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Dimensional Analysis of Emotion Trajectories Before and After Disordered Eating Behaviors in a Sample of Women with Bulimia Nervosa

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Abstract

There is an established relationship between increases in negative affect and engagement in binge eating and purging behaviors. Some evidence suggests that these behaviors may also be maintained via subsequent increases in positive affect. However, negative and positive affect are broad terms encompassing many emotions, and there is a theoretical speculation that every emotion consists of at least of three separate dimensions: valence, arousal, and approach/withdrawal. We conducted secondary analyses on a previously collected dataset using ecological momentary assessment in 133 women with bulimia nervosa. Participants rated their experience of discrete emotions and bulimic behaviors six times per day. Negative and positive emotions were organized within the 3-dimensional space characterized by valence, arousal, and approach/withdrawal. With multilevel modeling, we examined the trajectories of dimensionally defined emotion constructs prior and subsequent to bulimic behaviors as well as on days with and without bulimic behaviors. Negative valence, high arousal, and avoidance typified emotions that reached the highest levels before bulimic behaviors and were at the highest mean levels on days with bulimic behaviors. Arousal did not appear to moderate the trajectories of positive emotions. Application of a dimensional understanding of emotions may help elucidate the complex relationship between mood and disordered eating.

Conflicts of interest: None.

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1. Introduction

Bulimia nervosa (BN) is robustly associated with mood disturbances (e.g., Haedt-Matt and Keel, 2011; Smyth et al., 2007). According to the affect regulation model, binge eating and purging are maintained because both are negatively reinforced via temporary relief of emotional distress (Hawkins and Clement, 1984; Polivy and Herman, 1993). Research utilizing ecological momentary assessment (EMA) methodology supports this hypothesis by demonstrating the trajectory of negative affect increases prior to and decreases following bulimic behaviors (e.g., Smyth et al., 2007; Berg et al., 2013).

Positive valence has not been extensively studied in relation to bulimic behaviors (Haedt-Matt & Keel 2011). However, there is some evidence that self-reported contentment may increase during and post binge-eating episodes while satisfaction ratings may continue to increase up to an hour after binge eating (Hetherington et al., 1994). It may be that during and following binge eating, positive emotions increase due to the ingestion of highly palatable foods, which act on the dopamine reward pathway in the brain (Small, et al., 2003). EMA results also suggest an opposite trajectory to that of negative emotions, such that positive emotions decrease prior to, and increase after, binge eating and/or purging (e.g., Smyth et al., 2007; Engel et al., 2013).

EMA protocols are ideal for testing momentary relationships between mood and disordered eating because the temporal order of emotions and behaviors can be determined from time-stamped momentary data with minimal influence from recall bias (Mehl and Conner, 2012). Previous EMA research has either assessed overall negative and/or positive affect (Haedt-Matt and Keel, 2011) or has studied discrete emotional states (Berg et al., 2013; Wegner et al., 2001) in relation to bulimic behaviors. However, negative and positive affect are broad terms encompassing multiple different emotions (Macht, 2008) and individual emotions are comprised of various dimensions including valence (pleasantness/unpleasantness), arousal (alert/lethargic) and motivational urges (approach/avoid; Morgan and Heise, 1988; Russell et al., 1989; Scherer, 2005). Heterogeneity in broad constructs like negative and positive affect may be obscuring how features of emotional experience both immediately and over-time differentially impact eating behaviors.

The most widely used dimensional model of emotions consists of two continua: emotional valence and emotional arousal (Morgan and Heise, 1988; Russell et al., 1989). Discrete emotions can be reliably mapped onto a theoretical space defined by these two dimensions (e.g., Posner et al., 2009; Posner et al., 2005; Russell et al., 1989) and results from neurobiological studies provide further support for these dimensions. Findings suggest distinctive neural pathways for the processing of pleasant/unpleasant versus arousing stimuli: The amygdala responds to highly arousing stimuli (e.g., pictures, words) irrespective of valence (Kensinger and Schacter, 2006; Posner et al., 2005), the right dorsolateral prefrontal cortex appears to be involved in the processing of negative valence, and the left insular cortex may be important in processing positive valence (Posner et al., 2009). In addition, specific peripheral physiological responses correspond to self-reported valence and arousal levels (Posner et al., 2005, Posner et al., 2009; vanOyen et al., 1995).

However, a two-dimensional emotional theory is not sufficient to map all aspects of emotional experience (e.g., Morgan and Heise, 1988). A motivation dimension consisting of approach and withdrawal actions (also termed “potency or “dominance” in other studies) is relevant in discriminating negative emotions, such as anger and fear, both high in arousal and negatively valenced (Carver and Harmon-Jones, 2009; Harmon-Jones, E. and Harmon-Jones, C., 2010; Kreibig et al., 2010; Morgan and Heise, 1988). Opposite motivational systems are engaged during high approach (e.g., anger) versus high withdrawal (e.g., sadness, anxiety, guilt) emotional states (Kreibig et al., 2010). The approach/withdrawal dimension also receives support from neurobiological data, as results across EEG studies indicate that distinct cortical circuits are involved in organizing approach behaviors (left anterior cortical activation) versus avoidance behavior (elevated activity in the right anterior cortex; e.g., Carver and Harmon-Jones, 2009; Coan and Allen, 2009). Thus, each of the three dimensions appears relevant in understanding emotional experiences.

The valence dimension is usually the only dimension of emotional experience considered in empirical investigations of affect regulation in BN. However negative emotions that are also high in arousal may be the most aversive and associated with the greatest distress and, therefore, extremely difficult to tolerate (Chapman et al., 2006). Support for exploring a dimensional model of emotional experience in relation to maladaptive behaviors is evident in the nonsuicidal self-injury (NSSI) literature. In experimental studies of individuals who engage in NSSI, participants described reductions in anxiety following proxies for self-harm, and demonstrated reduced physiological arousal (e.g., heart rate, skin resistance level, blood volume, respiration rate) post imagined NSSI or pain (for a review see Klonsky, 2007). Arousal level may also be important in positive reinforcement from maladaptive behaviors, as low arousal positive emotions such as calmness are the most common affect states reported after engaging in NSSI (Klonsky, 2009). Additionally, positive emotions identified as low arousal emotions showed the largest pre- to post-change scores (i.e., increased markedly) following NSSI (Claes et al., 2010) and self-reported increases in these emotions, along with decreases in high arousal negative emotions, strongly predicted frequency of lifetime skin-cutting (Klonsky 2009).

In this study, we re-organized negatively and positively valenced emotion-based descriptors according to three theorized underlying dimensions of emotional experiences (valence, arousal, and approach/avoidance). We classified discrete emotion words into five dimensionally-defined constructs: high arousal negative emotions that promote avoidance behaviors, high arousal negative emotions that promote approach behaviors, low arousal negative emotions that promote avoidance behaviors, high arousal positive emotions that promote approach behaviors, and low arousal positive emotions that promote approach behaviors (see Table 1). We chose to explore our hypotheses in relation to binge eating only, purging only, and combined binge eating and purging, because there is some evidence that individual emotions differentially impact eating behaviors (e.g., Macht, 1999) and, therefore, perhaps different bulimic behaviors serve to regulate different dimensions of emotions.

Because we were interested in understanding what features of emotional experiences momentarily prompt and are regulated by bulimic behaviors as well as what emotions typify days that include bulimic behaviors, we chose to conduct within-day and between-day

analyses. Trajectory analyses of emotion constructs before and after engagement in binge and/or purging (i.e., within-day analyses) answer the question: On days with bulimic behaviors, what features of emotions are most related to engagement in bulimic behaviors? Analyses comparing average levels of emotional constructs on days with and without binge eating and/or purging (i.e., between-day analyses) answer the question: On days that include symptoms, which emotion constructs are most likely to be elevated?

1.1 Hypotheses

1.1.1 Within-day hypotheses for negatively valenced emotion constructs.—

Given findings with NSSI (Claes et al., 2010; Klonsky 2007; Klonsky 2009), we expected that a pattern of emotional experience characterized by negative valence, high arousal, and avoidance motivations would be the most aversive, urgent, and challenging to regulate and, thus, be the most associated with bulimic behaviors compared to negative emotions characterized by either lower arousal or an approach-orientation. Previous studies utilizing this sample have shown that all negative emotions rise preceding bulimic behaviors (Smyth et al., 2007; Berg et al., 2013). However, we further hypothesized that high arousal avoidance-promoting negative emotions would show the greatest increases (i.e., steepest positive linear slope) and reach the highest peak values (i.e., highest magnitude) prior to binge and/or purge behaviors compared to high arousal approach-promoting and low arousal avoidance-promoting negative emotions. We also hypothesized that the trajectories of high arousal and approach-promoting negative emotions would demonstrate significant and positive quadratic and cubic estimates prior to each behavior, representing an acceleration of emotion change prior to behaviors.

Similarly, we hypothesized that all negative emotions would show significant decreases subsequent to all disordered eating behaviors, as previously shown in this sample (Smyth et al., 2007; Berg et al., 2013). We further expected that the consequent trajectories of high arousal and avoidance-promoting negative emotions would be distinct from high arousal approach-promoting and low arousal avoidance-promoting negative emotions, because emotions characterized by heightened physiological arousal and avoidance urges show the largest reduction pre- to post- NSSI (Claes et al., 2010). We hypothesized that high arousal, avoidance-promoting negative emotions would decrease the most rapidly, as evident by the steepest negative linear slope compared to the other emotion constructs, and be the only emotion construct to show significant and negative quadratic and cubic estimates.

1.1.2 Within-day hypotheses for positively valenced emotion constructs.—

As previously shown in this sample (Smyth et al., 2007), we expected that both positive emotion constructs (high and low in arousal) would decrease prior to all bulimic behaviors at a similar rate and trajectory as evidenced by significant and negative linear, quadratic, and cubic coefficients. We did not predict that the positive emotion constructs would show significantly different nadirs prior to behaviors. However, we hypothesized that arousal level may differentially impact positive reinforcement from binge eating, given that ingestion of highly palatable food may be rewarding and results from NSSI indicate that relief and calm follow certain maladaptive behaviors (e.g., Small et al., 2003; Klonsky, 2009). Thus, we expected that, following binge eating; low arousal positive emotions would increase

significantly with a steep slope (i.e., positive linear, quadratic and cubic coefficient), but high arousal positive emotions would show a flat trajectory (i.e., non-significant linear, quadratic, cubic estimates). Consistent with previous results in this sample (Smyth et al., 2007), we expected that positive moods would also increase following purge and combined binge and purge events and we did not hypothesize that arousal level would impact the trajectory of positively valenced emotions after purge and combined binge and purge events.

1.1.3 Between-day hypotheses for negatively valenced emotion constructs.

—Because we expected high arousal negative emotions that promote avoidance to be the most challenging to regulate, we also hypothesized that this emotion construct would reach higher mean levels on days with binge eating and/or purging compared to days without behaviors. We did not expect average levels of either low arousal avoidance-promoting or high arousal approach-promoting negative emotions to differ between days with and without bulimic behaviors.

1.1.4 Between-day hypotheses for positively valenced emotion constructs.—

We anticipated that average levels of all positive emotions would be significantly lower on days with purge and combined binge and purge events than days without behaviors, replicating previous results (Smyth et al., 20007). We also hypothesized that mean levels of high arousal positive emotions would be significantly lower on binge-only compared to days without binge eating episodes. However, because we expected that positive emotions characterized by low arousal would increase sharply following binge eating, we expected this emotion construct to be similar on days with and without binge eating.

2. Methods

The current study is a reanalysis of data from a previous study utilizing EMA to examine the relationship of affect to binge eating and purging (Smyth et al., 2007). Even though this data set has been used for several other papers (e.g., Smyth et al., 2007; Berg et al., 2013; Zunker et al., 2011) the present manuscript addresses a unique theoretically based research question that was not addressed in any of the previous publications. That is, while the previous manuscripts focused entirely on the valence of emotional states, the present manuscript tests a dimensional theory of emotion, which includes arousal and approach/avoidance dimensions. Thus, we believe this is a distinct contribution.

2.1 Participants

Female participants ($n = 133$) were recruited from the community to participate via advertisements and clinical referrals. Participants were 18 years of age, literate, not suffering from a current psychotic disorder, and met criteria for BN according to the Diagnostic and Statistical Manual of Mental Disorders (4th ed., DSM-IV; APA, 1994). Informed consent was obtained from all participants and this research.

Demographics of the study participants were determined in the original study (Smyth et al., 2007). Briefly, the average participant age was 25.3 years ($SD = 7.6$, range = 18–55) and most were Caucasian ($n = 127$, 95.5%). The mean body mass index (BMI) was 23.9 kg/m² ($SD = 5.2$ kg/m², range = 17.1kg/m² - 47.6kg/m²) and all were at least at 85% of their ideal

body weight. Most participants (85.5%) reported a lifetime mood disorder diagnosis and 53.4% met criteria for a mood disorder at the time of the assessment. Anxiety disorders were also common, in that 58.6% met criteria for a lifetime diagnosis of an anxiety disorder and 50.4% met criteria at the time of the assessment.

2.2 Measures-EMA

2.2.1 Positive and Negative Affect Scale (PANAS: Watson, et al., 1988).—We used a modified version of the PANAS for EMA data collection, which consisted of discrete emotions using a 5-point ordered ranking scale, with choices ranging from “not at all” to “extremely” (see Table 1). The PANAS is considered appropriate as a momentary measure of emotion and shows acceptable test/retest reliability with momentary data (Watson and Clark, 1994). The Cronbach’s alpha for the Negative Affect scale in this sample was 0.92, consistent with the internal consistency of the full Negative Affect scale when assessed at the momentary level (See Table 1 for the words utilized in the current study and the internal consistency of the generated emotion constructs).

2.2.2 Profile of Mood States (POMS: Lorr and McNair, 1971).—The POMS also specifically assesses state fluctuations in emotions, and can be re-administered frequently to assess momentary emotional change (McNair et al., 1989). The Anger/Hostility subscale of the POMS has four items measured using the same 5-point ordered ranking scale (“not at all” to “extremely”) as the PANAS. The POMS was used to assess momentary anger and hostility. In this sample the Cronbach’s alpha was 0.89 (see Table 1).

2.2.3 The Eating Disorder and Self-Destructive Behavior Checklist (Smyth et al., 2007).—This 19-item checklist represents an amalgam of items from other measures of disordered eating. Participants recorded engagement in various behaviors (e.g., binge eating, self-induced vomiting, diuretic misuse, and laxative misuse) either immediately after the behavior or at the next scheduled recording.

2.3 Measures-interview

2.3.1 Structured Clinical Interview for DSM-IV Axis I Disorders (SCID-IP; First et al., 1995).—The Eating Disorder Module of the SCID-IP was given to assess eating pathology and diagnose BN and other current and lifetime conditions according to the DSM-IV criteria. Interrater reliability for the diagnosis of DSM-IV BN was 1.0.

2.4 Procedure

We conducted a secondary data analysis of 133 women with BN who participated in EMA data collection for a period of two weeks (Smyth et al., 2007). Participants were signaled six times throughout the day and were asked to report their emotional state and occurrence of disordered eating 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 with a standard deviation of 30 minutes. Each time participants were signaled, they were instructed to provide their emotional state and any behaviors not already logged. Participants also were

asked to rate their emotional state directly following engagement in a disordered eating (i.e., event-contingent reporting). In addition, participants completed end-of-day ratings (i.e., interval ratings) to summarize the experiences of the full day.

2.4.1 Dimensionally defined emotion constructs.—Emotion words were taken from the EMA data (i.e., POMS anger/hostility subscale and selected words from the PANAS; see Table 1). We combined rating information from several sources to classify the emotion words. In order to categorize words in terms of arousal (high and low) and valence (positive and negative) we referenced Klonsky's (2009) examination of dimensional emotional antecedents and consequences of NSSI behaviors in which 40 emotional states were independently rated on the dimensions of valence and arousal by two experts (Dr. J.A. Coan and Dr. G. Hajack). Emotion 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 words representing guilt or shame (i.e., "ashamed," "dissatisfied with self," and "angry at self") as a high arousal, avoidance-promoting, negative emotions. Additionally, a previous confirmatory factor analysis in the present 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., 2013).

Approach/avoidance dimension was then added to arousal ratings by referencing the classification scheme described by Morgan and Heise (1988). From these sources of information, the first and second author each independently rated the emotion words used in the EMA protocol. Our classification of each word was identical (Table 1).

In order to calculate the values for the three emotion constructs, we averaged scores across the items (i.e., the participant ratings of each emotion word) to achieve a common metric across all emotion constructs.

2.5 Data analytic strategy

2.5.1 Within-day analyses.—Using generalized estimating equation (GEE) models, we examined the pre-behavior and post-behavior trajectories of each negative (i.e., high arousal and avoidance-promoting, low arousal and avoidance-promoting, high arousal and approach-promoting) and positive (i.e., high arousal and low arousal) emotion construct separately using piecewise linear, quadratic, and cubic functions centered on the time at which either a bingeonly, a purge-only, or combined binge and purge event occurred. 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, behaviors. 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/deceleration 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. To test our hypotheses, we examined the significance of the intercept and linear estimate for each model as well as the confidence intervals around these estimates. Non-overlapping confidence intervals indicate significant differences in the magnitudes and slopes between emotion constructs. In order to further compare pre- and post- trajectories between the three emotion constructs, we also examined the significance of the quadratic, and cubic parameters.

2.5.2 Between-days analyses.—We compared average values for each of the five emotion constructs on days that included disordered eating behaviors and days that did not using GEE models. Average scores were calculated by aggregating across within-day assessments such that the levels of each of the emotion states reflected the average values for each person on each day. Data for each day reflected combined emotion construct ratings scores for each participant, and days were coded to distinguish between event and non-event days. Binge-only, purge-only, and combined binge and purge events were analyzed separately. Only main effects were examined in order to determine if levels of each emotion construct differed between days with and without behaviors. If the 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 construct 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 constructs differed significantly between event and nonevent days. As with the within-day models, comparisons between mean levels of emotion constructs on event and non-event days were done by determining if confidence intervals around the marginal means did not overlap.

3. Results

Average compliance rate for the sample was 86% (median = 90%) and 75% of the participants responded to 83% or more of the signals. Main analyses were based on recordings of 296 binge-only episodes, 784 combined binge and purge episodes, and 721 purge-only episodes. On average, participants reported at least one binge episode on 39.7% of the days, at least one purge episode on 49.0% of the days, and combined binge and purge events on 30.8% of the days. The average number of binge episodes reported by participants during the study period was 8.20 ($SD = 6.79$, range = 0–34) and 11.40 purging episodes ($SD = 9.85$, range 0–48).

3.1 Normality

The distributions of each of the five emotion constructs were examined for normality violations. Each emotion construct was significantly positively skewed and platykurtic. These values remained problematic after logarithmic and natural log transformations. Thus, GEE models were more appropriate than mixed models for multilevel analyses of 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 constructs in the current study; Liang and Zeger, 1986). In particular, gamma with log link distributions appropriate for skewed data (Ballinger, 2004).

3.2 Tests of main hypotheses: Within-day analyses

3.2.1 Negative emotion constructs.—Consistent with previous studies in this sample, all dimensionally defined negative emotion constructs (i.e., high arousal, avoidant; high arousal, approach; and low arousal, avoidant) increased linearly (i.e., significant positive linear coefficient; all $ps < 0.001$) prior to engagement in all disordered eating behaviors and decreased linearly (significant negative linear coefficient, all $ps < .001$) following disordered eating behaviors (Table 2). Confidence intervals for the linear coefficients for all emotion constructs overlapped, suggesting that antecedent and consequent linear slopes were not different preceding or following behaviors (Table 2, Figure 1).

High arousal avoidance-promoting negative emotions reached significantly higher magnitudes pre-behaviors (determined by non-overlapping confidence intervals around the intercept value) than high arousal approach-promoting negative emotions but not low arousal avoidance-promoting negative emotions. Overlapping confidence intervals around the intercept values for high arousal, approach-promoting, negative emotions and low arousal, avoidance promoting, negative emotions may suggest that the magnitude comparison between these two emotion constructs was not different.

The trajectories between the negatively valenced emotion constructs differed somewhat before and after behaviors, as the pattern of significant quadratic and cubic coefficients was not identical across behaviors between high arousal avoidance-promoting, high arousal approach-promoting, and low arousal avoidance-promoting emotions. All negatively valenced emotion constructs, regardless of arousal level or motivation, showed significant and positive antecedent quadratic and cubic coefficients prior to binge eating-only and purging-only events, signifying that the initial antecedent linear slopes were deflected up and the rate of affect change for each emotion construct was accelerated (i.e., positive and significant quadratic and cubic coefficient estimates). The antecedent quadratic and cubic coefficients were significant only for high arousal and avoidant negative emotions for combined binge eating and purging. While the initial positive linear antecedent slope was accelerated (positive and significant quadratic coefficient estimate), this initial acceleration was slightly dampened (rather than intensified) by a negative cubic coefficient.

Following binge eating, only the low arousal and avoidance-promoting emotion construct demonstrated a significant negative consequent quadratic coefficient estimate, suggesting that the initial negative linear slope was accelerated only for these emotions (e.g., sadness, loneliness). Additionally, the initial downward deflection from the quadratic component was further intensified (significant cubic coefficient) for low arousal and avoidant negative emotions following binge-only events. None of the emotion constructs demonstrated significant consequent quadratic coefficient estimates following purge-only events. Finally, only the high arousal and avoidance-promoting emotions demonstrated a significant and

negative consequent quadratic coefficient estimate following combined binge eating and purging. Thus, the initial negative linear slope was accelerated only for high arousal and avoidance-promoting negative emotions following combined binge and purge events. However, the consequent cubic coefficient was positive, suggesting that the initial downward deflection from the quadratic consequent coefficient was dampened.

3.2.2 Positive emotion constructs.—All dimensionally defined positive emotion constructs decreased linearly (i.e., significant negative linear coefficient; all $ps < 0.001$) prior to engagement in binge and/or purging. Both positive emotion constructs also increased linearly (significant positive linear coefficient, all $ps < 0.001$) following each behavior (Table 3, Figure 2). For both binge eating or purging, the initial antecedent linear slopes for positive emotions were deflected downward and levels of both high and low arousal positive emotion constructs decreased at an accelerated rate (i.e., negative and significant quadratic coefficient estimates). Because the antecedent cubic coefficients for positively valenced emotion constructs 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 construct was further accelerated. For combined binge eating and purge events, neither the antecedent quadratic nor cubic coefficient was significant. There were no observed differences between trajectories or the intercepts (nadirs) of high arousal and low arousal positive emotion constructs before any behavior.

All positively valenced emotions rose linearly (significant positive linear coefficient; all $ps < 0.001$) after binge and/or purge behaviors. The quadratic consequent coefficient estimate was only significant for the high arousal positive emotions after binge eating, suggesting that the initial positive linear slope following binge eating was accelerated only for high arousal positive emotions. Neither positively valenced emotion construct showed an accelerated trajectory following purging only or combined binge eating and purging.

3.3 Between-day Analyses

3.3.1 Negative emotion constructs.—The results of all between-day hypotheses with negatively valenced emotion constructs are given in Table 4. Overall, negative emotion constructs (i.e., high arousal, avoidant; high arousal, approach; and low arousal, avoidant) were different on days characterized by eating disordered behaviors (i.e., binge eating and/or purging) compared to days without eating disorder behaviors (all $ps < 0.002$). Based upon comparisons of marginal means using confidence intervals, high arousal avoidance-promoting emotions were significantly higher on days that included binge and/or purge events compared to non-event days. Marginal mean comparisons for low arousal avoidance-promoting negative emotions were also significantly higher on days that included binge events compared to days that did not. Marginal mean comparisons between days with and without purge and combined binge and purge behaviors were overlapping for low arousal avoidance-promoting negative emotions, suggesting no differences. Confidence intervals overlapped for days with and without binge and/or purge behaviors for high arousal approach-oriented emotions, suggesting no differences. Comparisons of marginal means between high arousal approach-promoting emotions and high arousal avoidance-promoting

emotions indicated that approach-oriented emotions were significantly lower across days that included a binge and/or purge event (i.e., all confidence intervals did not overlap).

3.3.2 Positive emotion constructs.—Results of between-day analyses with positively valenced emotion constructs are presented in Table 5. Levels of both high and low arousal positive emotions were affected by the presence or absence of with binge-eating episodes (all $ps < .01$). Based upon marginal meal comparisons, only low arousal positive emotions were significantly lower on days that included binge-eating events (i.e., non-overlapping confidence intervals). Purge behaviors and combined binge eating and purging were significantly related to changes in low arousal positive emotions but not high arousal positive emotions (all $ps < .001$). However, marginal means analysis showed that confidence intervals overlapped for days with and without purge and combined binge and purge behaviors for low arousal positive emotions, suggesting no differences in mean levels.

4. Discussion

The purpose of this study was two fold: 1) Apply a dimensional theory of emotions to within- day trajectory analyses of emotional experiences before and after bulimic behaviors and 2) examine if emotion constructs assembled according to a theoretical understanding of the dimensional model reach different levels on days with and without binge eating and/or purging in a sample of women with bulimia nervosa. Complimentary findings from both these analyses (within-day and between-day) are useful in helping to understand the complex relationship between emotions and disordered eating.

4.1 Within-day analyses

Several novel findings should be highlighted from the within-day analyses. As hypothesized, negative emotions characterized by high arousal and avoidance motivation reached the highest magnitudes prior to binge-only events, purge-only events, and combined binge eating and purging events when compared to negative emotions high in arousal but approach-promoting. Unexpectedly, high arousal avoidance-oriented negative emotions did not reach higher magnitudes prior to behaviors when compared with low arousal avoidance-oriented negative emotions. This pattern of findings suggests that emotions that promote avoidance/withdrawal are the *most* motivating of bulimic behaviors regardless of arousal level. These data extend previous findings by providing *momentary* evidence that avoidance motivations are fundamental to engagement in bulimic behaviors. Although our results cannot demonstrate that aversive self-awareness, high arousal, or negative valence was reduced *during* behaviors, they appear generally consistent with escape theory; i.e., that disordered eating functions as an “escape” from emotional distress (Heatherton and Beaumeister, 1991). In contrast to hypotheses, there were no evident slope or magnitude differences prior to any of the three behaviors between low arousal avoidance-oriented negative emotions and high arousal but approach-oriented negative emotions, suggesting that a reduction in high arousal may also be an important motivator for dysregulated eating behaviors. Further support for this conclusion appears to be that negative, high arousal, and avoidance-promoting emotions comprised the only emotion construct to show an accelerated antecedent trajectory prior to engagement in combined binge eating purging. However, this

finding 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 farther away from the behavior and, thus, are less strongly related to behavior engagement (Bolger and Laurenceau, 2013).

Anger is considered an ‘approach based emotion.’ Previous studies have cited anger as a central emotion to eating disorders (e.g., Milligan and Waller, 2000; Milligan et al., 2002; Milligan and Waller, 2001). However, our findings suggest that, rather than approach-oriented emotions, high arousal emotions characterized by avoidance motivations (e.g., guilt, anxiety) may be particularly prompting of bulimic events because these emotions reach the highest magnitude prior to behaviors. Notably, the high arousal approach-promoting negative emotion construct (i.e., anger-related) showed significant linear trajectories prior to all behaviors. Moreover, these trajectories were similar to those of the low arousal avoidance-promoting and high arousal avoidance-promoting negative emotion constructs. Thus, these results do not suggest that anger-related emotions are irrelevant to bulimic behaviors nor are they inconsistent with prior work. Instead of contradicting previous conclusions, these data supplement earlier investigations on the role of anger-related emotions to disordered eating, because prior work often did not compare anger against other emotions, preventing the relative influence of anger/approach-orientation from being determined.

Consequent trajectory analyses supported the affect regulation model of bulimia, as all negatively valenced emotion constructs displayed trajectories characterized by a significant linear decrease following binge and/or purge behaviors. The quadratic and cubic coefficients were found to be significant following binge eating for the emotion construct characterized by low arousal and avoidance motivations. This finding may lend further support to our conclusion from the antecedent trajectories: that avoidance-promoting emotions are strongly related to bulimic behaviors. Similar to results from the antecedent trajectories and consistent with our predictions, only the emotion construct composed of avoidant emotions high in arousal showed a significant quadratic coefficient following combined binge and purge events. This finding may offer some support to our hypothesis that high arousal, avoidance-promoting emotions decline at an accelerated rate, at least following certain bulimic behaviors.

Consistent with Smyth et al., (2007) all positive emotions (high and low arousal) decreased significantly before and increased significantly following all bulimic behaviors. Unexpectedly, overlapping confidence intervals suggest that differences in direction or rate are unlikely between high arousal and low arousal positively valenced emotion constructs before or after behaviors. A significant quadratic consequent coefficient for high arousal positive emotions post –binge eating was the only observed difference. However, as this is the only distinction (i.e., no additionally observed trajectory differences, no intercept/nadir differences, no slope differences) for any of the behaviors, it can be considered minor. Further, the quadratic portion of the trajectory is less strongly related to behaviors than the linear component (Bolger and Laurenceau, 2013), meaning this one difference should not be overly interpreted. Therefore, these results extend current knowledge regarding the relationship between positive emotions and bulimic behaviors by suggesting that disordered

eating behaviors may be positively reinforced by overall increases in levels of positive valence regardless of arousal level.

4.2 Between-day analyses

To our knowledge, this is the first study to investigate differences in dimensionally defined emotion constructs between days that include bulimic events and days that do not in a sample of women with clinically significant BN pathology. Therefore, all between-day findings from the current study are novel. Consistent with previous studies, mean levels of negatively valenced emotions were statistically different on days with bulimic events and days without. Most importantly, these data demonstrate that high arousal, avoidance-promoting negative emotions are higher on days that include binge eating and/or purging behaviors, as expected. Contrary to expectations, low arousal, avoidance-promoting, negative emotions were also higher on days with binge eating events. Equally interesting and consistent with conclusions from within-day analyses as well as our predictions, are results showing that high arousal approach-promoting emotions do not show higher mean levels on days that include any of the disordered eating behaviors and are lower across all event days than high arousal avoidance-promoting, emotions. Because the approach/avoidance dimension is the only tested aspect of emotional experience that differentiates emotions like guilt and anxiety (avoidance-oriented) from anger (approach-oriented), these between-day analyses further demonstrate that avoidance motivations, particularly when paired with high arousal levels, may be particularly relevant to bulimic behaviors.

It is possible that low arousal, avoidance-promoting, negative mood states (e.g., sadness) may 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 et al., 2010). However, it may also be that binge-only days are associated with mean differences in low arousal, avoidance-oriented, negative emotions compared to non-binge days because individuals are engaging in prolonged periods of dietary restriction and are experiencing associated low mood and energy levels. According to the cognitive behavioral model of disordered eating (Fairburn, 2008), caloric restriction is a prominent precursor to binge eating and EMA data also show that caloric restriction increases risk for binge eating (Zunker, et al., 2011). Low caloric intake and protein malnutrition are related to elevations in corticotrophin-releasing hormone and reductions in serotonin functioning, both of which correspond with the development of sad or depressed mood states and difficulty regulating mood (Chandler-Laney et al., 2007; Fox and Power, 2009). Even in healthy populations, extreme diets have been related to increased reports of lower mood and decreased alertness (Fox and Power, 2009; Roky et al., 2000). However, it is a limitation of between-day analyses, being that we cannot be certain if emotion constructs are higher on days with behaviors because these types of emotions are prompting behaviors or if engagement in behaviors increases levels of certain emotions. Thus, it may be that binge eating increases avoidance-oriented low arousal emotions like sadness.

Contrary to hypotheses, low arousal positive emotions were different on days with binge eating and/or purging compared to days without behaviors. Additionally, low but not high,

arousal positive emotions were significantly lower on days characterized by binge eating. Mean values were not lower for either positively valenced emotion construct on days with purge or combined binge eating and purging compared to days without these behaviors. Therefore, positively valenced emotions characterized by low arousal may be largely responsible for previously described differences in positive affect on days with and without bulimic behaviors (Smyth et al., 2007). Perhaps these lower arousal positive emotions are lower on days with bulimic behaviors because bulimic events are occurring in the context of high arousal emotions.

4.3 Limitations

Despite theoretical precedence and empirical support for organizing emotions into groups based on the dimensions of arousal, valence, and approach/withdrawal ((e.g., Claes et al., 2010; Fox and Power, 2009; Klonsky et al., 2009; Morgan and Heise, 1988; Posner et al., 2005; Poser et al., 2009), the resulting emotion constructs assembled in the current study were not data driven. 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. Future studies may benefit from the inclusion of measures utilizing dimensional assessments of emotions, such as the affect grid (Russel et al., 1989), in order to eliminate the necessity for reorganizing discrete emotions and to directly measure changes in valence, affect, and approach/withdrawal motivations before and after disordered eating behaviors.

Additionally, EMA remains a form of self-report (Mehl and Conner, 2012). Thus, the extent to which subject noncompliance impacts findings is unknown (Crosby et al., 2009). Also, although the within-day data provide strong support for the chronological relationship between changes in emotions and disordered eating behaviors, they are correlational. We cannot state that changes in emotional dimensions cause disordered eating behaviors (e.g., Haedt-Matt and Keel, 2011; Smyth et al., 2007), nor can we claim that engaging in binge eating, purging, or combined binge eating and purging causes reductions in negatively valenced emotions (Haedt-Matt and Keel, 2011).

Our analytical plan of comparing confidence intervals allows for confidently determining if statistical differences exist when intervals do not overlap, however, it is possible for significance differences to exist when confidence intervals are overlapping. Although this means that conclusions may be less precise when confidence intervals are overlapping because differences may still be present, as far as we know, this represents the best method for comparing across models to address our hypotheses. Further, if additional differences (i.e., those not detected due to overlapping confidence intervals) exist between coefficients, this would serve to strengthen our conclusion that a dimensional model of emotions is useful in understanding disordered eating.

Finally, these results may not generalize to men, adolescents, clinical populations, or across racial or ethnic identities.

4.4 Conclusions

The current study demonstrates that a three-dimensional model of emotional experience consisting of arousal, valence, and approach/withdrawal continua has merit in understanding disordered eating behaviors. Perhaps most importantly, the dimensional understanding of emotions provides theoretically-based explanations for why discrete emotions, like disgust, anxiety, and guilt, prompt bulimic behaviors (i.e., to “escape” or avoid highly distressing emotions characterized by high physiological arousal). Findings within-day analyses may also be helpful in treatment planning. For example, momentary strategies, including distress tolerance, may be appropriate in coping with increasing physiological arousal and strong avoidance urges in order to forestall engagement in bulimic behaviors. Future studies can extend these results and 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 in EMA protocols and possibly pairing self reports with physiological data (e.g., heart rate).

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Highlights

- Dimensions of emotional experience impact bulimic behaviors differently.
- Negative, high arousal, and avoidant emotions are highest before bulimic behaviors.
- Negative, high arousal, and avoidant emotions are highest on days with behaviors.
- Avoidance-promoting emotions appear the most motivating of bulimic behaviors.
- Arousal may not moderate the influence of positive emotions on bulimic behaviors.

Figure 1.

Trajectories of negative emotions in relation to binge and/or purge events. Red = high arousal, negative valence, avoidant emotions; blue = high arousal, negative valence, approach emotions; green = low arousal, negative valence, avoidant emotions. Dashed lines represent 95% confidence intervals around the trajectory for each emotion construct and colors are matched to the corresponding trajectory. Emotions measured via modified PANAS and POMS 5-point scales.

Figure 2.

Trajectories of positive emotions in relation to binge and/or purge events. Purple = low arousal, positive valence, approach emotions; orange = high arousal, positive valence, approach emotions. Dashed lines represent 95% confidence intervals around the trajectory for each emotion construct and colors are matched to the corresponding trajectory. Emotions measured via modified PANAS and POMS 5-point scales.

Table 1

PANAS and POMS items categorized by Valence, Arousal, and Approach/Avoidance

Dimensional-Defined Emotion Constructs	PANAS and POMS emotion words
Negative Valence, High Arousal, Avoidant (Cronbach's $\alpha = 0.91$)	Distressed (PANAS) Disgusted (PANAS) Afraid (PANAS) Ashamed (PANAS) Nervous (PANAS) Jittery (PANAS) Angry at Self (PANAS) Dissatisfied with Self (PANAS)
Negative Valence, High Arousal, Approach (Cronbach's $\alpha = 0.81$)	Angry (POMS) Irritable (PANAS) Annoyed (POMS) Peeved (POMS)
Negative Valence, Low arousal, Avoidant (Cronbach's $\alpha = 0.89$)	Sad (PANAS) Lonely (PANAS)
Positive Valence, High Arousal, Approach (Cronbach's $\alpha = 0.89$)	Enthusiastic (PANAS) Alert (PANAS) Determined (PANAS) Attentive (PANAS)
Positive Valence, Low Arousal, Approach (Cronbach's $\alpha = 0.88$)	Calm (PANAS) Happy (PANAS) Proud (PANAS) Relaxed (PANAS) Cheerful (PANAS) Confident (PANAS)

Note: The five dimensionally-defined emotion constructs were developed according to previously published empirical work and consultation with experts

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

Table 2

Behavior	Variable	HNAV				HNAP				LNAV			
		Est	SE	p	95% CI	Est	SE	p	95% CI	Est	SE	p	95% CI
Binge-only	Intercept	1.044	0.031	<0.001	0.983, 1.104	0.853	0.041	<0.001	0.773, 0.932	0.984	0.038	<0.001	0.910, 1.059
	Hours to behavior	0.088	0.007	<0.001	0.075, 0.100	0.082	0.010	<0.001	0.063, 0.101	0.087	0.009	<0.001	0.071, 0.104
	(Hours to behavior) ²	0.008	0.001	<0.001	0.006, 0.010	0.008	0.001	<0.001	0.006, 0.011	0.008	0.001	<0.001	0.006, 0.010
	(Hours to behavior) ³	0.0002	2.6E-5	<0.001	0.0001, 0.0002	0.0002	3.8E-5	<0.001	0.0002, 0.003	0.0002	3.3E-5	<0.001	0.0001, 0.0003
	(Hours to behavior) ² *Pre/Post	-0.063	0.024	<0.001	-0.087, -0.040	-0.063	0.033	<0.001	-0.096, -0.031	-0.050	0.029	<0.001	-0.079, -0.021
	(Hours to behavior) ² *Pre/Post	-0.002	0.001	0.187	-0.004, 0.001	-0.001	0.002	0.366	-0.005, 0.002	-0.003	0.001	0.012	-0.006, -0.001
	(Hours to behavior) ³ *Pre/Post	-0.0004	4.9E-5	<0.001	-0.0005, -0.0003	-0.0004	7.2E-5	<0.001	-0.001, -0.0003	-0.0003	6.5E-5	<0.001	-0.0005, -0.0002
Purge-only	Intercept	0.978	0.033	<0.001	0.914, 1.041	0.795	0.038	<0.001	0.720, 0.870	0.940	0.038	<0.001	0.866, 1.015
	Hours to behavior	0.075	0.009	<0.001	0.058, 0.092	0.055	0.010	<0.001	0.035, 0.075	0.074	0.010	<0.001	0.055, 0.093
	(Hours to behavior) ²	0.007	0.001	<0.001	0.005, 0.009	0.005	0.001	<0.001	0.003, 0.008	0.007	0.001	<0.001	0.004, 0.010
	(Hours to behavior) ³	0.0002	3.7E-5	<0.001	0.0001, 0.0002	0.0001	4.9E-5	0.010	3.1E-5, 0.002	0.0002	4.6E-5	<0.001	8.0E-5, 0.0003
	(Hours to behavior) ² *Pre/Post	-0.049	0.029	<0.001	-0.078, -0.021	-0.043	0.033	<0.001	-0.076, -0.010	-0.045	0.034	<0.001	-0.078, -0.011
	(Hours to behavior) ² *Pre/Post	-0.003	0.001	0.066	-0.005, 0.002	-0.001	0.002	0.528	-0.005, 0.002	-0.002	0.002	0.159	-0.006, 0.001
	(Hours to behavior) ³ *Pre/Post	-0.0003	6.4E-5	<0.001	-0.0004, -0.0002	-0.0002	8.9E-5	0.009	-0.0004, -5.9E-5	-0.003	8.4E-5	<0.001	-0.0005, -0.0001
Binge & Purge	Intercept	0.938	0.031	<0.001	0.878, 0.999	0.758	0.037	<0.001	0.686, 0.830	0.892	0.037	<0.001	0.819, 0.964
	Hours to behavior	0.036	0.004	<0.001	0.029, 0.044	0.023	0.004	<0.001	0.015, 0.032	0.034	0.004	<0.001	0.026, 0.042
	(Hours to behavior) ²	0.001	0.0003	0.018	0.0001, 0.001	-2.1E-5	0.0003	0.950	-0.001, 0.001	5.8E-5	0.0003	0.846	-0.001, 0.001
	(Hours to behavior) ³	-7.6E-5	1.3E-5	<0.001	-0.0001, -5.0E-5	-9.0E-5	1.8E-5	<0.001	-0.0001, -5.5E5	-10.0E-5	1.5E-5	<0.001	-0.0001, -7.0E-5
	(Hours to behavior) ² *Pre/Post	-0.017	0.010	<0.001	-0.027, -0.007	-0.015	0.012	<0.001	-0.027, -0.003	-0.015	0.012	<0.001	-0.026, -0.003
	(Hours to behavior) ² *Pre/Post	-0.001	0.0003	0.005	-0.002, -0.0003	-1.6E-5	0.0004	0.966	-0.001, 0.001	-9.3E-5	0.0003	0.769	-0.001, 0.001
	(Hours to behavior) ³ *Pre/Post	0.0001	1.6E-5	<0.001	8.2E-5, 0.0001	0.0001	2.2E-5	<0.001	8.1E-5, 0.002	.0001	1.8E-5	<0.001	9.6E-5, 0.0002

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; confidence intervals that do not overlap indicate significant differences between emotion constructs; bold indicates statistically significant values at $p < 0.05$

Table 3

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

Behavior	Variable	LPAP				HPAP			
		Est	SE	p	95% CI	Est	SE	p	95% CI
Binge-only	Intercept	0.807	0.030	<0.001	0.748, 0.866	0.899	0.028	<0.001	0.844, 0.954
	Hours to behavior	-0.065	0.006	<0.001	-0.076, -0.054	-0.051	0.007	<0.001	-0.064, -0.038
	(Hours to behavior) ²	-0.007	0.0007	<0.001	-0.008, -0.005	-0.006	0.0009	<0.001	-0.008, -0.004
	(Hours to behavior) ³	-0.0002	2.5E-5	<0.001	-0.0002, -0.0001	-0.0002	3.1E-5	<0.001	-0.0002, -0.0001
	(Hours to behavior) [*] Pre/Post	0.060	0.022	<0.001	0.038, 0.081	0.029	0.022	<0.001	0.007, 0.050
	(Hours to behavior) ² *Pre/Post	0.001	0.001	0.655	-0.002, 0.003	0.003	0.001	0.011	0.001, 0.006
	(Hours to behavior) ³ *Pre/Post	0.0004	4.8E-5	<0.001	0.0003, 0.0005	0.0003	5.2E-5	<0.001	0.0002, 0.0004
Purge-only	Intercept	0.868	0.029	<0.001	0.812, 0.924	0.944	0.028	<0.001	0.890, 0.999
	Hours to behavior	-0.045	0.007	<0.001	-0.059, -0.032	-0.031	0.008	<0.001	-0.046, -0.015
	(Hours to behavior) ²	-0.005	0.0009	<0.001	-0.006, -0.003	-0.004	0.001	<0.001	-0.006, -0.002
	(Hours to behavior) ³	-0.0001	3.3E-5	<0.001	-0.0002, -5.2E-5	-0.0001	3.8E-5	0.001	-0.0002, -5.0E-5
	(Hours to behavior) [*] Pre/Post	0.049	0.025	<0.001	0.024, 0.073	0.030	0.024	<0.001	0.006, 0.053
	(Hours to behavior) ² *Pre/Post	-0.0004	0.001	0.734	-0.003, 0.002	0.001	0.002	0.470	-0.002, 0.004
	(Hours to behavior) ³ *Pre/Post	0.0003	5.5E-5	<0.001	0.0002, 0.0004	0.0002	6.0E-5	<0.001	9.4E-5, 0.0003
Binge & Purge	Intercept	0.902	0.027	<0.001	0.850, 0.954	0.965	0.026	<0.001	0.914, 1.017
	Hours to behavior	-0.018	0.003	<0.001	-0.024, -0.012	-0.009	0.004	0.033	-0.017, -0.001
	(Hours to behavior) ²	-0.0003	0.0002	0.143	-0.001, 0.0001	-0.0002	0.0003	0.451	-0.001, 0.0003
	(Hours to behavior) ³	5.5E-5	1.1E-5	<0.001	3.3E-5, 7.6E-5	3.9E-5	1.5E-5	0.008	1.0E-5, 6.8E-5
	(Hours to behavior) [*] Pre/Post	0.015	0.009	<0.001	0.006, 0.024	0.011	0.010	<0.001	0.001, 0.021
	(Hours to behavior) ² *Pre/Post	0.0004	0.0002	0.075	-4.5E-5, 0.001	0.0002	0.0003	0.534	-0.0004, 0.001
	(Hours to behavior) ³ *Pre/Post	-8.5E-5	1.3E-5	<0.001	-0.0001, -5.9E-5	-5.3E-5	1.6E-5	0.001	-8.4E-5, -2.1E-5

Note: Est. = Parameter 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; confidence intervals that do not overlap indicate significant differences between emotion constructs; bold indicates statistically significant values at $p < 0.05$

Table 4
Between-Day Multilevel Models for Binge, Purge, and Binge/Purge Episodes with Negatively Valenced Constructs

Behavior	Variable	HNAV				HNAP				LNAV			
		Est	SE	p	95% CI	Est	SE	p	95% CI	Est	SE	p	95% CI
Binge-only	Intercept	0.913	0.032	<0.001	0.849, 0.976	0.739	0.038	<0.001	0.664, 0.814	0.872	0.038	<0.001	0.797, 0.949
	Bingeda y	-0.184	0.025	<0.001	-0.233, -0.134	-0.129	0.031	<0.001	-0.190, -0.068	-0.166	0.030	<0.001	-0.226, -0.107
	Bingeda y Mean	2.491	0.080		2.338, 2.654*	2.094	0.080		1.943, 2.257	2.392	0.091		2.220, 2.577*
	Nonbingeday Mean	2.073	0.065		1.950, 2.204*	1.840	0.057		1.732, 1.955	2.026	0.078		1.879, 2.184*
Purge-only	Intercept	0.886	0.033	<0.001	0.822, 0.950	0.717	0.036	<0.001	0.645, 0.788	0.838	0.039	<0.001	0.763, 0.914
	Purgeda y	-0.161	0.029	<0.001	-0.218, -0.103	-0.108	0.033	0.001	-0.172, -0.044	-0.128	0.034	<0.001	-0.195, -0.061
	Purgeda y Mean	2.425	0.079		2.274, 2.585*	2.048	0.075		1.907, 2.199	2.313	0.089		2.144, 2.494
	Nonpurgeday Mean	2.065	0.069		1.934, 2.205*	1.838	0.060		1.723, 1.959	2.034	0.081		1.881, 2.200
Binge & Purge	Intercept	0.881	0.031	<0.001	0.820, 0.943	0.707	0.036	<0.001	0.637, 0.777	0.832	0.038	<0.001	0.759, 0.906
	BPday	-0.177	0.027	<0.001	-0.230, -0.124	-0.101	0.032	0.002	-0.163, -0.038	-0.132	0.035	<0.001	-0.200, -0.065
	BPday Mean	2.414	0.076		2.270, 2.567*	2.028	0.072		1.892, 2.174	2.299	0.086		2.136, 2.475
	NonBPday Mean	2.023	0.067		1.896, 2.159*	1.834	0.060		1.719, 1.956	2.014	0.083		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 for the marginal means between days with behaviors and days without; bold indicates statistically significant values at $p < 0.05$.

Table 5

Between-Day Multilevel Models for Binge, Purge, and Binge/Purge Episodes for Positively Valenced Emotion Constructs

Behavior	Variable	LNAP				HPAP			
		Est	SE	<i>p</i>	95% CI	Est	SE	<i>p</i>	95% CI
Binge-only	Intercept	0.913	0.027	<0.001	0.860, 0.965	0.973	0.025	<0.001	0.924, 1.021
	Bingeday	0.107	0.022	<0.001	0.065, 0.150	0.055	0.022	0.012	0.012, 0.098
	Bingeday <i>Mean</i>	2.491	0.067		2.363, 2.625 [*]	2.645	0.065		2.520, 2.776
	Non-bingeday <i>Mean</i>	2.773	0.065		2.648, 2.904 [*]	2.795	0.064		2.671, 2.924
Purge-only	Intercept	0.932	0.026	<0.001	0.881, 0.984	0.983	0.025	<0.001	0.935, 1.031
	Purgeday	0.090	0.023	<0.001	0.045, 0.135	0.045	0.024	0.060	−0.002, 0.092
	Purgeday <i>Mean</i>	2.540	0.067		2.413, 2.674	2.672	0.066		2.547, 2.804
	Non-purgeday <i>Mean</i>	2.779	0.069		2.647, 2.918	2.796	0.068		2.666, 2.931
Binge & Purge	Intercept	0.941	0.026	<0.001	0.891, 0.991	0.991	0.023	<0.001	0.946, 1.037
	BPday	0.082	0.022	<0.001	0.038, 0.126	0.032	0.022	0.136	−0.010, 0.074
	BPday <i>Mean</i>	2.562	0.065		2.437, 2.694	2.694	0.063		2.574, 2.820
	Non-BPday <i>Mean</i>	2.781	0.070		2.647, 2.922	2.782	0.068		2.652, 2.918

Note: Est. = Parameter estimate; LNAP = 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 $p < 0.05$