, cubic - were created for each behavior). Data was selected such that only days during which the behavior (either binge-only, purge-only, or combined binge and purge) occurred once were used for within-day analyses. One of the five emotion groups was entered as the dependent variable and the time (linear), $time^2$ (quadratic), and $time^3$ (cubic), were entered as covariates along with the dummy-coded variable representing pre- versus post- behavior. All main effects were added to the model, as were all two-way interactions with the dummy-coded time variable. The difference between the antecedent and consequent linear slopes and the consequent cubic and quadratic coefficients (post-behavior portion of the trajectory curve) were generated by multiplying the time variables by the dummy-coded pre-post variable. The type of model was specified as a gamma with log link model and the first-order autoregressive correlation structure (AR(1)) was selected as the working correlation matrix. Choosing the AR(1) correlation structure allows for correction of any autocorrelation in the errors of the dependent variable (i.e., emotion ratings; Bolger & Laurenceau, 2013). This is necessary because measures of the dependent variable taken closer together in time are more similar than measures taken farther apart in time (i.e., they are not independent of each other and their level of nonindependnece changes according to the time between each measurement; Bolger & Laurenceau, 2013). Observations that are adjacent are the most affected, however these relationships tend to fade rapidly such that the correlations between observations a day apart is much lower than observations in the same day and the correlation between observations several days apart are negligible (Bolger & Laurenceau, 2013).

The output from these models provided all antecedent coefficient estimates, consequent quadratic and cubic coefficient estimates, and an estimate for the difference between the linear antecedent and consequent coefficient estimates. However, the linear consequent coefficient estimate remained to be calculated (i.e., not given directly in the output). In order to generate the actual linear consequent coefficient estimate, the difference estimate was added to the linear antecedent coefficient estimate.

**Between-days analyses.** These analyses compared average values for each of the five mood groups on days that included disordered eating behaviors and days that did not. Average scores were calculated by aggregating across within-day assessments such that the levels of each of the mood groups reflected the average values for each person on each day. Data for each day reflected combined emotion ratings scores for each participant and days were dummy coded to distinguish between event and non-event days. Binge-only, purge-only, and combined binge and purge events were analyzed separately.

Fifteen between-day models were completed using GEE models with a gamma with log link distribution to account for positive skew (SPSS, Version 22; IBM, 2013). All between-day analyses utilized an M-dependent correlation matrix because goodness of fit analyses (i.e., the quasi likelihood under independence model criterion: QIC and the corrected quasi likelihood under independence model criterion: QICC) indicated that this matrix was a better fit than the AR(1) matrix for several of the models. Importantly, the M-dependent matrix, like the AR(1) matrix, also accounts for the relationships between measurements taken close together in time (i.e., one measurement apart for these analyses; Heck, Thomas, & Tabeta, 2012). One of the five emotion groups were entered as the dependent variable and a dummy-coded variable indicating if a study day included a behavior or not (i.e., 1 = a specified behavior occurred on that day and 0 = a specified behavior did not occur on that day) was entered as the predictor. Only main effects were examined and in order to determine if levels of each emotion group differed between days with and without behaviors. If the dummy-coded predictor did not reach significance in the model, it was determined that the behavior was not a significant predictor of changes in average levels of the emotion groups across event and non-event days. If the model was significant, estimated marginal means were examined to determine if the mean level of the emotion group differed significantly between event and nonevent days (i.e., mean values did not overlap).

# Chapter 3

# RESULTS

The 133 participants included in these study analyses provided a total of 13,055 momentary reports including 10,307 responses to random signals, 1118 event records of specific behaviors, and 1630 end-of-day recordings over 1,956 total participant days (*M* = 14.8 days, range 5-19). Main analyses were based on recordings of 1,088 binge-only episodes, 2,727 combined binge and purge episodes, and 2,117 purge-only episodes. During the two-week study period, binge-only, purge-only, and combined binge and purge events occurred moderately frequently. On average, participants reported at least one binge episode on 40% of the days, at least one purge episode on 46% of the days, and combined binge and purge events on 33% of the days. The average number of binge episodes reported by participants during the study period was 8.65 (*SD* = 6.68, range = 1-34) and 11.47 purging episodes (*SD* = 9.24, range 1-48; Berg et al., 2012; Smyth et al., 2007).

**Compliance with EMA protocol**

Overall, participants complied well with the signal-contingent ratings, as the average compliance rate for the sample was 86% (median = 90%) and 75% of the participants responded to 83% or more of the signals. Compliance rates were also similar across the anchored times points, demonstrating that participants were generally equally responsive throughout the day (i.e., time point 1 = 81%, time point 2 = 85%, time point 3 = 86%, time point 4 = 88%, time point 5 = 88%, and time point 6 = 87%). Furthermore, a majority of ratings were completed within five minutes of the signal (median lag time to response = 4 minutes) and 75% of the ratings were entered within 20 minutes of the signal (Berg et al., 2012; Smyth et al., 2007). Notably, compliance rates cannot be generated for event/behavior-contingent ratings (Bolger & Laurenceau, 2013).

No missing data were imputed for analyses, but "all available data" from the three forms of EMA assessment (i.e., event/behavior-, interval-, and signal-contingent) was utilized and pooled together from each momentary assessment across days and subjects for analyses (i.e., multilevel analyses). Thus, all data points provided by each participant were used, even if they missed previous signaled ratings or did not fully complete measures during a rating.

**Normality**

Before analyses were performed, the distributions of the emotion groups (i.e., HNAV, HNAP, LNAV, LPAP, and HPAP) were examined for normality violations. Each emotion group was significantly positively skewed and platykurtic (i.e., skew and kurtosis values were more than twice the standard error of skeweness and kurtosis and histograms reveled visual non-normality). These values remained problematic after logarithmic and natural log transformations, thus, it was decided that GEE models were more appropriate than mixed models for multilevel analyses with these data. GEE models are derivations of the general linear model specifically appropriate for analysis of longitudinal, nested, and repeated measures data that allow for non-normal distributions depending on the nature of the dependent variable (e.g., emotion groups in the current study; Liang & Zeger, 1986). In particular, gamma with log link distributions are uniquely appropriate for skewed data (Ballinger, 2004).

**Correlations between emotion groups**

Correlations between the five emotion groups showed expected relationships (see Table 5). The strongest correlations were between HNAV and HNAP emotions and HNAV and

LNAV emotions, likely because HNAV emotions have in common two dimensional placements with both HNAP and LNAV emotions. Expressly, HNAV emotions share both high arousal and negative valence with HNAP emotions and share both negative valence and avoidance motivation with LNAV emotions. HNAV emotions were more strongly related to both HNAP and LNAV than were these two emotion groups correlated with each other, as LNAV emotions and HNAP emotions only share negative valence (i.e., are different in arousal levels and approach/avoidance motivation). As would be expected, all negative emotions were negatively related to the two positive mood groups (i.e., LPAP and HPAP) and the positive mood groups were correlated strongly with each other.

**Tests of Main Hypotheses: Within-Day Analyses**

The results of all within-day analyses for all behaviors are given in Tables 1 and 2 and illustrated in Figures 1-6. Consistent with hypotheses, all negatively valenced emotion groups (i.e., HNAV, HNAP, LNAV) increased linearly prior to engagement in all disordered eating behaviors and positively valenced emotion groups (LPAP and HPAP) decreased linearly before engagement in behaviors. There is also some evidence that trajectories between the negative emotion groups differed between before and after behaviors, as the pattern of quadratic and cubic coefficients was not identical between HNAV, HNAP, and LNAV emotions across behaviors. Additionally, HNAV emotions, as hypothesized, reached significantly higher magnitudes pre-behaviors than HNAP emotions, but did not (inconsistent with predictions) reach higher magnitudes than LNAV emotions prior to disordered eating behaviors. Unexpectedly, there were no observed differences in either antecedent or consequent linear slopes for any behavior (i.e., the confidence intervals overlapped for the linear estimates) for any of the negatively valenced emotion groups. Furthermore, our hypotheses that LNAV emotions would continue to rise following binge-only and combined binge and purge events were not supported as all negatively valenced emotions decreased following behaviors. Consistent with predictions, both high and low arousal positively valenced emotions (LPAP and HPAP) decreased at similar rates and trajectories preceding all behaviors, however, positively valenced emotions did not show differences in trajectories post-behaviors as anticipated. The only exception was seen in binge-only events, in which HPAP, but not LPAP emotions showed a significant quadratic consequent coefficient. A more detailed description of the observed trajectories specific for each behavior is given below.

**Binge-only events.** For coefficient estimates, confidence intervals, and graphical representation of the trajectories prior to and following binge-only events see Tables 1 and 2, Figure 1 (for negatively valenced emotion groups), and Figure 2 (for positively valenced emotion groups). HNAV, HNAP, and LNAV all demonstrated significant and positive linear antecedent coefficient estimates as hypothesized (i.e., levels of all negatively valenced emotions rose significantly prior to binge-only events). However, contrary to expectations, overlapping confidence intervals indicated that none of the linear coefficients (i.e., slopes) immediately prior to or following binge-only events for any emotion group were significantly different from each other. As expected, HNAV emotions reached a significantly higher magnitude/intercept before binge-only events than HNAP emotions but, inconsistent with predictions, the difference in magnitude between the intercepts of HNAV emotions and LNAV emotions prior to binge-only events did not reach significance. In contrast to our hypotheses, all negatively valenced emotion groups (i.e., HNAV, HNAP, LNAV) showed significant and positive antecedent quadratic and cubic coefficients. Therefore, the initial antecedent linear slopes were deflected up and the rate of affect change for each emotion group was accelerated (i.e., positive and significant quadratic coefficient estimates). Because the antecedent cubic coefficients for all negatively valenced emotion groups were also all significant and positive, the initial upward deflection from the quadratic component was intensified and the rate of affect change for each negative emotion group was further accelerated. As expected, both LPAP and HPAP emotions showed significant negative linear coefficient estimates prior to reported binge-only events (i.e., all positively valenced emotions decreased significantly prior to episodes of binge eating). Furthermore and as expected, the antecedent trajectories, slopes, and intercepts of the positively valenced emotions did not differ significantly. The initial antecedent linear slopes for positive emotions were deflected downward and levels of both high and low arousal positive emotion decreased at an accelerated rate (i.e., negative and significant quadratic coefficient estimates). Because the antecedent cubic coefficients for positively valenced emotion groups were also both significant and negative, the initial downward deflection from the quadratic component was intensified and the rate of affect change for each positive emotion group was further accelerated.

As hypothesized, HNAV and HNAP emotions demonstrated significant negative linear consequent estimates, although, LNAV emotions also demonstrated a negative and significant linear consequent coefficient estimate rather than the predicted significant positive linear consequent estimate (i.e., levels of all negatively valenced emotions decreased significantly subsequent to binge-only events). Furthermore, only LNAV emotions also demonstrated a significant and negative consequent quadratic coefficient estimate, suggesting that the initial negative linear slope was accelerated only for LNAV emotions following binge-only events. Additionally, the initial downward deflection from the quadratic component was further intensified for LNAV emotions following binge-only events, because the consequent cubic coefficient was also significant and negative. In contrast to hypotheses, both LPAP and HPAP emotions rose significantly following binge-only events (i.e., both positively valenced emotion groups demonstrated significant and positive linear consequent coefficient estimates). The only difference in the trajectories between high arousal and low arousal positively valenced emotions was seen in the significant and positive quadratic consequent coefficient estimate for HPAP emotions, suggesting that the initial positive linear slope following binge–only events was accelerated only for HPAP emotions. The initial upward deflection from the quadratic component was further intensified for HPAP emotions following binge-only events, as evidenced by the significant and positive consequent cubic coefficient.

**Combined binge and purge events.** For coefficient estimates, confidence intervals, and graphical representation of the trajectories prior to and following combined binge and purge events see Tables 1 and 2, Figure 3 (for negatively valenced emotion groups) and Figure 4 (for positively valenced emotion groups). HNAV, HNAP, and LNAV all demonstrated significant and positive linear antecedent coefficient estimates as hypothesized (i.e., levels of all negatively valenced emotions rose significantly prior to combined binge and purge events). However, contrary to expectations, overlapping confidence intervals indicated that none of the linear coefficients (i.e., slopes) immediately prior to or following combined binge and purge events for any emotion group were significantly different from each other. As expected, HNAV emotions reached a significantly higher magnitude/intercept before combined binge and purge events than HNAP emotions but, inconsistent with predictions, the difference in magnitude between the intercepts of HNAV emotions and LNAV emotions prior to binge-only events did not reach significance. Partially consistent with our hypotheses, only HNAV emotions showed significant antecedent quadratic and cubic coefficient estimates. The initial positive linear antecedent slope was accelerated only for HNAV emotions (i.e., positive and significant quadratic coefficient estimate). However, the initial deflection from the quadratic component was dampened, as the antecedent cubic coefficient for HNAV emotions was negative and significant. Quadratic antecedent coefficient estimates were not significant for HNAP or LNAV emotions. As expected, both LPAP and HPAP emotions showed significant negative linear coefficient estimates prior to combined binge and purge events (i.e., all positively valenced emotions decreased significantly prior to episodes of combined binge and purge events). Furthermore and as expected, the antecedent trajectories, slopes, and intercepts of the positively valenced emotions did not differ significantly. Neither high or low arousal positive emotions demonstrated a significant antecedent quadratic coefficient.

As hypothesized, HNAV and HNAP emotions demonstrated significant negative linear consequent estimates, although, LNAV emotions also demonstrated a negative and significant linear consequent coefficient estimate rather than the predicted significant positive linear consequent estimate (i.e., levels of all negatively valenced emotions decreased significantly subsequent to combined binge and purge events). However, only HNAV emotions also demonstrated a significant and negative consequent quadratic coefficient estimate, suggesting that the initial negative linear slope was accelerated only for HNAV emotions following combined binge and purge events. The initial downward deflection from the quadratic consequent coefficient for HNAV emotions following combined binge and purge events was dampened, as the consequent cubic coefficient was positive and significant. In contrast to hypotheses, both LPAP and HPAP emotions rose significantly following combined binge and purge events (i.e., both positively valenced emotion groups demonstrated significant and positive linear consequent coefficient estimates). However, neither positively valenced emotion group demonstrated a significant quadratic coefficient estimate following combined binge and purge events. No significant differences were observed between the consequent trajectories and slopes of HPAP and LPAP emotions following combined binge and purge events.

**Purging.** For coefficient estimates, confidence intervals, and graphical representation of the trajectories prior to and following purge-only events see Tables 1 and 2, Figure 5 (for negatively valenced emotion groups), and Figure 6 (for positively valenced emotion groups). HNAV, HNAP, and LNAV all demonstrated significant and positive linear antecedent coefficient estimates as hypothesized (i.e., levels of all negatively valenced emotions rose significantly prior to purge-only events). However, contrary to expectations, overlapping confidence intervals indicated that none of the linear coefficients (i.e., slopes) immediately prior to or following purge-only events for any emotion group were significantly different from each other. As expected, HNAV emotions reached a significantly higher magnitude/intercept before purge-only events than HNAP emotions but, inconsistent with predictions, the difference in magnitude between the intercepts of HNAV emotions and LNAV emotions prior to purge-only events did not reach significance. In contrast to our hypotheses, all negatively valenced emotion groups (i.e., HNAV, HNAP, LNAV) showed significant and positive antecedent quadratic and cubic coefficients. Therefore, the initial antecedent linear slopes were deflected up and the rate of affect change for each emotion group was accelerated (i.e., positive and significant quadratic coefficient estimates). Because the antecedent cubic coefficients for all negatively valenced emotion groups were also all significant and positive, the initial upward deflection from the quadratic component was intensified and the rate of affect change for each negative emotion group was further accelerated. As expected, both LPAP and HPAP emotions showed significant negative linear coefficient estimates prior to reported purge-only events (i.e., all positively valenced emotions decreased significantly prior to purge-only events). Furthermore and as expected, the antecedent trajectories, slopes, and intercepts of the positively valenced emotions did not differ significantly. The initial antecedent linear slopes for positive emotions were deflected downward and levels of both high and low arousal positive emotion decreased at an accelerated rate (i.e., negative and significant quadratic coefficient estimates). Because the antecedent cubic coefficients for positively valenced emotion groups were also both significant and negative, the initial downward deflection from the quadratic component was intensified and the rate of affect change for each positive emotion group was further accelerated.

As hypothesized, HNAV, HNAP, and LNAV emotions all demonstrated significant negative linear consequent estimates (i.e., levels of all negatively valenced emotions decreased significantly subsequent to purge-only events). However, in contrast to hypotheses, there were no observed differences in consequent linear slopes between the negative emotion groups following purge-only events. Additionally none of the negatively valenced emotion groups demonstrated significant consequent quadratic coefficient estimates following purge-only events. In contrast to hypotheses, both LPAP and HPAP emotions rose significantly following purge-only events (i.e., both positively valenced emotion groups demonstrated significant and positive linear consequent coefficient estimates). However, neither positively valenced emotion group demonstrated a significant quadratic coefficient estimate following purge-only events. No significant differences were observed between the consequent trajectories and slopes of HPAP and LPAP emotions following combined binge and purge events.

**Summary.** Several novel findings should be highlighted from the with-in day analyses. In particular, avoidance- oriented emotions reached the highest magnitudes before engagement in bulimic behaviors. In particular, highly arousing avoidance-promoting emotions reached significantly higher magnitudes precipitating binge-only events, purge-only events and combined binge eating and purging events than highly arousing approach-oriented emotions. Low arousal avoidant emotions did not show higher intercept values than highly arousing approach-oriented moods, indicating that the combination of high arousal and avoidance motivations are the most motivating. Additionally, this is the first investigation of potential differences between positively valenced emotions in prompting and reinforcing bulimic behaviors. These data show that all positively valenced emotions, regardless of arousal levels, act similarly on these behaviors. Changes in arousal levels, for positively valenced emotions, did not additionally motivate or reinforce these behaviors, as would have been evidenced by either significantly different slopes, notably different trajectories, or differences in magnitudes pre-behaviors. One plausible interpretation of these findings is that emotional valence emerged as the only motivating and reinforcing dimension of positively valenced emotions in relation to bulimic events.

**Tests of Main Hypotheses: Between-Day Analyses**

**Negative valenced emotion groups.** The results of all between-day hypotheses are given in Tables 3 and 4 and overall are consistent with hypotheses. Mean levels of all negative emotion groups were shown to be statistically different across days that included either binge-only, purge-only, or combined binge and purge events. As predicted, marginal mean analyses revealed that HNAV emotions were significantly higher on days that included binge-only, purge-only, and combined binge and purge events compared to non-event days. However, marginal means for LNAV emotions were only significantly higher on days that included binge events compared to days that did not include binge events. In accordance with our predictions, the marginal means for LNAV emotions were not significantly different between days that included purge and combined binge and purge events and days that did not include these behaviors. Additionally, mean levels of HNAP emotions were not significantly different between days with binge events, combined binge and purge events, or purge events compared to days without these behaviors. Furthermore the mean level of HNAP emotions was significantly lower across days that included a disordered eating behavior than the mean level of HNAV emotions. This finding is consistent with within-day analyses, in that HNAV emotions reached higher magnitudes than HNAP emotions across behaviors.

**Positive valence emotion groups.** For binge-only days, levels of both LPAP and HPAP emotions were statistically significant as predicted. However, the marginal means analyses revealed that only mean levels of LPAP emotions were significantly higher on days without binge events. Consistent with hypotheses, purge-only and combined binge and purge days were significant predictors for levels of LPAP emotions across event and nonevent days. However, discordant with hypotheses, these models were not significant for HPAP emotions. Furthermore, marginal mean analyses revealed that average levels of LPAP emotions were not significantly lower on days with purge-only or combined binge and purge events compared to days without these events.

**Summary.** This is the first study to investigate differences in emotions groups between days that include bulimic events and days that do not in a sample of women with clinically significant BN pathology. Therefore, all findings from the current study are novel. Most importantly, these data demonstrate that emotions high in arousal levels that prompt avoidance behaviors are higher on days that include either binge eating, purging, or combined binge eating and purging behaviors. Emotions that are low in arousal but still promote avoidance behaviors are only higher on days with binge eating events. Equally interesting and consistent with conclusions from within-day analyses, are results showing that emotions high in arousal level but prompting of approach behaviors do not show higher mean levels on days that include any of the disordered eating behaviors and are lower across all event days than emotions high in arousal but prompting of avoidance behaviors. Because approach versus avoidance motivations are the only dimension that differentiates these emotions from high arousal, negatively valenced, avoidant emotions; between-day analyses further demonstrate that avoidance motivations are particularly relevant to bulimic behaviors. These data are also the first to show that low arousal positively valenced emotions reach higher mean levels only on days that include binge events. Furthermore, our results suggest that mean levels of high arousal positively valenced emotions are not different between days with purge-only or combined binge eating and purge events. Thus, levels of positively valenced high arousal emotions do not change significantly between days with and without purge-only and combined binge and purge events and mean levels of low arousal positively valenced emotions are not lower on days with these behaviors. These results demonstrate that changes in positively valenced moods are not much altered by bulimic behaviors.

Table 1

*Within-Day Multilevel Models for Binge, Purge, and Binge/Purge Episodes with Negatively Valenced Emotion Groups*

| | | | | HNAV | | | | HNAP | | | | LNAV | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Behavior | Variable | Est | *SE* | *p* | 95% CI | Est | *SE* | *p* | 95% CI | Est | SE | p | 95% CI |
| Binge-only | Intercept | 1.044 | .031 | **<.001** | .983,1.104 | .853 | .041 | **<.001** | .773, .932 | .984 | .038 | **<.001** | .910,1.059 |
| | Hours to behavior | .088 | .007 | **<.001** | .075, .100 | .082 | .010 | **<.001** | .063, .101 | .087 | .009 | **<.001** | .071, .104 |
| | (Hours to behavior)$^2$ | .008 | .001 | **<.001** | .006, .010 | .008 | .001 | **<.001** | .006, .011 | .008 | .001 | **<.001** | .006, .010 |
| | (Hours to behavior)$^3$ | .0002 | 2.6E-5 | **<.001** | .0001, .0002 | .0002 | 3.8E-5 | **<.001** | .0002, .0003 | .0002 | 3.3E-5 | **<.001** | .0001, .0003 |
| | (Hours to behavior)*Pre/Post | -.063 | .024 | **<.001** | -.087, -.040 | -.063 | .033 | **<.001** | -.096, -.031 | -.050 | .029 | **<.001** | -.079, -.021 |
| | (Hours to behavior)$^2$*Pre/Post | -.002 | .001 | .187 | -.004, .001 | -.001 | .002 | .366 | -.005, .002 | -.003 | .001 | **.012** | -.006, -.001 |
| | (Hours to behavior)$^3$*Pre/Post | -.0004 | 4.9E-5 | **<.001** | -.0005, -.0003 | -.0004 | 7.2E-5 | **<.001** | -.001, -.0003 | -.0003 | 6.5E-5 | **<.001** | -.0005, -.0002 |
| Purge-only | Intercept | .978 | .033 | **<.001** | .914, 1.041 | .795 | .038 | **<.001** | .720, .870 | .940 | .038 | **<.001** | .866, 1.015 |
| | Hours to behavior | .075 | .009 | **<.001** | .058, .092 | .055 | .010 | **<.001** | .035, .075 | .074 | .010 | **<.001** | .055, .093 |
| | (Hours to behavior)$^2$ | .007 | .001 | **<.001** | .005, .009 | .005 | .001 | **<.001** | .003, .008 | .007 | .001 | **<.001** | .004, .010 |
| | (Hours to behavior)$^3$ | .0002 | 3.7E-5 | **<.001** | .0001, .0002 | .0001 | 4.9E-5 | **.010** | 3.1E-5, .0002 | .0002 | 4.6E-5 | **<.001** | 8.0E-5, .0003 |
| | (Hours to behavior)*Pre/Post | -.049 | .029 | **<.001** | -.078, -.021 | -.043 | .033 | **<.001** | -.076, -.010 | -.045 | .034 | **<.001** | -.078, -.011 |
| | (Hours to behavior)$^2$*Pre/Post | -.003 | .001 | .066 | -.005, .0002 | -.001 | .002 | .528 | -.005, .002 | -.002 | .002 | .159 | -.006, .001 |
| | (Hours to behavior)$^3$*Pre/Post | -.0003 | 6.4E-5 | **<.001** | -.0004, -.0002 | -.0002 | 8.9E-5 | **.009** | -.0004, -5.9E-5 | -.0003 | 8.4E-5 | **<.001** | -.0005, -.0001 |
| Binge & Purge | Intercept | .938 | .031 | **<.001** | .878, .999 | .758 | .037 | **<.001** | .686, .830 | .892 | .037 | **<.001** | .819, .964 |
| | Hours to behavior | .036 | .004 | **<.001** | .029, .044 | .023 | .004 | **<.001** | .015, .032 | .034 | .004 | **<.001** | .026, .042 |
| | (Hours to behavior)$^2$ | .001 | .0003 | **.018** | .0001, .001 | -2.1E-5 | | .950 | -.001, .001 | 5.8E-5 | | .846 | -.001, |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | .0003 | | | | .0003 | | .001 |
| | (Hours to behavior)$^3$ | -7.6E-5 | 1.3E-5 | **<.001** | -.0001, -5.0E-5 | -9.0E-5 | 1.8E-5 | **<.001** | -.0001, -5.5E-5 | -10.0E-5 | 1.5E-5 | **<.001** | -.0001, -7.0E-5 |
| | (Hours to behavior)*Pre/Post | -.017 | .010 | **<.001** | -.027, -.007 | -.015 | .012 | **<.001** | -.027, -.003 | -.015 | .012 | **<.001** | -.026, -.003 |
| | (Hours to behavior)$^2$*Pre/Post | -.001 | .0003 | **.005** | -.002, -.0003 | -1.6E-5 | .0004 | .966 | -.001, .001 | -9.3E-5 | .0003 | .769 | -.001, .001 |
| | (Hours to behavior)$^3$*Pre/Post | .0001 | 1.6E-5 | **<.001** | 8.2E-5, .0001 | .0001 | 2.2E-5 | **<.001** | 8.1E-5, .0002 | .0001 | 1.8E-5 | **<.001** | 9.6E-5, .0002 |

Note: Est. = Parameter estimate; HNAV = high arousal, negative valence, avoidant emotions; HNAP = high arousal, negative valence, approach emotions; LNAV = low arousal, negative valence, avoidant emotions; SE = standard error; CI = confidence intervals; *pre/post indicates consequent trajectories; Bold indicates statistically significant values at $p < .05$

Table 2

*Within-Day Multilevel Models for Binge, Purge, and Binge/Purge Episodes with Positively Valenced Emotion Groups*

| | | LPAP | | | | HPAP | | | |
|---|---|---|---|---|---|---|---|---|---|
| Behavior | Variable | Est | *SE* | *p* | 95% CI | Est | *SE* | *p* | 95% CI |
| Binge-only | Intercept | .807 | .030 | **<.001** | .748, 866 | .899 | .028 | **<.001** | .844, .954 |
| | Hours to behavior | -.065 | .006 | **<.001** | -.076, -.054 | -.051 | .007 | **<.001** | -.064, -.038 |
| | (Hours to behavior)$^2$ | -.007 | .0007 | **<.001** | -.008, -.005 | -.006 | .0009 | **<.001** | -.008, -.004 |
| | (Hours to behavior)$^3$ | -.0002 | 2.5E-5 | **<.001** | -.0002, -.0001 | -.0002 | 3.1E-5 | **<.001** | -.0002, -.0001 |
| | (Hours to behavior)*Pre/Post | .060 | .022 | **<.001** | .038, .081 | .029 | .022 | **<.001** | .007, .050 |
| | (Hours to behavior)$^2$*Pre/Post | .001 | .001 | .655 | -.002, .003 | .003 | .001 | **.011** | .001, .006 |
| | (Hours to behavior)$^3$*Pre/Post | .0004 | 4.8E-5 | **<.001** | .0003, .0005 | .0003 | 5.2E-5 | **<.001** | .0002, .0004 |
| Purge-only | Intercept | .868 | .029 | **<.001** | .812, .924 | .944 | .028 | **<.001** | .890, .999 |
| | Hours to behavior | -.045 | .007 | **<.001** | -.059, -.032 | -.031 | .008 | **<.001** | -.046, -.015 |
| | (Hours to behavior)$^2$ | -.005 | .0009 | **<.001** | -.006, -.003 | -.004 | .001 | **<.001** | -.006, -.002 |
| | (Hours to behavior)$^3$ | -.0001 | 3.3E-5 | **<.001** | -.0002, -5.2E-5 | -.0001 | 3.8E-5 | **.001** | -.0002, -5.0E-5 |
| | (Hours to behavior)*Pre/Post | .049 | .025 | **<.001** | .024, .073 | .030 | .024 | **<.001** | .006, .053 |
| | (Hours to behavior)$^2$*Pre/Post | -.0004 | .001 | .734 | -.003, .002 | .001 | .002 | .470 | -.002, .004 |
| | (Hours to behavior)$^3$*Pre/Post | .0003 | 5.5E-5 | **<.001** | .0002, .0004 | .0002 | 6.0E-5 | **<.001** | 9.4E-5, .0003 |
| Binge & Purge | Intercept | .902 | .027 | **<.001** | .850, .954 | .965 | .026 | **<.001** | .914, 1.017 |
| | Hours to behavior | -.018 | .003 | **<.001** | -.024, -.012 | -.009 | .004 | **.033** | -.017, -.001 |
| | (Hours to behavior)$^2$ | -.0003 | .0002 | .143 | -.001, .0001 | -.0002 | .0003 | .451 | -.001, .0003 |
| | (Hours to behavior)$^3$ | 5.5E-5 | 1.1E-5 | **<.001** | 3.3E-5, 7.6E-5 | 3.9E-5 | 1.5E-5 | **.008** | 1.0E-5, 6.8E-5 |
| | (Hours to behavior)*Pre/Post | .015 | .009 | **<.001** | .006, .024 | .011 | .010 | **<.001** | .001, .021 |
| | (Hours to behavior)$^2$*Pre/Post | .0004 | .0002 | .075 | -4.5E-5, .001 | .0002 | .0003 | .534 | -.0004, .001 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | (Hours to behavior)$^3$*Pre/Post | -8.5E-5 | 1.3E-5 | **<.001** | -.0001, -5.9E05 | -5.3E-5 | 1.6E-5 | **.001** | -8.4E-5, -2.1E-5 |

Note: Est. = Estimate; LPAP = low arousal, positive valence, approach emotions; HPAP = high arousal, positive valence, approach emotions; SE = standard error; CI = confidence intervals; *pre/post indicates consequent trajectories; Bold indicates statistically significant values at $p < .05$

Table 3

*Between-Day Multilevel Models for Binge, Purge, and Binge/Purge Episodes with Negatively Valenced Emotion Groups*

| | | HNAV | | | | HNAP | | | | LNAV | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Behavior | Variable | Est | *SE* | *p* | 95% CI | Est | *SE* | *p* | 95% CI | Est | *SE* | *p* | 95% CI |
| Binge-only | Intercept | .913 | .032 | **<.001** | .849, .976 | .739 | .038 | **<.001** | .664, .814 | .872 | .038 | **<.001** | .797, .949 |
| | Bingeday | -.184 | .025 | **<.001** | -.233, -.134 | -.129 | .031 | **<.001** | -.190, -.068 | -.166 | .030 | **<.001** | -.226, -.107 |
| | Bingeday *Mean* | 2.491 | .080 | | 2.338, 2.654* | 2.094 | .080 | | 1.943, 2.257 | 2.392 | .091 | | 2.220, .2.577* |
| | Non-bingeday *Mean* | 2.073 | .065 | | 1.950, 2.204* | 1.840 | .057 | | 1.732, 1.955 | 2.026 | .078 | | 1.879, 2.184* |
| Purge-only | Intercept | .886 | .033 | **<.001** | .822, .950 | .717 | .036 | **<.001** | .645, .788 | .838 | .039 | **<.001** | .763, .914 |
| | Purgeday | -.161 | .029 | **<.001** | -.218, -.103 | -.108 | .033 | **.001** | -.172, -.044 | -.128 | .034 | **<.001** | -.195, -.061 |
| | Purgeday *Mean* | 2.425 | .079 | | 2.274, 2.585* | 2.048 | .075 | | 1.907, 2.199 | 2.313 | .089 | | 2.144, 2.494 |
| | Non-purgeday *Mean* | 2.065 | .069 | | 1.934, 2.205* | 1.838 | .060 | | 1.723, 1.959 | 2.034 | .081 | | 1.881, 2.200 |
| Binge & Purge | Intercept | .881 | .031 | **<.001** | .820, .943 | .707 | .036 | **<.001** | .637, .777 | .832 | .038 | **<.001** | .759, .906 |
| | BPday | -.177 | .027 | **<.001** | -.230, -.124 | -.101 | .032 | **.002** | -.163, -.038 | -.132 | .035 | **<.001** | -.200, -.065 |
| | BPday *Mean* | 2.414 | .076 | | 2.270, 2.567* | 2.028 | .072 | | 1.892, 2.174 | 2.299 | .086 | | 2.136, 2.475 |
| | Non-BPday *Mean* | 2.023 | .067 | | 1.896, 2.159* | 1.834 | .060 | | 1.719, 1.956 | 2.014 | .083 | | 1.857, 2.185 |

Note: Est. = Parameter estimate; HNAV = high arousal, negative valence, avoidant emotions; HNAP = high arousal, negative valence, approach emotions; LNAV = low arousal, negative valence, avoidant emotions; bingeday = days during which a binge event occurred; Purgeday = days during which a purge event occurred; BPday = days during which a combined binge and purge event occurred; SE = standard error; CI = confidence intervals; * = 95% confidence intervals do not overlap; Bold indicates statistically significant values at $p < .05$

Table 4

*Between-Day Multilevel Models for Binge, Purge, and Binge/Purge Episodes with Positively Valenced Emotion Groups*

| | | LNAP | | | | HPAP | | | |
|---|---|---|---|---|---|---|---|---|---|
| Behavior | Variable | Est | *SE* | *p* | 95% CI | Est | *SE* | *p* | 95% CI |
| Binge-only | Intercept | .913 | .027 | **<.001** | .860, .965 | .973 | .025 | **<.001** | .924, 1.021 |
| | Bingeday | .107 | .022 | **<.001** | .065, .150 | .055 | .022 | **.012** | .012, .098 |
| | Bingeday *Mean* | 2.491 | .067 | | 2.363, 2.625* | 2.645 | .065 | | 2.520, 2.776 |
| | Non-bingeday *Mean* | 2.773 | .065 | | 2.648, 2.904* | 2.795 | .064 | | 2.671, 2.924 |
| Purge-only | Intercept | .932 | .026 | **<.001** | .881, .984 | .983 | .025 | **<.001** | .935, 1.031 |
| | Purgeday | .090 | .023 | **<.001** | .045, .135 | .045 | .024 | .060 | -.002, .092 |
| | Purgeday *Mean* | 2.540 | .067 | | 2.413, 2.674 | 2.672 | .066 | | 2.547, 2.804 |
| | Non-purgeday *Mean* | 2.779 | .069 | | 2.647, 2.918 | 2.796 | .068 | | 2.666, 2.931 |
| Binge & Purge | Intercept | .941 | .026 | **<.001** | .891, .991 | .991 | .023 | **<.001** | .946, 1.037 |
| | BPday | .082 | .022 | **<.001** | .038, .126 | .032 | .022 | .136 | -.010, .074 |
| | BPday *Mean* | 2.562 | .065 | | 2.437, 2.694 | 2.694 | .063 | | 2.574, 2.820 |
| | Non-BPday *Mean* | 2.781 | .070 | | 2.647, 2.922 | 2.782 | .068 | | 2.652, 2.918 |

Note: Est. = Parameter estimate; LPAP = low arousal, positive valence, approach emotions; HPAP = high arousal, positive valence, approach emotions; bingeday = days during which a binge event occurred; Purgeday = days during which a purge event occurred; BPday = days during which a combined binge and purge event occurred SE = standard error; CI = confidence intervals; * = 95% confidence intervals do not overlap; Bold indicates statistically significant values at $p < .05$

Table 5

*Bivariate Correlations between Dimensionally Determined Emotion Groups*

| Emotion Group | HNAV | HNAP | LNAV | LPAP | HPAP |
|---|---|---|---|---|---|
| 1. HNAV | * | .718** | .665** | -.498** | -.210** |
| 2. HNAP | | * | .554** | -.463** | -.225** |
| 3. LNAV | | | * | -.467** | -.305** |
| 4. LPAP | | | | * | .708** |
| 5. HPAP | | | | | * |

Note: HNAV = high arousal, negative valence, avoidant emotions; HNAP = high arousal, negative valence, approach emotions; LNAV = low arousal, negative valence, avoidant emotions; LPAP = low arousal, positive valence, approach emotions; HPAP = high arousal, positive valence, approach emotions.

*$p < .05$, **$p < .001$

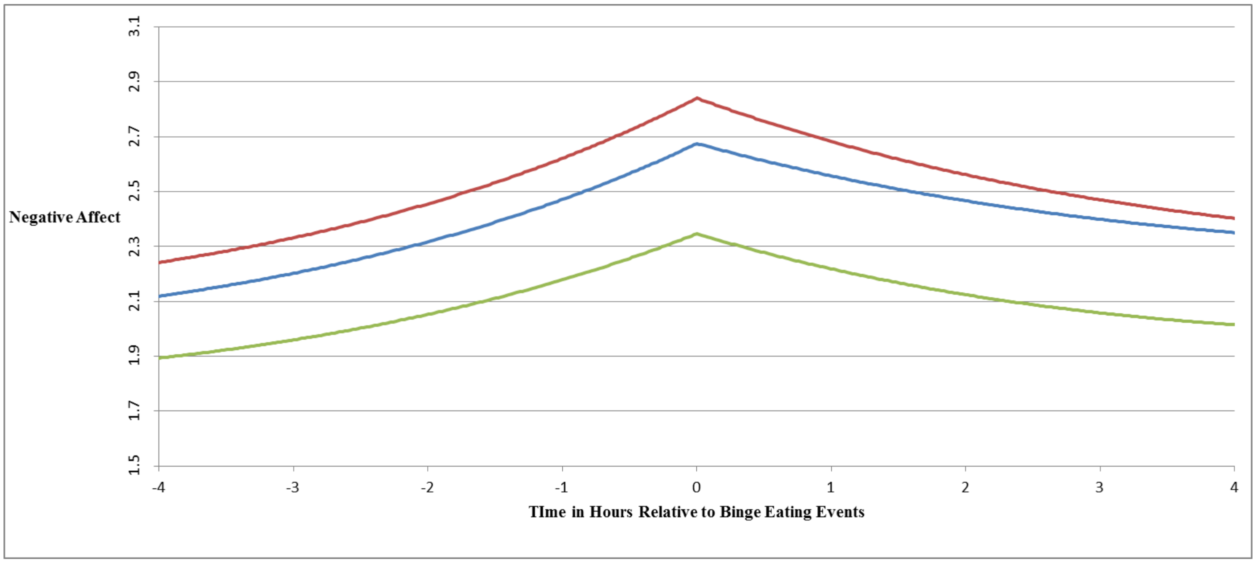


*Figure 1.* Level of high arousal negative valence avoidant emotions (HNAV), high arousal negative valence approach emotions (HNAP), and low arousal negative valence avoidant (LNAV) emotions over time in relation to binge-only events. Red = HNAV emotions; Blue = LNAV emotions; Green = HNAP emotions.

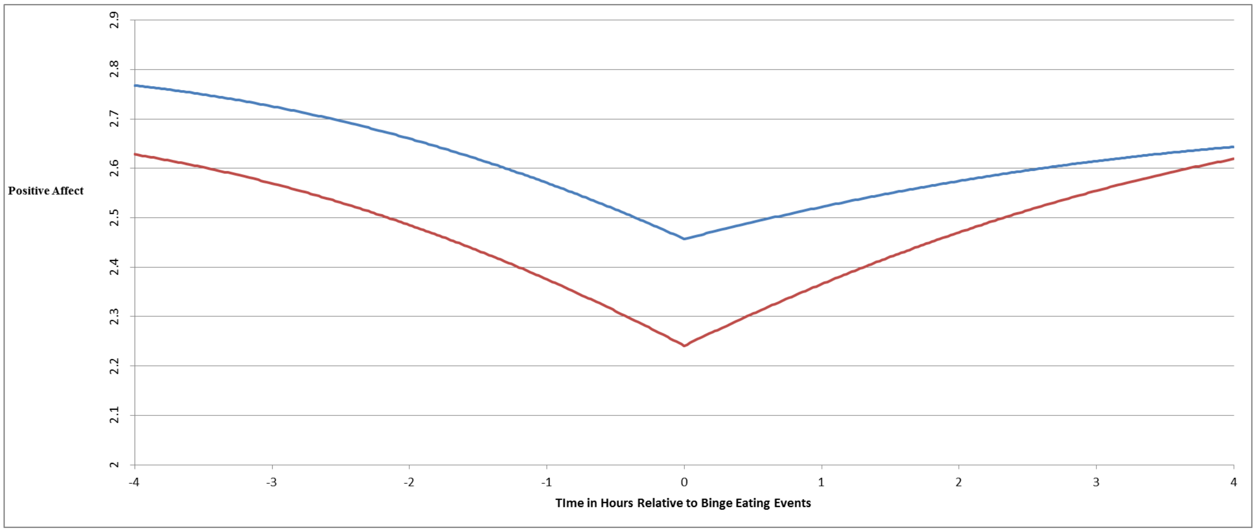


*Figure 2.* Level of low arousal positive valence approach emotions (LPAP) and high arousal positive valence approach emotions (HNAP) over time in relation to binge-only events. Red = LPAP emotions; Blue = HPAP.

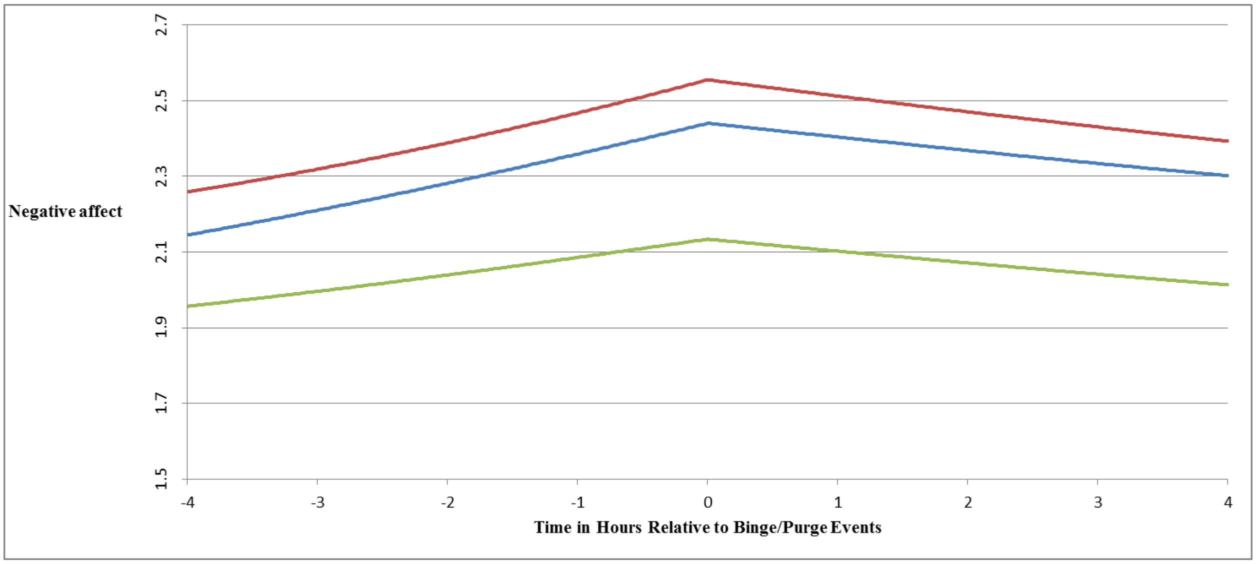


*Figure 3.* Level of high arousal negative valence avoidant emotions (HNAV), high arousal negative valence approach emotions (HNAP), and low arousal negative valence avoidant (LNAV) emotions over time in relation to combined binge and purge events. Red = HNAV emotions; Blue = LNAV emotions; Green = HNAP emotions.

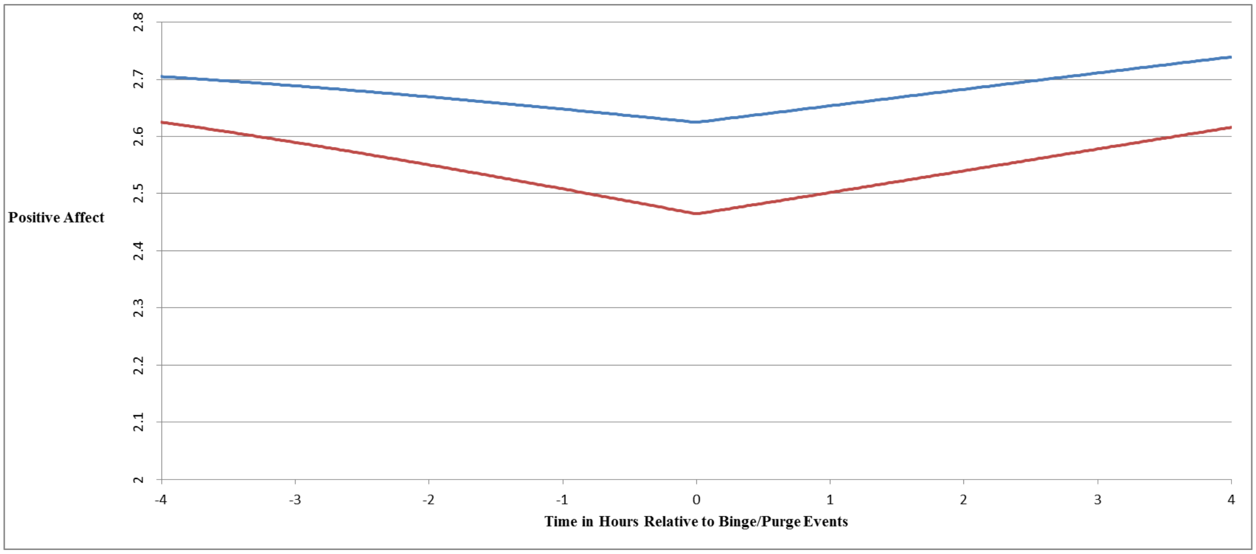


*Figure 4.* Level of low arousal positive valence approach emotions (LPAP) and high arousal positive valence approach emotions (HNAP) over time in relation to combined binge and purge events. Red = LPAP emotions; Blue = HPAP.

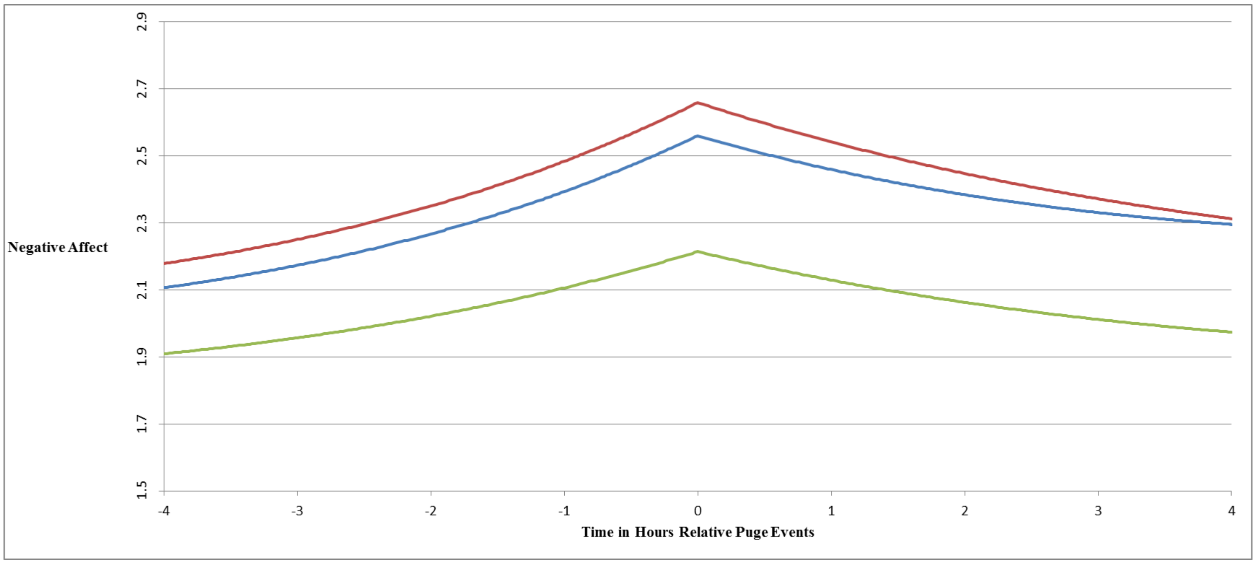


*Figure 5.* Level of high arousal negative valence avoidant emotions (HNAV), high arousal negative valence approach emotions (HNAP), and low arousal negative valence avoidant (LNAV) emotions over time in relation to purge-only events. Red = HNAV emotions; Blue = LNAV emotions; Green = HNAP emotions.

# Chapter 4

# DISCUSSION

The purpose of this study was to apply a dimensional theory of emotions to within-day trajectory analyses of emotional experiences before and after disordered eating behaviors in a sample of women with bulimia nervosa. Additionally, we wanted to examine if emotions, grouped together based on a theoretical understanding of these dimensions, were different between days that included disordered eating behaviors and days that did not. We reviewed literature and polled experts to determine the placement of 24 discrete mood states assessed in the parent study (Smyth et al., 2007) on three dimensions of emotional experience: arousal (e.g., degree of alertness versus lethargy), valence (degree of pleasantness versus unpleasantness), and motivation (degree of engagement versus withdrawal from one's environment). Five groups were generated according to these dimensions (i.e., HNAV, HNAP, LNAV, LPAP and HPAP) and separate within-day (i.e., trajectory) and between-day models were analyzed for each emotion group across binge-only, purge-only, and combined binge and purge events. Findings from these models will be discussed as they relate to trajectories prior to behaviors (i.e., antecedent portions of curves), following behaviors (i.e., consequent portions of curves), and between-day findings.

## Emotion Group Trajectories Before Disordered Eating Behaviors

In replication of previous findings, our results demonstrate that negatively valenced emotions (i.e., negative affect) rise significantly before binge eating and purging behaviors (Berg et al., 2012; Engel et al., 2013; Haedt-Matt & Keel, 2011; Smyth et al., 2007). Thus, irrespective of arousal level and approach/avoidance motivation, negative moods significantly increased prior to binge-only, purge-only, or combined binge and purge events. No differences in slopes were observed between negatively valenced emotions, suggesting that the rate of increases across HNAV, HNAP, and LNAV emotions was equivalent.

Consistent with hypotheses and with results reported by Smyth et al., (2007) all positive moods (high and low arousal) decreased significantly before all disordered eating events and no trajectory differences were observed between high and low arousal positively valenced emotion groups. Additionally, the intercepts between HPAP and LPAP emotions were not statistically different. Thus, our results extend current knowledge about the behavior of positive moods before bulimic behaviors, in that arousal level did not influence the slope, trajectory, or intercept of positively valenced emotions prior to binge eating, purging behaviors, or combined binge eating and purging behaviors.

While generally consistent with previous studies conducted using the same sample, the reported trajectory findings for negatively valenced moods were different in a several notable ways. Neither Berg et al., (2012) or Engel et al., (2007) found significant antecedent trajectories for hostility or anger before purge-only events. Engel et al., (2007) also failed to find a significant trajectory for anger prior to binge eating. In contrast, the HNAP emotion group in the current study, composed of items from the PANAS hostility and the POMS anger-hostility subscales, demonstrated significant antecedent trajectories across binge-only, purge-only and combined binge and purge events. It is likely that the addition of the “peeved” and “annoyed” items in the construction of the HNAP emotion group contributed to the observed linear trajectory difference before purge-only events compared to results reported by Berg et al., (2012). However, differences between the current study and Engel et al., (2007) are likely reflective of distinctive analytical strategies. Engel et al., (2007) calculated anger trajectories from least square slopes analyses and included these values as predictors in two-level hierarchical generalized linear models with a binomial sampling distribution. The goals of these models were to predict the presence or absence of binge eating and purging behaviors. In the present study, GEE models examined changes in mood in relation to disordered eating behaviors.

As predicted, only HNAV emotions showed an accelerated antecedent trajectory (i.e., a significant quadratic coefficient the same sign as the linear coefficient) before combined binge and purge events. This result also is dissimilar from the analyses conducted for Berg et al., (2012) because, in the cited study, all emotion factors (e.g., Fear, Guilt, Hostility, and Sadness) showed significant antecedent quadratic coefficients before combined binge and purge events. The noted finding is relevant because it was a predicted difference. However, it should not be overly emphasized because linear coefficients for all emotion groups were significant in the current study and quadratic coefficients represent portions of the curve father away from the behavior (Bolger & Laurenceau, 2013). Changes closer to the behavior (i.e., linear coefficients) are considered to be more strongly related to engagement in the behavior than trajectory changes farther away (Bolger & Laurenceau, 2013). However, this finding does lend support to our hypothesis that HNAV emotions should show unique trajectories from HNAP and LNAV emotions prior to disordered eating behaviors. In addition to the non-significant linear, quadratic, and cubic coefficients reported by Berg et al., (2012) for the Hostility factor preceding purge-only events, the only other coefficient that was differentially found to be significant in our antecedent results was the cubic coefficient for LNAV emotions preceding purge-only events (Sadness factor in Berg et al., 2012). Although we used similarly constructed multilevel models as those reported in Berg et al., (2012), we employed GEE models rather than mixed model designs. It is, therefore, possible that the slight differences found between quadratic and cubic coefficients in our study are due to different analytical approaches.

Although HNAV emotions showed comparable antecedent trajectories to both HNAP and LNAV emotions, the magnitudes reached by HNAV emotions at the intercept (i.e., time of the disordered eating event) were significantly higher than the magnitudes reached by HNAP emotions for all behaviors. This finding is partially consistent with our hypotheses: We expected HNAV emotions to reach higher magnitudes than both HNAP emotions and LNAV emotions. Results suggested that binge eating, purging behaviors, and combined binge eating and purging are strongly prompted by avoidance (versus approach) motivations. The importance of avoidance motivations to disordered eating behaviors can be inferred because both HNAV and LNAV emotions encourage withdrawal from environmental stimuli whereas HNAP emotions encourage environmental engagement (Carver & Harmon-Jones, 2009). In addition, it appears that the combination of high arousal with strong urges to withdraw most strongly prompts disordered eating behavior because LNAV emotions (i.e., low arousal with avoidance motivations) did not reach statistically higher magnitudes than HNAP (high arousal approach motivations) emotions. Therefore, it may be that the primary reason for binge-only, purge-only, and combined binge eating and purge events is the reduction of highly arousing emotions that promote avoidance behaviors. These data provide preliminary evidence that avoidance motivations are fundamental to engagement in bulimic behaviors and suggest that a reduction in high arousal levels is also an important motivation for disordered eating.

Berg et al., (2012) reported that the Guilt subscale of the PANAS reached higher magnitudes before binge-only and combined binge and purge events than the PANAS Sadness, Hostility, and Fear subscales. The HNAV emotion group in the current study consists of items from the Guilt subscale (e.g., “ashamed”) as well as items from the PANAS Fear subscale (e.g., “nervous”) and additional items judged to have negative valence, high arousal, and avoidance motivations (e.g., “distressed”) as noted in previous studies (Klonsky 2009; Morgan & Heise, 1988). It is possible that combing items from the Fear and Guilt subscale reduced the homogeneity of the HNAV construct and, therefore, made it less likely that we would be able to detect differences between it and other constructs. However, this explanation alone seems unlikely, as HNAV emotions reached higher magnitudes than HNAP emotions across all behaviors and the Guilt factor did not reach higher magnitudes than other PANAS factors before purge-only events (Berg et al., 2012). Furthermore, our trajectory findings largely correspond with findings reported by Berg et al., (2012) and we found additional significant antecedent coefficients using the emotional groups constructed according to the dimensional emotional model. Bivariate correlations between HNAV, HNAP, and LNAV emotion groups in our sample also were consistent with expectations, suggesting that while correlated, these groups were related to each other in predictable ways (i.e., highest correlations between HNAV and HNAP and between HNAV and LNAV but lower correlation between LNAV and HNAP). Finally, the composition of the HNAV emotion group was derived from three-dimensional models of emotion (Morgan & Heise, 1988), previous expert polls (Klonsky 2009), additional input from a moral emotions expert (Dr. Tangney), and ratings by current study investigators. However, it is also notable that the moral emotions are not included in many affect circumplexes (Feldman, 1995; Posner et al., 2005; Neuman & Waldstein, 2001) and have been rated differently by experts on arousal and approach/avoidance dimensions (Klonsky 2009; Morgan & Heise, 1988), reflecting the inherent difficulty in mapping discrete emotions onto a three-dimensional space.

**Relevance of avoidance/approach dimension to disordered eating.** The approach/avoidance motivational dimension can be considered a key dimensional of emotional experience despite its absence from many emotional circumplex models. Results across EEG studies indicate that unique cortical circuits are involved in organizing behavior to reach goals or incentives versus behaviors that are organized to avoid threats or punishments (Carver & Harmon-Jones, 2009). Consistently, approach motivations are represented by left anterior cortical activation while avoidance motivation is displayed by elevated activity in the right anterior cortex (Carver & Harmon-Jones 2009; Coan & Allen, 2004). However, most research has equated positive valence with approach motivation and negative valence with avoidance motivations (Carver & Harmon-Jones, 2009). Importantly, studies which have disentangled valence from motivational systems have discovered that anger-related emotions are routinely associated with left anterior cortical activity, therefore, activating approach motivational circuits (Carver & Harmon-Jones, 2009). Thus, anger can be classified as an appetitive or approach emotion, in part, because it elicits various biological responses representative of approach emotions such as left anterior cortical activity, a characteristic pattern of cardiovascular activity, and similar facial expressions as positively valenced emotions (Carver & Harmon-Jones, 2009; Harmon-Jones, E. & Harmon-Jones, C, 2011). Additionally, the definition of anger suggests a thwarted goal or disruption of an approach behavior (Carver & Harmon-Jones 2009). Therefore, anger contravenes theories of emotions, which purport that appetitive or approach-motivated emotions are always positively valenced and negatively valenced emotions are always associated with withdrawal or aversion (Carver & Harmon-Jones, 2009). Furthermore, classifying anger as an approach emotion allows for the discrimination between anger emotions and other highly arousing negative mood states such as anxiety and fear that promote avoidance behaviors (Carver & Harmon-Jones, 2009; Morgan & Heise, 1988).

Higher intercept values for HNAV emotions compared to HNAP emotions supports previous research suggesting that disordered eating behaviors manifest as a way to withdraw from aversive self-awareness (e.g., shame and guilt following failure) and is consistent with escape theory (Cooper, 2005; Fox & Power, 2009; Heatherton & Beaumeister, 1991). However, given that anger acts as an approach-related emotion, evidence that avoidance motivations may more strongly incite disordered eating appears contradictory to previous literature citing anger as a central emotion to eating disorders (Milligan & Waller, 2000; Milligan, Waller, & Andrews, 2002; Milligan & Waller, 2001). For example, higher levels of state anger have been found in clinical samples of women who engage in binge eating and vomiting and higher mean levels of anger were shown to predict binge eating and self-induced vomiting in this sample (Engel et al., 2007; Waller et al., 2003). Importantly, many studies investigating the role of anger-related emotions to disordered eating did not compare anger against other emotions preventing the relative influence of anger from being determined.

Several emotional models of eating disorders purport that certain emotions, such as anger, are suppressed or avoided because individuals consider these emotions to be ego-dystonic, frightening, or inappropriate (Corstophine, Mountford, Tomlinson, Waller, & Meyer, 2006; Fox & Power 2009; Waller et al., 2003). Correspondingly, anger has been shown to be especially challenging for individuals with bulimic symptoms to regulate, as individuals report high levels of state anger concurrent with difficult expressing anger-related emotions (Waller, et al., 2003). Presumably, binge eating and purging behaviors evolve as methods to avoid anger expression and resist anger urges (e.g., Fox & Power, 2009; Safer, Telch, & Chen, 2003). However, this model suggests that individuals with disordered eating are aware of urges to express anger (i.e., approach motivations) and choose instead to suppress the emotion (avoidance behavior). This description is resonant of emotional models that discriminate between primary and secondary emotional responses (e.g., Linehan 1993; Linehan 2015). Accordingly, primary anger is theorized to be followed by secondary guilt, disgust, or fear because anger is considered inappropriate, frightening, or ego-dystonic (Fox & Power, 2009; Linehan, 1993; Linehan, 2015). Negative emotions in these models are then combined or "coupled" together such that an unacceptable emotion is inhibited by an acceptable emotion (Fox & Power, 2009). Anger and fear could also be "coupled" because many situations evoke both emotions concurrently (e.g., anger at being in a car crash and fear that you or the other driver is badly hurt) and both are associated with similar physiological responses (i.e., "fight or flight" response to threats; Carver & Harmon-Jones, 2009). It is possible that when both emotions are elicited by an environmental situation, certain individuals who consider anger to be ego-dystonic, act on avoidance motivations. Results from the current analyses could offer support for theories of "coupled emotions" because all negatively valenced emotions rose before each disordered eating behavior, but HNAV emotions reached higher magnitudes than HNAP emotions at the time behaviors occurred. Therefore, HNAP emotions (i.e., anger related affect) and associated approach motivations may have been suppressed by avoidance motivations associated with concurrent increases in HNAV emotions (e.g., guilt, anxiety, disgust).

**Emotion Group Trajectories Following Disordered Eating Behaviors**

Consequent trajectory analyses supported the affect regulation model of bulimia as all negatively valenced emotion groups (i.e., HNAV, HNAP, LNAV) displayed trajectories characterized by a significant linear decrease following binge-only, purge-only, and combined binge and purge events. There were no differences in consequent slopes between any of the negative moods, signifying that all negatively valenced moods decrease at similar rates following disordered eating behaviors (i.e., overall decline in negative valence). Interestingly, it appears from the combined negatively valenced trajectory graphs for binge-only and purge-only events (see Figures 1 and 5) that the slopes between LNAV and HNAV emotions would likely intersect if the time frame was extended beyond four hours post-behaviors. This may indicate that the consequent slope for LNAV emotions stabilizes before the slope of HNAV emotions.

While these overall results are consistent with previous studies utilizing multilevel trajectory analytic methods (Berg et al., 2012; Engel et al., 2013; Smyth et al., 2007), they are distinct from studies which have employed single point analyses (e.g., Engel et al., 2013; Haedt-Matt & Keel, 2011). Contrary to hypotheses, LNAV emotions did not rise following binge-only or combined binge and purge events and, instead, showed the most accelerated decline following binge only events (i.e., the only negatively valenced mood group with a significant negative consequent quadratic coefficient accelerating the linear negative linear consequent coefficient). Thus, differences in arousal level and avoidance/approach dimensions did not alter the direction of consequent trajectories of negatively valenced moods, further solidifying conclusions that reported increases in negative mood following binge eating are best explained via differences in analytical methods (Engel et al., 2013). Similar to meta-analytic results describing levels of negative moods post-purge-only behaviors, all negatively valenced emotion groups decreased following purge-only events (Haedt-Matt & Keel, 2011).

Comparisons across the negatively valenced trajectory graphs for binge-only, purge-only, and combined binge and purge events (Figures 1, 3, and 5) also revealed that negatively valenced emotion groups did not decrease beyond pre-behavior engagement levels even four hours post disordered eating events. Consistent with previous literature on the affect regulation model (Haedt-Matt & Keel, 2011; Smyth et al., 2007), this comparison demonstrates that disordered eating behaviors are not effective at reducing overall levels of negative affect, but rather function as short-term relief from acute peaks in negatively valenced moods (Haedt-Matt & Keel, 2011; Ferriter & Ray, 2011; Smyth et al., 2007).

Similar to antecedent models, slight differences were found between results from the current study and those reported in Berg et al., (2012). As all linear coefficients were significant in these analyses but linear slopes were not unique, it is important to remember that the differences in cubic and quadratic coefficients should not be interpreted as representing consequential differences between emotion groups. Instead these differences signify only slight changes in trajectories farther from behavior engagement. Additionally, differences in the significance of cubic and quadratic coefficients between Berg et al., (2012) and the current study most likely are reflective of differences in analytic approaches (i.e., GEE versus mixed models). The quadratic and cubic coefficients were found to be significant in the current study for LNAV emotions following binge-only events. This may suggest that negatively valenced, low arousal, emotions show an accelerated decline following binge-only behaviors. Of note, the Sadness factor from Berg et al. (2012) did not show significant quadratic or cubic coefficients following binge-only events. As in the antecedent results, only HNAV emotions showed significant quadratic coefficients following combined binge and purge events. Notably, this finding offers some support to our hypotheses that HNAV emotions should show trajectories different from other negatively valenced mood states and suggests that HNAV emotions decline at an accelerated rate following combined binge and purge events. This result is discrepant from results reported by Berg et al., (2012), as the Sadness factor also showed a significant quadratic coefficient following combined binge and purge events. Finally, the Hostility cubic coefficient following purge-only events was not found to be significant by Berg et al., (2012) but was in the current study.

As anticipated, LPAP emotions increased following all disordered eating behaviors, however, HPAP emotions also ascended at equivalent rates to LPAP emotions (discrepant from hypotheses). Thus, arousal level did not influence the direction or gradient of the linear slope of positively valenced emotion groups following disordered eating behaviors. Results extend previously reported conclusions (Smyth et al., 2007) by showing that equivalent to positive affect changes post binge-only and post purge-only events, positive affect also increases following combined binge and purge events. In contrast to analyses conducted with single point analyses, there was no indication that positively valenced moods continued to decrease following binge-only events (Haedt-Matt & Keel, 2011). These findings also appear to eliminate post-behavior variations in arousal levels as sources of additional positive reinforcement. The only observed difference between HPAP emotions and LPAP emotions throughout the within-day analyses is represented by the significant quadratic consequent coefficient for HPAP emotions following binge-only events. No other antecedent, consequent, or intercept differences were noted. Taken alone, this finding does not justify concluding that high and low positive valence emotions function differently before and after disordered eating behaviors. It seems more appropriate to interpret these findings as showing that disordered eating behaviors are positively reinforced by overall increases in levels of positive valence regardless of arousal level.

**Emotion Group Differences between Event and Non-event days**

To our knowledge, this study is the first investigation of differences between groups of emotions on days that include disordered eating and days that do not in a sample of women with clinically significant eating pathology. Previous studies have investigated overall levels of negative and positive affect on event and non-event days, concluding that negative affect is higher and positive affect is lower on days during which disordered eating behaviors occurred (Engel et al., 2013; Smyth et al., 2007). Additionally, Wegner et al., (2002) examined changes in subscales of the PANAS and POMS (e.g., Depression/Dejection, Anger/Hostility, Positive Affect, and Negative Affect) in a small (27 participant) college sample, concluding that negative affect was higher on event days and positive affect lower on event days than non-event days. Similarly, our analyses revealed that levels of HNAV, HNAP, and LNAV emotion groups were significantly different on days that included binge-only, purge-only, or combined binge and purge events. However, only average levels of HNAV emotions were shown to be higher across behaviors on event days. HNAP emotions did not show higher mean levels on event days for any behavior, and average levels of LNAV were only higher for binge-only days. These findings suggest that average higher levels of HNAV emotions are related to the occurrence of binge-only, purge-only, and combined binge and purge events. Consistent with within-day trajectory analyses, HNAV emotions also were higher on event days for each behavior than HNAP emotions. Taken together, it's possible that this pattern of results further supports theories that HNAV emotions are "coupled" with other mood states (Fox & Power, 2009; Linehan, 1993; Linehan, 2003). Higher levels of HNAV emotions on event days may suggest an additional rise of secondary emotions (e.g., shame, disgust, anxiety) resultant from primary ego-dystonic emotions (e.g., anger, frustrated).

In a class analysis of mood trajectories by day, Crosby et al., (2009) reported that the highest percentage of binge-only and purge-only events occurred on days with increasing levels of negative affect, high levels of stable negative affect, and 'U-shaped' negative affect (i.e., moderate levels of initial and final negative affect with lower levels of negative affect between these ratings; Crosby et al., 2009). Disordered eating occurred at lower frequency on days with low stable negative affect and decreasing negative affect (Crosby et al., 2009). The authors concluded that the mood trajectory patterns most indicative of bulimic behaviors suggest that these events are more likely to occur in the later half of the day and, therefore, are more likely to be driven by escalating negative mood states that reach a "threshold" (Crosby et al., 2009). These pattern may be reflected in our results, as individuals may be experiencing higher levels of overall negative moods on event days (e.g., stable high levels of negative affect) as represented by significant differences for all negative mood groups between event and non-event days. Days with increasing negative affect, and consequentially the days most likely to include a binge, purge, or combined binge and purge event, may be characterized by gradual elevations in arousal levels and urges to avoid, possibly from suppressed or coupled negative moods. Smyth et al, (2007) reported similar conclusions by asserting that bulimic behaviors occur on "dysphoric days" and further stating that mood becomes increasingly more negative approaching an eating disorder event. Importantly, this is the first study to examine differences in groups of emotions derived from dimensional models of emotional experience between days with and without disordered eating behaviors. Therefore, we can only speculate about the differences observed in this study, and future studies should test these conclusions by measuring valence, arousal, and approach/avoidance dimensions specifically. Additionally, this pattern may be different for days in which multiple behaviors occurred, as we limited our analyses to days with only one occurrence of each specified disordered eating event.

Average levels of LNAV emotions also were higher on days characterized by binge-only events. Caloric restriction has been shown to increase the likelihood of binge eating using EMA data (Zunker, et al., 2011). Low caloric intake and protein malnutrition also have been related to elevations in corticotrophin-releasing hormone and reductions in serotonin functioning, both of which have been shown to correspond with the development of sad or depressed mood states and difficulty regulating mood (Chandler-Laney et al., 2007; Fox & Power, 2009). Even in healthy populations, extreme diets have been related to increased reports of lower mood and decreased alertness (Fox & Power, 2009; Roky, Iraki, HajKhlifa, Ghazal, & Hakkou, 2000), and, according to the dual pathway model (Stice, 2001), dieting increases risk for disordered eating via increases in negative affect. Thus, it is possible that binge-only days are associated with mean differences in LNAV moods (e.g., sadness) compared to non-binge days because individuals are engaging in prolonged periods of dietary restriction and are experiencing associated low mood and energy levels. It is also possible that LNAV mood states may just be more strongly related to binge eating than to purging behaviors or combined binge eating and purging. Some findings associate sadness with binge eating (Macht, 2008) and sadness has been shown to increase attentional allocation to food stimuli in experimental paradigms (e.g., Hepworth, Mogg, Brignell, & Bradley, 2010).

Although analyses indicated that there were significant differences between event and non-event days across behaviors for LPAP emotions, only on binge-only days were average levels of LPAP emotions significantly lower. Significant differences between HPAP emotions only were found between binge-only days and days without binge-only events. However, mean levels of HPAP emotions were not shown to be significantly lower on binge-only days. Levels of HPAP emotions were not significantly different on days with or without purge-only events or days with or without combined binge and purge events. These findings suggest positively valenced emotions characterized by low arousal are likely the emotions responsible for differences in positive affect between event and non-event days reported in previous studies (Smyth et al., 2007). Although speculative, it may be that LPAP emotions were significantly different between event and non-event days and showed lower mean levels on binge-only event days because individuals are less likely to report feeling calm and relaxed on days that are marked by higher arousal states. (i.e., higher mean levels of HNAV emotions, significant differences on event days for HNAP emotions and similar levels of HPAP emotions between event and non-event days).

Results from both between-day analyses and within-day trajectory analyses suggest that disordered eating behaviors are not prompted by alterations in positively valenced moods (Crosby et al., 2009). Further supporting this conclusion is evidence that both high and low arousal positively valenced moods were present at equal or higher mean levels across event and non-event days compared to negatively valenced emotion groups. Similar findings have been reported in relation to NSSI, as individuals who engage in NSSI do not report lower levels of positive affect when compared with individuals who do not engage in NSSI (Klonsky et al., 2003). Taken together, these results may signify that the capacity to experience positive affect is not reduced despite reliance on dysregulated behaviors for negative mood regulation (Klonsky et al., 2003).

**The Trade-Off Theory**

The current results do not support the trade-off theory (Haedt-Matt & Keel, 2011; Kenardy et al., 1996). HNAV emotions did not reach significantly higher magnitudes than LNAV emotions before any disordered eating event but, instead, showed intercepts higher than HNAP emotions. This is problematic for the theory as both HNAP and HNAV are considered to be high on both negative valence and arousal levels. Therefore, arousal cannot be responsible for the higher magnitudes reached by HNAV emotions. In fact, it seems more likely that differences in avoidance/approach motivations are related to the higher magnitudes reached by HNAV emotions prior to behavior engagement. Additionally, all consequent trajectories for negatively valenced emotion groups showed similar rates of descent. Support for the trade-off theory would have been evident had HNAV and HNAP emotions declined as a steeper rate following behaviors than LNAV emotions or had LNAV emotions, but not HNAV or HNAP emotions, demonstrated a significant positive or flat trajectory post-behaviors (Haedt-Matt & Keel, 2011). Despite a lack of evidence from the current study for the trade-off theory, it is important to note that arousal was not measured directly. Therefore, to specifically test this theory, arousal and valence dimensions should be assessed using a dimensional measure and results should be examined for significantly greater decreases in arousal levels than improvements in valence.

**Possible Moderators**

Results from the current study suggest that negatively valenced moods that elicit intense urges to avoid emotional and environmental stimuli and increase arousal levels may most strongly prompt disordered eating behaviors. Support for this conclusion is shown in trajectory analyses demonstrating that HNAV emotions, but not LNAV emotions, reached significantly higher magnitudes before all disordered eating behaviors than did HNAP emotions, and between-day analyses revealing higher mean levels of only HNAV emotions on days which include purge-only or combined binge and purge events. However, we failed to find any significant differences in either antecedent or consequent linear slopes between negatively valenced moods. Evidence of significantly different linear coefficients between negatively valenced mood states would represent the strongest support for including arousal and approach/avoidance dimensions into our understanding of the relationship between mood and disordered eating behaviors. However, it is possible that moderators obscured trajectory differences in the current study and could be examined in future work.

**Difficulty distinguishing between arousal and valence.** Individuals have varying levels of insight into their emotional experiences and, therefore, differ in their ability to differentiate emotions (e.g., Barrett, 1998; Feldman, 1995; Linehan, 2015). Distinguishing among discrete emotions becomes increasingly difficult between emotions that share valence and arousal levels (Barrett, 1998). Thus, individuals who have difficulty noticing the dimensions of arousal and valence show altered placements of discrete moods on two-dimensional graphs of emotions and have altered "affective circumplexes" from individuals who take both dimensions into account when determining their mood (Barrett, 1998; Feldman, 1995). For example, in an ideal circumplex the correlation between anxiety and depression would be moderate, however, an individual who is valenced-focused (e.g., unaware of changes in arousal) would have a much higher correlation between these two mood states (Feldman, 1995). In essence, individuals who are valence-focused are more likely to confuse mood states and report higher co-occurrences of emotions with similar valence levels (i.e., experience globally positive of negative moods; Barrett, 1998). Thus, emotions such as anxiety, anger, guilt, sadness, etc. would frequently be reported together. As engagement in dysregulated eating behaviors represents poor overall emotion regulation (Linehan 2015; Safer et al., 2003), it is conceivable that many of our participants had difficulty distinguishing between discrete moods. Thus, our ability to detect unique antecedent and consequent negative mood trajectories using dimensional groups derived from discrete mood states would be reduced.

**Alexithymia.** Relatedly, some literature identifies individuals with eating disorders as having "alexithymia" or a profound difficulty in identifying discrete moods, distinguishing feelings from somatic sensations, and describing their emotions to others (e.g., Bydlowski et al., 2005; Fox & Power, 2009). Reasons cited for the development of this cognitive deficit include higher levels of childhood abuse in histories of individuals with disordered eating and higher levels of expressed emotion in families of individuals with disordered eating (e.g., Rayworth, Wise, & Harlow, 2004; Zabala, Macdonald, & Treasure, 2009). Relevant findings show that individuals with disordered eating, irrespective of the duration of the illness, show a global deficit in emotion-processing independent of concurrent mood disorders that markedly reduces individuals' ability to identify moods in themselves and in others (Bydlowski et al., 2005). It also appears that, while individuals with eating disorders have adequate verbal skills, they cannot access these to describe emotional experiences (Bydlowski et al., 2005). Therefore, the ability of individuals with eating disorders to understand and tolerate emotions is dramatically reduced, resulting in easily feeling overwhelmed by emotions (Bydlowski et al., 2005).

As individuals in the current sample met criteria for bulimia nervosa, it is possible that many also exhibited low emotional understanding and therefore were not able to differentiate which discrete moods they experienced. Particularly when experiencing urges to binge eat and purge, participants may have felt overwhelmed and indicated experiencing many negative moods simultaneously, making it difficult to distinguish unique trajectories for mood groups. Notably, individuals with anorexia may exhibit more difficulty with emotional awareness than individuals with bulimia (Bydlowski et al., 2005) and some contend that this represents an after affect of extreme dieting on cognitive functioning (Fox & Power, 2009). As it is unclear the extent to which individuals with bulimia (showing varying levels of caloric restriction) show diminished emotional recognition, measures of alexithymia (i.e., the Toronto Alexithymia Scale: TAS; Levels of Emotional Awareness Scale) could be included in future studies (Lane, Quinlan, Schwartz, Walker, & Zeitlin, 1990; Taylor, Ryan, & Bagby, 1985). Future studies also may benefit from combining dimensional assessment of emotions (eliminating the necessity for individuals to label discrete moods) with physiological measurements that can be easily be adopted into an EMA protocol (e.g., heart rate monitors).

**Negative urgency.** Individuals with eating disorders, and particularly those individuals who engage in binge eating and purging behaviors, have often been characterized as having high levels of trait impulsivity (Stice, 2002). Additionally, previous studies have indicated that higher levels of impulsivity increase sensitivity to intense mood states, making engagement in maladaptive behaviors more likely (Bekker, van de Meerendonk, & Mollerus, 2004; Engel et al., 2007; Wonderlich, Connolly, & Stice, 2004). A specific facet of impulsivity, negative urgency (or the tendency for rash action under emotional distress), has routinely been shown to be more strongly related to and a better predictor of binge eating and purging the than the broadly defined impulsivity term and other facets of impulsivity (e.g., Whiteside & Lynam 2001; Fischer, Peterson, & McCarthy, 2013; Fischer, Smith, & Cyders, 2008). Recent evidence demonstrates that urgency interacts with acute mood, specifically the arousal component of acute mood, to predict palatable food consumption in a laboratory setting (Davis-Becker, Fischer, & Miller in submission). Perhaps highly arousing emotions are only intensely aversive and uniquely prompting of disordered eating behaviors for individuals who also show high levels of trait urgency. If so, then their trajectories would likely be lost in the amalgamation of all mood ratings across all days for all subjects. Future EMA work may consider including assessment of negative urgency (UPPS-P; Whiteside & Lynam, 2001) in study protocols.

**Value of Dimensional Models of Emotional Experience**

Despite generally similar antecedent and consequent trajectories between HNAV, HNAP, and LNAV emotions; differences in intercept magnitudes and in mean levels of negatively valenced moods between event and non-event days support assertions that emotional dimensions add to our understanding of the relationship between mood and disordered eating. In addition to these preliminary findings, there are several other factors that enhance the value of using this dimensional model in studying disordered eating behaviors with EMA methodology.

The debate between discrete versus dimensional models of emotions continues as multiple authors report new evidence for physiological/autonomic nervous system specificity for discrete moods (e.g., Kolodyazhniy et al., 2011**;** Murugappan et al., 2010; Stephens et al., 2010). Still, others allege that specific moods cannot be differentiated via autonomic responses because emotional identification requires cognitive processing to organize valence, arousal, perceptions/interpretations, and memories into emotional experiences (Neuman, & Waldstein, 2001; Posner et al., 2005; Posner et al., 2009). Many studies promoting models of discrete emotions argue for the presence of basic emotions (e.g., anger, sadness, disgust, happiness, and fear) that evolved to prepare an organism for unique actions, and therefore, require distinct somatic changes (Ekman, 1992a; 1992b). Importantly, which emotions and the number of basic emotions remains unclear, and none include the moral emotions of guilt and shame (Fox & Power, 2009). This is because guilt and shame are considered emotions that are learned once an individual develops prerequisite skills, i.e., the ability to recognize themself as distinct from others and the ability to understand and internalize behavior standards (Eisenberg, 2000). However, throughout the disordered eating literature, guilt and shame have shown robust associations with the common core beliefs found in eating disorders and are related to explanations regarding the negative impact of thin-ideal internalization on body dissatisfaction/body shame (e.g., Goss & Allan, 2009 Stice & Shaw, 1994). Additionally, results indicate that guilt and shame are related to engagement and reinforcement from binge eating and purging (Berg et al., 2012). Therefore, a model that does not specify predictions for these mood states seems inappropriate for the understanding of disordered eating behavior. While traditional two-dimensional models also neglected guilt and shame and demonstrated difficulty differentiating between anger and anxiety, the addition of the potency or approach/withdrawal dimension allows for all emotions to be differentiated using these dimensions (Morgan & Heise, 1988).

Emotional theories using discrete mood states also are extremely complicated, requiring the discussion of primary and secondary moods or other descriptions (e.g., “coupled emotions”) to explain mood co-occurrence and contradictory motivational urges (Fox and Power, 2009; Linehan, 1993; Linehan 2015). Dimensional models appear to better, and more parsimoniously, account for overlapping/ambiguous physiological sensations and mood co-occurrence (e.g., emotions share similar placements on arousal and/or valence dimensions). Furthermore, every individual does not appear to experience discrete moods at constant valence and arousal levels (“unique affective circumplexes; Feldman, 1995; Barrett, 1998) but dimensional models allow for individuals to simply rate their placement on each dimension. This may be far easier, especially for individuals with low levels of emotion understanding, than attempting to label the combined experience of all three dimensions as a single emotion. This could be particularly helpful for emotions that change meaning based on their “direction” (e.g., anger at self versus anger at others). However, it is not likely or desirable that dimensions replace the use and understanding of emotion names, because these constructs do facilitate communication of affective experiences (Linehan, 2015). In addition, learning to understand specific emotions is related to improved emotion regulation and effective behavior management even when emotionally distressed ( Linehan 2015). However, dimensional models may be an effective way to assess emotional experiences using EMA study designs and may simplify generalization of results across studies.

**Strengths**

The current study is unique in the application of a dimensional model of emotional experience to the understanding of emotional trajectories before and after binge-only, purge-only, and combined binge and purge events. Previous research examining the relationship between mood and disordered eating behaviors focused on the broad constructs of negative and positive affect (Haedt-Matt & Keel, 2011; Smyth et al., 2007) or studied the trajectories of discrete mood states (Berg et al., 2012; Wegner et al., 2001). While exceptionally important findings have emerged from these studies, particularly evidence from trajectory analyses in support of the affect regulation model (Smyth et al., 2007; Berg et al., 2012; Engel et al., 2007), a more nuanced understanding of the negative and positive reinforcement forces acting on disordered eating may have been obscured by heterogeneous terms like “negative affect.” Additionally, individuals with eating disorders may have difficulty distinguishing between discrete moods, but may be more accurate at recognizing their level of arousal, valence, and motivation to avoid or engage. Using a dimensional model to organize emotional experiences allows for more homogeneous emotional states to be studied while simultaneously providing possible explanations for observed differences in how emotions influence behavior (i.e., different levels of negative valence and arousal and approach versus avoidance motivations).

In addition to the novelty of applying a dimensional model to emotional experiences before and after disordered eating behaviors, the current study has several additional strengths. EMA protocols overcome significant methodological problems that are hallmarks of retrospective study designs (Engel et al., 2013; Mehl & Conner, 2012; Smyth et al., 2007). Rather than attempting to remember behaviors that occurred days or weeks apart from an assessment period, participants in the current study were asked to report on behaviors and moods that occurred minutes or, at most, hours in the past (Crosby et al., 2009). Thus, the temporal order of moods and eating behaviors can be determined from time-stamped momentary data with minimal influence from recall bias because antecedent mood ratings are reported before behaviors. The behavior and antecedent ratings are separate, meaning participants are not attempting to reconstruct their mood given their behavior (i.e., "I must have been upset because I binged;" Engel et al., 2013). Relatedly, the signal-contingent, event-contingent, and end of day ratings provided a large number of observations, allowing for powerful statistical techniques to estimate more comprehensive depictions of the relationship between emotional groups and disordered eating behaviors than single point analyses would allow (Berg, et al., 2012; Engel, et al., 2007). Further, the two-week study length can be considered a strength because conclusions made from multiple assessments of mood before and after episodes of binge eating and purging are less likely to have been influenced by chance events (Haedt-Matt & Keel, 2011). EMA data also allows for behavior and mood to be studied more 'in context' than would experimental or survey methods, thereby, extending the external validity of these findings (Mehl & Conner, 2012). Finally, by examining binge-only, purge-only, and combined binge and purge events separately, the relationship between mood and each type of behavior could be studied for differences and similarities (Berg et al., 2012).

The sample used in this study also represents an important strength. The sample was large and was composed of women with clinically significant levels of eating pathology who were evaluated via structured clinical interviews by highly trained and reliable assessors and who were not seeking treatment. Findings may then be more generalizable then studies who utilize treatment-seeking populations, as research suggests that those individuals suffer from greater pathology and higher levels of overall negative affect (Berg et al., 2012; Haedt-Matt & Keel, 2011).

**Limitations**

Despite theoretical precedence for organizing emotions into groups based on the dimensions of arousal, valence, and approach/withdrawal (Fox & Power, 2009; Morgan & Heise, 1988; Posner et al., 2005; Poser et al., 2009), the resulting emotional groups used in the current study (i.e., HNAV, HNAP, LNAV, LPAP, HPAP) were not empirically generated. Additionally, several of the items from the PANAS and POMS were not used in the current study because there was no theoretical justification for placing them in one group versus another. However, the aim of this study was to specifically test a theoretical organization of emotional states using dimensional theory rather than examine factors determined statistically. Importantly, it is clear from results reported by Berg et al., (2012) that differentially organized groups of emotions (grouped according to a factor analysis in Berg et al., 2012) show slightly altered results. In general, this limitation represents the difficulty of mapping emotions onto dimensions because the same emotion words are not used in all dimensional models and words are not consistently placed along axes across studies or across experts (Feldman, 1995; Klonsky 2009; Morgan & Heise, 1988; Neuman & Waldstein, 2001; Posner et al., 2005). We decided to model our dimensional groups from emotional ratings reported in the self-harm literature (Klonsky, 2009) because NSSI and bulimic pathology have been hypothesized to show similar emotional motivations and consequences (Chapman et al., 2006; Gratz, 2003; Klonsky 2007; Klonsky, 2009; Klonsky & Muehlenkamp, 2007; Nock et al., 2009). However, as several of our results deviate from the NSSI literature, it will be important for future studies to utilize dimensional assessments, such as the affect grid (Russel et al., 1989), to directly measure changes in valence, affect, and approach/withdrawal motivations before and after disordered eating behaviors.

Although EMA methodology has multiple strengths, it is still a form of self-report (Mehl & Conner, 2012). Therefore, it is possible that individuals did not report all instances of binge eating and purging, and/or reported episodes that did not occur. However, the extent to which noncompliance impacts findings is unknown (Crosby et al., 2009). Participants also were trained in defining binge episodes, but all episodes reported during the EMA protocol were self-rated (Berg et al., 2012). Previous research has suggested that lay definitions of binge eating emphasize loss of control over amount of food consumed (e.g., Beglin & Fairburn, 1992). It is possible that participants counted eating episodes as binge episodes if loss of control was present despite the amount of food eaten and, therefore, the relationships described in the current study may really be between loss of control eating episodes and changes in emotional dimensions (Berg et al., 2012; Haedt-Matt & Keel, 2011). Although there is evidence that reactivity is minimal in EMA studies, there is some concern that self-monitoring, particularly in signal-contingent study designs, may influence behavior (Stein & Corty, 2003). Previous results from this sample demonstrated that mood patterns were not significantly different between the first and second week of the paradigm, suggesting that self-monitoring did not reduce initial behavior frequency (Crosby et al., 2009). The current study also employed a 2-day trail period to train participants, provide feedback on compliance, and reduce possible reactivity effects (Smyth et al., 2007).

EMA data are rarely collected in the moments immediately surrounding events, but these few seconds may be principal in determining and motivating behavior (Engel et al., 2013). However, it is likely that collecting data during such a small time window would elevate reactivity and markedly reduce ecological validity because participants would be completing the EMA protocol at points when their mood and cognitions could be the most intense (i.e., these moments would naturally prompt behaviors of interest not EMA ratings; Engel et al., 2013). Relatedly, the current study focused on the four hours before and after events. It is possible that the temporal relationship between emotions and disordered eating differs outside of this time frame in ways that are relevant to understanding reinforcement schedules and behavior motivations (Berg et al., 2012). While the focus of this study was how different dimensions of negative and positive affect influence disordered eating behaviors, we did not study negative mood precipitants (Engel et al., 2013). It may be that specific cognitive states (e.g., ruminating over gaining weight), other behaviors (e.g., weighing, fat checking), or interpersonal interactions (arguments, social comparison and "fat talk") prompt negative moods that are strongly related to disordered eating (e.g., Gapinski, Brownell, & LaFrance, 2003; Tiggerman, & McGill, 2004). Since we discovered that avoidance motivations are strongly relevant to engagement in binge eating, purging, and combined binge eating and purging, it would be informative to ascertain the types of internal or external events that generate these motivations. Overall, there are numerous other contextual factors including behaviors, personality traits, and thinking patterns that might influence these relationships or help to explain them.

The current data provide strong support for the temporal relationship between changes in mood and disordered eating behaviors, but they are still correlational and, therefore, we cannot allege that changes in emotional dimensions cause disordered eating behaviors (e.g., Haedt-Matt & Keel, 2011; Smyth et al., 2007). Similarly, we cannot claim that engaging in binge eating, purging, or combined binge eating and purging causes reductions in negatively valenced moods and increases in positively valenced moods (Haedt-Matt & Keel, 2011). However, experimental study designs are not limited by the same restrictions on inferring causation and multiple studies have reported that experimentally induced mood states are related to caloric intake (Chua, Touyz, & Hill, 2004; Macht, 2008). The data from the current study support the ecological validity of experimental paradigms by showing that negatively valenced moods are related to eating behaviors and that arousal and approach/avoidance motivations may further motivate palatable food consumption (Davis-Becker, Fischer, & Miller, 2015; Haedt-Matt & Keel, 2011).

Despite the large number of participants with clinically significant eating pathology, there are limitations within our sample. Only adult women who were not seeking treatment were included and, therefore, these results may not generalize to men, adolescents, or treatment seeking populations. This sample is composed of only women who met criteria for bulimia nervosa and, therefore, we cannot assume that our findings related to binge-only events would extend to individuals with binge eating disorder. Additionally, as our sample was primarily Caucasian, these results also should not be generalized across ethnic or racial groups.

The participants in our sample also reported low levels of NSSI and, therefore, may differ meaningfully from treatment seeking populations where bulimia is often highly comorbid with NSSI (Claes et al., 2010). Despite co-occurrence rates between bulimic behaviors and NSSI reaching as high as 72% (Claes et al., 2010), only 19 women out of 133 (14.3%) reported NSSI over the two-week EMA period for a total of 55 instances of NSSI in this sample (Muehlenkamp et al., 2009). Therefore, it is possible that the current sample represents a unique group of women with bulimia who show different affect regulation motivations than individuals with disordered eating who more frequently engage in NSSI.

**Conclusions**

The current study demonstrates that a dimensional model of emotional experiences has merit in understanding disordered eating behaviors. Our results were largely consistent with previous literature in showing that negatively valenced moods increase while positively valenced moods decrease before binge-only, purge-only, and combined binge and purge events. These results extend previous findings by suggesting that negatively valenced emotions composed of high avoidance motivations, possibly coupled with high arousal levels, are the most motivating emotions (e.g., higher magnitudes in within-day analyses and higher levels between event and non-event days). Consequent trajectory analyses demonstrated further support for the affect regulation model in that all negatively valenced moods decreased following disordered eating behaviors. We discovered that behaviors may be positively reinforced only by increases in positive valence irrespective of arousal levels. This is the first study to examine how differences in positively valenced moods may reinforce disordered eating. The dimensional model suggests that negatively valenced moods do not act identically on disordered eating, but perhaps more importantly, the model provides theoretically based explanations for how discrete moods, like disgust, anxiety, and shame, prompt bulimic behaviors. Future studies can test hypotheses that high motivations to avoid environmental stimuli and high arousal levels explain relationships between certain emotions and disordered eating by utilizing dimensional measures paired with physiological data.

## REFERENCES


Agras, W. S., & Telch, C. F. (1998). The effects of caloric deprivation and negative affect on binge eating in obese binge-eating disordered women. *Behavior Therapy, 29*(3), 491-503.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: American Psychiatric Publishing.

American Psychiatric Association (1994). *Diagnostic and statistical manual of mental disorders* ($4^{th}$ ed.). Washington, DC: Author.

Ballinger, G.A. (2004). Using generalized estimating questions for longitudinal data analysis. *Organizational Research Methods, 7(*2), 127-150.

Barrett, L.F. (1998). Discrete emotions or dimensions? The role of valence focus and arousal focus*.* *Cognition and Emotion, 12(4)*, 579-599.

Bekker, M. H. J., van de Meerendonk, C., & Mollerus, J. (2004). Effects of Negative Mood Induction and Impulsivity on Self-Perceived Emotional Eating. *International Journal of Eating Disorders, 36*(4), 461-469.

Beglin, S. J., & Fairburn, C. G. (1992). What is meant by the term "binge"? *The American Journal of Psychiatry, 149*, 123–124.

Berg, K.C., Crosby, R.D., Cao, L., Peterson, C.B., Engel, S.G., Mitchell, J.E., & Wonderlich, S.A. (2012). Facets of Negative Affect Prior to and Following Binge-Only, Purge-Only, and Binge/Purge Events in Women With Bulimia Nervosa. *Journal of Abnormal Psychology, 122*(1), 111-118.

Bolger, N. & Laurenceau, J.P. (2013). *Intensive longitudinal methods: An introduction to diary and experience sampling research*. New York, NY: The Guilford Press.

Bydlowski, S. Corcos, M., Jeammet, P., Paterniti, S., Berthoz, S., Laurier,…Consoli, S.M. (2005*). International Journal of Eating Disorders, 37*, 321-329.

Carver, C.S. & Harmon-Jones, E. (2009). Anger is an approach-related affect: Evidence and implications. *Psychological Bulletin*, *135*(2), 183-204.

Chandler-Laney, P.C., Castaneda, E., Pritchett, C.E., Smith, M.L., Giddings, M., Artiga, A.I., & Boggiano, M.M. (2007). A history of caloric restriction induces neurochemical and behavioral changes in rats consistent with models of depression. *Pharmacology Biochemistry and Behavior, 87*(1), 104-114.

Chanel, G., Kronegg, J., Grandjean, D., & Pun, T. (2006). Arousal elevation using EEG's and peripheral physiological signals. In *Multimedia Content Representation* (pp. 530-537). Springer Berlin Heidelberg.

Chapman, A. L., Gratz, K. L., & Brown, M. Z. (2006). Solving the puzzle of deliberate self-harm: The experiential avoidance model. *Behaviour research and therapy*, *44*(3), 371-394.

Chua, J.L., Touyz, S., & Hill, A.J. (2004). Negative mood-induced overeating in obese binge eatingers: an experimental study. *International Journal of Obesity, 28*, 606-610.

Claes, L. Klonsky, D.E., Muehlenkamp, J. Kuppens, P., & Vandereycken. (2010). The affect-regulation function of nonsuicidal self-injury in eating-disorder patients: Which affect states are regulated? *Comprehensive Psychiatry, 51*, 386-292.

Coan, J. A., & Allen, J. J. B. (2004). Frontal EEG asymmetry as a moderator and mediator of emotion. *Biological Psychology, 67*, 7–49.

Cools, J., Schotte, D.E., & McNaly, R.J. (1992). Emotional arousal and overeating in restrained eaters. *Journal of Abnormal Psychology, 101(2),* 348-351.

Cooper, M.J. (2005). Cognitive theory in anorexia nervosa and bulimia nervosa: Progress, development and future directions. *Clinical Psychology Review, 25*, 511–531.)

Corstophine, E., Mountford, V., Tomlinson, S., Waller, G., & Meyer, C. (2007). Distress tolerance in the eating disorders. Eating Behaviours, 8, 91–97.

Crosby, R.D., Wonderlich, S.A., Engel, S., Simonich, H., Smyth, J., & Mitchell J.E. (2009). Daily mood patterns and bulimic behaivors in the natural environment. *Behavior Research and Therapy, 47*, 181-188.

Davis, K., & Fischer, S. (2012). The Influence of Trait Anger, Trait Anxiety and Negative Urgency on Disordered Eating. *Personality and Individual Differences* 307-310.

Davis-Becker, K., Fischer, S., & Miller, J.D. (in submission). Effects of attentional bias, negative urgency, and emotional dimensions on palatable food consumption.

Eisenberg, N. (2000). Emotion, regulation, and moral development. *Annual Review of Psychology, 51*, 665-697.

Ekman, P. (1992a). An argument for basic emotions. *Cognition & Emotion*, *6*(3-4), 169-200.

Ekman, P. (1992b). Are there basic emotions? *Psychological Review, 99*(3), 550-553.

Elmore, D. K., & de Castro, J. M. (1990). Self-rated moods and hunger in relation to spontaneous eating behavior in bulimics, recovered bulimics, and normals. *International Journal of Eating Disorders, 9*, 179–190.

Engel, S.G., Boseck, J.J., Crosby, R.D., Wonderlich, S.A., Mitchell, J. E., Smyth, J.,…Steiger, H. (2007). The relationship of momentary anger and impulsivity to bulimic behavior. *Behavior Research and Therapy, 45*, 437-447.

Engel, S.G., Wonderlich, S.A., Crosby, R.D., Mitchell, J.E., Crow, S., Peterson, C.B., … Gordon, K.H. (2013). The role of affect in the maintenance of anorexia nervosa: Evidence from a naturalistic assessment of momentary behaviors and emotion. *Journal of Abnormal Psychology, 122*(3), 709-719.

Feldman, L.A. (1995). Valence focus and arousal focus: Individual Differences in the structure of affective experience. *Personality and Social Psychology, 69*(1), 153-166.

Ferriter, C. & Ray, L.A. (2011). Binge eating and binge drinking: An integrative review. *Eating Behaviors, 12*, 99-107.

First, M. B., Spitzer, R. L., Gibbon, M., & Williams, J. B. (1995). Structured clinical interview for the DSM–IV axis I disorders—patient edition (SCID–I/P, version 2). New York, NY: New York State Psychiatric Institute, Biometrics Research Department.

Fischer, S., Peterson, C. M., & McCarthy, D. M. (2013). A prospective test of the influence of negative urgency and expectancies on binge eating and purging. *Psychology of Addictive Behaviors,* 294-300.

Fischer, S., Smith, G. T., & Cyders, M. A. (2008). Another look at impulsivity: A meta-analytic review comparing specific dispositions to rash action in their relationship to bulimic symptoms. *Clinical Psychology Review, 28*(8), 1413-1425.

Fox, J.R.E. & Power, M.J. 2009. Eating disorders and multi-level models of emotion: An integrated model. *Clinical Psychology and Psychotherapy, 16*, 240-274.

Gapinski, K.D., Brownell, K., & LaFrance, M. (2003). Body objectification and “Fat Talk”: Effects on emotion, motivation, and cognitive performance. *Sex Roles, 48,* 377-388.

Goss, K. & Allan, S. (2009). Shame, pride, and eating disorders *Clinical Psychology and Psychotherapy, 16,* 303-316.

Gratz, K.L. (2003). Risk factors for and functions of deliberate self-harm: An empirical and conceptual review. *Clinical Psychology: Science and Practice, 10*, 192-205.

Haedt-Matt, A. a, & Keel, P. K. (2011). Revisiting the affect regulation model of binge eating: A meta-analysis of studies using ecological momentary assessment. *Psychological bulletin*, *137*(4), 660-81.

Harmon-Jones, E., & Harmon-Jones C. (2010). On the relationship of trait PANAS positive activation and trait anger: Evidence of a suppressor relationship. *Journal of Research in Personality, 44*, 120-123.

Heatherton, T.F. & Baumeister, R.F. (1991). Binge eating as escape from self-awareness. *Psychological Bulletin, 110*(1), 86-108.

Heck, R.H., Tomas, S.L., Tabeta, L.N. (2012). *Multilevel modeling of categorical outcomes using IBM SPSS.* New York, NY: Taylor & Francis Group.

Hepworth, Mogg, Brignell, & Bradley (2010). Negative mood increases selective attention to food cues and subjective appetite. *Appetite, 54,* 134-142.

Hetherington, M. M., Altemus, M., Nelson, M. L., Bernat, A. S., & Gold, P. W. (1994). Eating behavior in bulimia nervosa: Multiple meal analyses. *The American Journal of Clinical Nutrition, 60*, 864–873.

Herzog, D. B., Keller, M. B., Sacks, N. R., Yeh, C. J., & Lavori, P. W. (1992). Psychiatric comorbidity in treatment-seeking anorexics and bulimics. *Journal of the American Academy of Child and Adolescent Psychiatry,31*, 810–817.

Holzer, S.R., Uppala, S., Wonderlich, S.A., Crosby, R.D., & Simonich, H. (2008). Mediational significance of PTSD in the relationship of sexual trauma and eating disorders. *Child Abuse & Neglect, 32,* 561-566.

Hudson, J.I., Hiripi, E., Pope, H.G., & Kessler, R.C. (2007). The prevalence and Correlates of Eating Disorders in the National Comorbidity Survey Replication. *Biological Psychiatry, 61*, 348-258.

IBM Corporation. (2013). IBM SPPSS Statistics for Macintosh (Version 22) [computer software]. Armonk, NY: Author.

Kashubeck-West, S., Mintz, L.B., & Saunders, K.J. (2001). Assessment of eating disorders in women. *The counseling Psychologist, 29*, 662-694.

Kaye, W.H., Greeno, C.G., Moss, H., Fernstrom, J., Fernstrom, M., Lilenfeld, L.R., Weltzin, T.E., & Mann, J.J. (1998). Alterations in serotonin activity and psychiatric symptoms after recovery from bulimia nervosa. *Archives of General Psychiatry 55*,927–935.

Kaye, W. H., Gwirtsman, H. E., George, D. T., Weiss, S. R., & Jimerson, D. C. (1986). Relationship of mood alterations to bingeing behaviour in bulimia. *British Journal of Psychiatry, 149*, 479–485.

Keel, P.K., Wolfe, B.E., Liddle, R.A., De Young, K.P., & Jimerson, D.C. (2007). Clinical features and physiological response to a test meal in purging disorder and bulimia nervosa. *Archives of General Psychiatry, 64* (9), 1058-1066.

Kenardy, J., Arnow, B., & Agras, W.S. (1996). The aversiveness of specific emotional states associated with binge-eating in obese subjects. *Australian and New Zealand Journal of Psychiatry, 30*, 839-844.

Kensinger, E.A. & Schacter, D.L. (2006). Processing emotional pictures and words: Effects of valence and arousal. *Cognitive, Affective, & Behavioral Neuroscience, 6*(2), 110-126.

Keski-Rahkonen, A., Hoek, H.W., Linna, M.S., Raevuori, A., Sihvola, E., Bulik, C.M., Rissanen, A., & Kaprio, J. (2009). Incidence and outcomes of bulimia nervosa: A nationwide population-based study. *Psychological Medicine, 39*, 823-831.

Klonsky, D.E. (2007). The functions of deliberate self-injury: A review of the evidence. *Clinical Psychology Review, 27*, 226-239.

Klonsky, D.E. (2009). The functions of self-injury in young adults who cut themselves: Clarifying the evidence for affect regulation. *Psychiatry Research, 166*(2-3), 260-268.

Klonsky, D.E., & Muehlenkamp, J.J. (2007). Self-injury- A research review for the practitioner. *Journal of Clinical Psychology, 63*(11), 1045-1056.

Klonsky, E.D., Oltmanns, T.F., & Turkheimer, E. (2003). Deliberate self-harm in a nonclinical population: Prevalence and psychological correlates. *The American Journal of Psychiatry, 160*(8), 1501-1508.

Kolodyazhniy, V., Kreibig, S. D., Gross, J. J., Roth, W. T., & Wilhelm, F. H. (2011). An affective computing approach to physiological emotion specificity: Toward subject-independent and stimulus-independent classification of film-induced emotions. *Psychophysiology, 48*, 908-922.

Lane, R.D., Quinlan, D.M., Schwartz, G.E., Walker, P.A., & Zeitlin, S.B. (1990). The levels of Emotional Awareness Scale: A cognitive-developmental measure of emotion. *Journal of Personality Assessment, 55*, 124–134.

Liang, K. Y., & Zeger, S. L. (1986). Longitudinal analysis using generalized linear models. Biometrika, 73, 13–22.

Lorr, M., & McNair, D. M. (1971). The Profile of Mood States manual. San Diego, CA: Educational and Industrial Testing Services.

Linehan, M.L. (1993). *Cognitive-behavioral treatment of borderline personality disorder.* New York, NY: The Guildford Press.

Linehan, M.M. (2015). DBT skills training manual (2nd ed.). New York, NY: The Guilford Press.

Macht, M. (2008). How emotions affect eating: A five-way model. *Appetite, 50,* 1-11.

McNair, D., Lorr, M., & Droppleman, L. (1989). Profile of mood states (POMS).

Mehl, M.R. & Conner, T.S. (Eds.). (2012). Handbook of research methods for studying daily life. New York, NY: The Guilford Press.

Milligan, R.J., & Waller, G. (2000). Anger and bulimic psychopathology among nonclinical women. *International Journal of Eating Disorders, 28*, 446-450.

Milligan, R.J., & Waller, G., (2001). Anger and impulsivity in non-clinical women. *Personality and Individual Differences, 30,* 1073-1078.

Milligan, R.J., Waller, G., & Andrews, B. (2002). Eating disturbances in female prisoners: The role of anger. Eating Behaviours, 3, 123–132

Morgan, R.L. & Heise, D., (1988). Structure of Emotions. *Social Psychology Quarterly, 5*(1), 19-31.

Muehlenkamp, J.J., Engel, S.G., Wadeson, A., Crosby, R.D., Wonderlich, S.A., & Simonich H. (2009). Emotional states preceding and following acts of nonsuicidal self-injury in bulimia nervosa patients. *Behavior Research and Therapy, 47*, 83-7.

Murugappan, M., Ramachandran, N., & Sazali Y. (2010). Classification of human emotion from EEG using discrete wavelet transform. *Journal of Biomedical Science and Engineering, 3,* 390-396.

Neuman, S.A. & Waldstein, S.R. (2001). Similar patterns of cardiovascular response during emotional activation as a function of affective valence and arousal and gender. *Journal of Psychosomatic Research, 50*, 245-253.

Nock, M.K., Prinstein, M.J., & Sterba, S.K. (2009). Revealing the forms and function of self-injurious thoughts and behaviors: A real-time ecological assessment study among adolescents and young adults. *Journal of Abnormal Psychology, 118*, 816-827.

O'Brien, K.M. & Vincent, N.K. (2003). Psychiatric comorbidity in anorexia and bulimia nervosa: nature, prevalence, and causal relationships. Clinical Psychology Review, 23, 57-74.

Pike, K. M., Loeb, K., & Walsh, T. (1995). Binge eating and purging. In D. Allison (Ed.), Handbook of assessment methods for eating behaviors and weight-related problems (pp. 303-346). Thousand Oaks, CA: Sage.

Posner, J., Russell, J. A., & Peterson, B. S. (2005). The circumplex model of affect: An integrative approach to affective neuroscience, cognitive development, and psychopathology. *Development and Psychopathology, 17*(3), 715-734

Posner, J., Russell, J.A., Gerber, A., Gorman, D., Colibazzi, T., Yu, S., … Peterson, B.S. (2009). The neurophysiological bases of emotion: An fMRI study of the affective circumplex using emotion-denoting words. *Human Brain Mapping, 30,* 883-895.

Rayworth, B.B., Wise, L.A., Harlow, B.L. (2004). Childhood abuse and risk of eating disorders in women. *Epidemiology, 15*(3), 271-278.),

Roky, R. Iraki, L., HajKhlifa, R., Ghazal, H.L., & Hakkou, F. (2000). Daytime alertness, mood, psychomotor performances, and oral temperature during Ramadan intermittent fasting. *Annals of Nutrition and Metabolism,* 44, 101-107.

Russell, J. A., Weiss, A., & Mendelsohn, G. A. (1989). Affect grid: A single-item scale of pleasure and arousal. *Journal of Personality and Social Psychology, 57*(3), 493-502.

Safer, D.L., Telch, C.F., & Chen, E.Y. (2003). *Dialectical behavior therapy for binge eating* *and bulimia.* New York, NY: The Guilford Press.

Segal, D. L., Hersen, M., & Van Hasselt, V. B. (1994). Reliability of the Structured Clinical Interview for DSM-1U-R: An evaluative review. Comprehensive Psychiatry, 35, 316-327.

Small, D.M., Jones-Gotman, M., & Dagher, A. (2003). Feeding-induced dopamine releases in dorsal striatum correlates with meal pleasantness ratings in healthy human volunteers. *Neuroimage, 19*, 1709-1715.

Smyth, J. M., Heron, K. E., Sliwinski, M. J., Wonderlich, S. A., Crosby, R. D., Mitchell, & Engel, S.G. (2007). Daily and momentary mood and stress are associated with binge eating and vomiting in bulimia nervosa patients in the natural environment. *Journal of Consulting and Clinical Psychology, 75*(4), 629-638.

Spitzer, R. L., Gibbon, M., & Williams, J. B. (1997). *User's guide for the Structured clinical interview for DSM-IV axis I disorders SCID-I: clinician version*. American Psychiatric Publishers.

Spoor, S. T., Bekker, M. H., Van Strien, T., & van Heck, G. L. (2007). Relations between negative affect, coping, and emotional eating. *Appetite*, *48*(3), 368-376.

Stephens, C. L., Christie, I. C., & Friedman, B. H. (2010). Autonomic specificity of basic emotions: Evidence from pattern classification and cluster analysis. *Biological Psychology, 3,* 463-473.

Stice, E. (2001). A prospective test of the dual pathway model of bulimic pathology: Mediating effects of dieting and negative affect. Journal of Abnormal Psychology, 110(1), 124–135.

Stice, E. (2002). Risk and maintenance factors for eating pathology: A meta-analytic review. *Psychological Bulletin, 128*(5), 825-848.

Stice, E., Marti, C.N., & Rhode, P. (2013). Prevalence, incidence, impairment, and course of the proposed DSM-5 eating disorder diagnoses in an 8-year prospective community study of young women. *Journal of Abnormal Psychology, 122*(2), 445-457.

Stice, E. & Shaw, H.E. (1994). Adverse effects of the media portrayed thin-ideal on women and linkages to bulimic symptomatology. *Journal of Social and Clinical Psychology, 13(3),* 288-308.

Taylor, G.J., Ryan, D., & Bagby, R.M. (1985). Toward the development of a new self-report alexithymia scale. *Psychotherapy and Psychosomatics, 44*, 191–199.

Tiggemann, M. & McGill, B. (2004). The role of social comparison in the effect of magazine advertisements on women's mood and body dissatisfaction. *Journal of Social and Clinical Psychology, 23*(1), 23-44.

Waller, G., Babbs, M., Milligan, R., Meyer, C., Ohanian, V., & Leung, N. (2003). Anger and core beliefs in the eating disorders. *International Journal of Eating Disorders*, *34*, 118-124.

Watson, D. & Clark, L.A. (1994). The PANAS-X: Manual for the positive and negative affect schedule-expanded form. Available from http://ir.uiowa.edu/psychology_pubs/11/

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology, 54*, 1063–1070.

Wegner, K. E., Smyth, J. M., Crosby, R. D., Wittrock, D., Wonderlich, S. A., & Mitchell, J. E. (2002). An evaluation of the relationship between mood and binge eating in the natural environment using ecological momentary assessment. *International Journal of Eating Disorders, 32*, 352–361.

Whiteside, S. P., & Lynam, D. R. (2001). The Five Factor Model and impulsivity: using a structural model of personality to understand impulsivity. *Personality and Individual Differences, 30*(4), 669-689.

Witvliet, C.V. & Vrana, S.R. (1995). Psychophysiological responses as indices of affective dimensions. *Psychophysiology, 32,* 436-443.

Wonderlich, S. A., Connolly, K. M., & Stice, E. (2004). Impulsivity as a risk factor for eating disorder behavior: Assessment implications with adolescents. *International Journal of Eating Disorders, 36*(2), 172-182.

Zabala, Macdonald, & Treasure, 2009. Appraisal of caregiving burden, expressed emotion and psychological distress in families of people with eating disorders: A systematic review. *European Eating Disorders Review, 17*, 338-349.

Zunker, C., Peterson, C.B., Crosby, R.D., Cao, L., Engel, S.G., Mitchell, J.E., & Wonderlich, S.A. (2011). Ecological momentary assessment of bulimia nervosa: Does dietary restriction predict binge eating? *Behavior Research and Therapy, 49(*10), 714-717.

*Appendix A*

**BN Palm words categorized by Arousal, Valence, and Approach vs. Avoidance**

**High Arousal, Negative Valence, Avoidance (HNAV)**
Distressed
Disgusted
Afraid
Ashamed
Nervous
Jittery
Angry at Self
Dissatisfied with Self

**High Arousal, Negative Valence, Approach (HNAP)**
Angry
Irritable
Annoyed
Peeved

**Low Arousal, Negative Valence, Avoidance (LNAV)**
Sad
Lonely

**Low Arousal Positive Valence (LPAP)**
Calm
Happy
Proud
Relaxed
Cheerful
Confident

**High Arousal Positive Valence (HPAP)**
Energetic
Alert
Determined
Attentive