An Investigation of Positive and Negative Affect Before, During, and After Binge Eating Episodes in Bulimia Nervosa

A Thesis
Submitted to the Faculty
of
Drexel University
by
Ashley Anne Witt
in partial fulfillment of the requirements for the degree of
Doctor of Philosophy
March 2015
Acknowledgments

I would like to express my gratitude to Dr. Michael Lowe, my primary advisor and dissertation chair, for his invaluable support and guidance over the last five years. I would also like to thank Dr. Graham Thomas for his incredible generosity with his time and expertise, as well as the other members of my committee, Dr. Meghan Butryn, Dr. David DeMatteo, and Dr. Matthew Nock, for their expert guidance.

I am grateful to Jennifer Gilbert, whose diligent efforts, positive attitude, and boundless patience helped to make this project possible. My fellow graduate students Laura Berner and Staci Berkowitz have dedicated their time to the execution of this project as well.

Finally, I want to express a special thank you to my family for their unwavering support.
Table of Contents

LIST OF TABLES ........................................................................................................... v
LIST OF FIGURES .......................................................................................................... vi
ABSTRACT ....................................................................................................................... vii
INTRODUCTION ............................................................................................................. 1
Maintenance of Binge Eating in BN .............................................................................. 2
The Present Study .......................................................................................................... 20
METHODS ...................................................................................................................... 22
Participants .................................................................................................................... 22
Procedures .................................................................................................................... 23
Measures ....................................................................................................................... 26
Data Analytic Strategy ................................................................................................. 28
RESULTS ........................................................................................................................ 33
Participant Flow and Characteristics ......................................................................... 33
EMA Descriptive Statistics and Compliance ............................................................... 34
Measure Reliability ..................................................................................................... 35
Primary Aims ................................................................................................................ 35
Exploratory Aims ......................................................................................................... 39
DISCUSSION .................................................................................................................. 39
Trajectories of Positive and Negative Affect Before and After Binge Episodes ............ 41
Comparison of Affect Before and During Binge Episodes ............................................ 44
General Discussion ..................................................................................................... 47
REFERENCES ............................................................................................................... 55
VITA

.................................................................75
List of Tables

1. Sample Characteristics ........................................................................................................68

2. Multilevel Models for Positive and Negative Affect Before and After Binge Episodes
   (Aim 1) ..............................................................................................................................69

3. Multilevel Models for Positive and Negative Affect Before vs. During Binge
   Episodes (Aim 2) ............................................................................................................70
List of Figures

1. Trajectories of positive affect before and after binge episodes .................................71

2. Trajectories of negative affect before and after binge episodes ..................................72

3. Positive affect before vs. during binge episodes, by rating type (binge reported during an event-contingent rating vs. reported at the next signal-contingent recording) ...............73

4. Negative affect before vs. during binge episodes, by rating type (binge reported during an event-contingent rating vs. reported at the next signal-contingent recording) ...............74
Abstract
An Investigation of Positive and Negative Affect Before, During, and After Binge Eating Episodes in Bulimia Nervosa
Ashley Anne Witt

Background: The affect regulation theory of binge eating suggests that binge eating is triggered by negative affect and functions to reduce negative affect. While binge eating frequently follows negative affect, available evidence suggests that negative affect increases immediately following a binge episode. However, it remains unclear whether short-term decreases in negative affect occur during the binge episode itself. In addition, the role of positive affect in binge eating is not well understood.

Objectives: (1) To examine trajectories of positive and negative affect before and after binge eating episodes among women with BN; and (2) to compare positive and negative affect during binge episodes to affect before binge episodes. Exploratory aims were (3) to compare trajectories of positive and negative affect before and after binge eating episodes that are anticipated vs. unanticipated; and (4) to compare trajectories of positive and negative affect before and after objective vs. subjective binge eating episodes.

Method: Thirty-five women with BN were asked to answer questions about binge eating and affect several times daily over a 14-day period using an ecological momentary assessment (EMA) procedure. Affect during binge episodes was assessed retrospectively during the EMA rating following each binge episode.

Results: Positive affect decreased in the hours before binge episodes and increased in the hours following binge episodes, while negative affect increased in the hours before binge episodes and decreased in the hours following binge episodes. Negative affect was rated
as higher and positive affect was rated as lower during binge episodes relative to before binge episodes. Trajectories of positive and negative affect did not differ based on anticipation of the binge episode or based on the size of the binge episode (objective vs. subjective).

**Discussion:** The present findings replicate prior research on trajectories of positive and negative affect before and after binge episodes, and suggest that these trajectories are consistent regardless of whether the binge was anticipated in advance and regardless of the size of the binge episode. Comparisons of positive and negative affect before vs. during binge episodes did not support the affect regulation hypothesis of binge eating, as affect was found to worsen during binge episodes. Results may be more consistent with theories suggesting reduced inhibitory control over eating during negative emotional states, but do not suggest that binge eating produces improvements in positive and negative affect in comparison to pre-binge affective states. Further research is needed to better understand factors that maintain binge eating.
Chapter 1: Introduction

Bulimia nervosa (BN) is an eating disorder characterized by a pattern of binge eating and behaviors performed to compensate for excessive food consumption, including self-induced vomiting, fasting, or excessive exercising. An episode of binge eating is characterized by consuming an objectively large quantity of food during a discrete period of time and by a sense of loss of control over eating. To meet criteria for BN based on the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), an individual must experience episodes of binge eating and compensatory behavior at least once per week for three months or more. An additional criterion for BN is overemphasis on body weight and shape in one’s self-evaluation (American Psychiatric Association, 2013). BN is differentiated from anorexia nervosa binge-eating/purging type (AN-B/P) based on body weight: if the individual is maintaining a significantly low body weight, the diagnosis of AN-B/P is given rather than the diagnosis of BN. BN is associated with numerous psychiatric and medical complications, including high rates of depression and anxiety (Herzog, Nussbaum, & Marmor, 1996; Wonderlich & Mitchell, 1997), social withdrawal, and other interpersonal difficulties (Bulik, 2002). Common medical difficulties among bulimic individuals include fluid and electrolyte imbalances, cardiac and skeletal myopathies, menstrual irregularity, and dental damage (American Psychiatric Association, 2000; Milosevic, 1999). BN has a lifetime prevalence rate of 1-3% among women and is approximately one-tenth as common among men (American Psychiatric Association, 2000).

Eating disorders constitute a significant public health problem and, at least in the case of BN, may have increased in prevalence over the past few decades (Grilo, 2006).
Although treatment efficacy has increased in recent years, the development of effective treatments remains a challenge. Cognitive behavioral therapy (CBT) is regarded as the gold standard of treatment for BN (Shapiro et al., 2007; Wilson, Grilo, & Vitousek, 2007). However, although this treatment has accumulated impressive empirical support, rates of abstinence from binge eating and purging have been found to range from 30-50% following CBT treatment (Fairburn et al., 2009; Keel, Mitchell, Miller, Davis, & Crow, 1999; Mitchell et al., 2002; Wilson, et al., 2007), leaving a substantial group of individuals with incomplete treatment response. Furthermore, there is considerable room for improvement in maintenance of treatment gains: for instance, two recent studies found relapse rates of 44% and 53%, respectively, among participants abstinent from binge eating and purging at the end of CBT treatment (Halmi et al., 2002; Mitchell et al., 2004). Approximately one-third of individuals with BN experience persistent problems with binge eating and purging at 10-year follow-up (Keel, et al., 1999). Thus, there is an urgent need for improvements in treatment efficacy and relapse prevention. An improved understanding of the psychopathology and maintenance of eating disorders is crucial for intervention development (Wilson, 2005).

**Maintenance of Binge Eating in BN**

Binge eating is a problematic behavior that is present across weight and diagnostic categories among eating-disordered individuals and is a defining feature in BN. Many individuals with eating disorders experience subjective binge eating episodes in addition to objective binge eating episodes, in which the amount of food consumed is not objectively large but feels excessive to the individual, with associated feelings of loss of control (e.g., Fairburn, Cooper, & Copper, 1986). A number of theories have been
proposed to account for the development of bulimic symptoms, including binge eating. The dual-pathway model of bulimic symptoms (Stice & Agras, 1998) is one of the most comprehensive theories of the etiology and maintenance of BN, suggesting that BN may develop either due to strict dieting, negative affect, or a combination of these two factors. This model also integrates sociocultural factors, suggesting that societal pressure to be thin and internalization of the thin ideal may lead to both dieting and negative affect when the body is perceived as discrepant from the ideal (Stice & Agras, 1998).

Theoretically, etiological and maintenance factors for a disorder or problematic behavior may be distinct; however, paralleling the etiological factors identified in the dual-pathway model, the predominant theories of the maintenance of binge eating tend to be either diet-related or affect-related.

**Diet-Related Theories of Binge Eating.** It has been observed that binge eating and dieting often co-occur (e.g., Pyle, Mitchell, & Eckert, 1981), and that dietary restraint is particularly prevalent among individuals with BN (e.g., Davis, Freeman, & Garner, 1988). Polivy and Herman (1985) proposed that dieting involves the imposition of cognitive control over eating in place of normal physiological regulatory mechanisms. Accordingly, restrained eaters are thought to be vulnerable to over-eating, or “counter-regulatory eating,” when cognitive control over eating is disrupted. Polivy and Herman proposed that disruptions of cognitive control over eating may result from violations of the individual’s diet, e.g. when a typically avoided food is consumed, or from emotional distress or alcohol use. In support of this hypothesis, a number of studies have demonstrated counter-regulatory eating after a high-calorie pre-load among individuals identified as restrained eaters by high scores on the Restraint Scale (e.g., Herman &
Mack, 1975; Herman, Polivy, & Silver, 1979). Furthermore, restrained eaters have been shown to exhibit increased counter-regulatory eating after consumption of a pre-load believed to be high in calories compared to a pre-load believed to be low-calorie despite the absence of actual caloric differences (Ruderman & Wilson, 1979), a finding that supports the idea that cognitive processes are involved in the disinhibition of eating once an individual’s diet is perceived to be “broken.” Of note, because the Restraint Scale includes items measuring disinhibition and weight fluctuation in addition to dietary restraint, it has been argued that it is not a pure measure of restraint and instead may identify unsuccessful chronic dieters (Heatherton, Herman, Polivy, King, & McGree, 1988). It is possible that high scorers on the Restraint Scale may show a pattern of dieting and disinhibited eating similar to the eating patterns of individuals with BN. Indeed, individuals with BN have been shown to have elevated scores on the Restraint Scale (Greenberg, 1986; Wilson & Smith, 1989).

The cognitive-behavioral model of BN (Fairburn, 2008) posits that binge eating is triggered by periods of restrictive dieting, which is thought to spur binge eating in multiple ways. Avoidance of eating or under-eating for long periods of time is believed to produce excessive appetite that may result in a binge episode when eating finally occurs, in line with studies of World War II conscientious objectors that found that binge eating can result from prolonged food deprivation (Keys, Brozek, Henschel, Mickelsen, & Taylor, 1950). A recent study that used ecological momentary assessment (EMA), a “real-time” naturalistic data collection approach in which participants are asked to complete measures at multiple points throughout the day, demonstrated that caloric restriction was associated with increased the likelihood of binge eating on the same day.
and the following day (Zunker et al., 2011). In addition, in line with Herman and Polivy’s Restraint Theory, it has been suggested that an abstinence violation effect may occur as a result of the existence of strict dietary rules (Fairburn, 1997; Stice, 2001; Ward, Hudson, & Bulik, 1993). When an individual breaks a strict dietary rule, he or she may be more likely to continue to eat due to the disinhibiting effect of viewing the rule as already broken (e.g., some individuals with BN report binge eating after eating a “forbidden food” due to the feeling that the day is “ruined” already). The presence of such strict rules therefore may paradoxically produce more binge eating than would occur if the individual were attempting to follow more flexible guidelines. Consistent with this theory, the reduction of dietary restraint during CBT has been shown to partially mediate reductions in binge eating (Wilson, Fairburn, Agras, Walsh, & Kraemer, 2002). The dual-pathway model, like the CBT model, suggests that both the abstinence violation effect and caloric depletion resulting from dieting may maintain binge eating (Stice, 2001), although this model also incorporates emotion regulation effects of binge eating (discussed in more detail below).

The longer-term effects of restrictive eating are also under investigation, and there is evidence that weight suppression, the discrepancy between an individual’s current weight and highest previous weight, is associated with increased frequency of binge eating (e.g., Lowe, Thomas, Safer, & Butryn, 2007) and longer duration of illness among individuals with BN (Lowe et al., 2011). The mechanisms of this association have yet to be clarified, although it has been proposed that weight suppression may produce biological and psychological drives that contribute to excessive food consumption and eventual weight regain (Lowe, et al., 2007). Findings in non-clinical populations indicate
that significant weight loss suppresses metabolism, which results in increased propensity toward weight gain (e.g., MacLean, Bergouignan, Cornier, & Jackman, 2011). Such a propensity toward weight gain is likely to be quite distressing to an individual with BN due to the over-valuation of weight and shape central to the disorder (American Psychiatric Association, 2000), and could lead to increased attempts to restrict food intake. Thus, over both the short and long-term, restrictive eating may be involved in the maintenance of binge eating, potentially via both cognitive and biological mechanisms.

**Affective Theories of Binge Eating.** A second major category of theories of the maintenance of binge eating involves negative affect. BN frequently co-occurs with depression and anxiety (Brewerton, Lydiard, Herzog, Brotman, & et al., 1995; Kaye, Bulik, Thornton, Barbarich, & Masters, 2004); in addition, there is high comorbidity between BN and problematic behaviors such as substance abuse, risky sexual behavior, impulsive spending, and non-suicidal self-injury (Lacey & Evans, 1986; Myers et al., 2006; Svirko & Hawton, 2007). Thus, affective regulation appears to be an area of difficulty for many individuals with BN, which raises questions about the relations between affect and the core behavioral features of BN. In addition, functional models of other types of maladaptive behaviors such as non-suicidal self-injury suggest that such behaviors serve an affect regulation function, with self-injurious behaviors apparently maintained by reductions in negative affect or increases in positive or desired affective or internal states (Armey, Crowther, & Miller, 2011; Franklin et al., 2010; Nock & Prinstein, 2004). These findings raise the question of whether similar processes operate in the maintenance of bulimic behaviors.
It has been proposed that binge eating is triggered by negative affective states and may serve to regulate negative affect. More specifically, binge eating may function to reduce the experience of aversive negative emotion, possibly by providing a distraction from the original distressing stimulus (Hawkins & Clement, 1984; Stice, 2001). Binge eating may therefore be maintained by negative reinforcement (i.e., reduction in an aversive stimulus). Escape theory is similar to the affect regulation theory of binge eating in suggesting that binge eating is triggered by negative affect, but specifies that binge eating results from temporary lapses in typical inhibitory control over eating as a result of aversive self-awareness (Heatherton & Baumeister, 1991). Of note, escape theory does not specify that binge eating serves to improve affective state.

The relation of affect and binge eating is difficult to study via retrospective self-report questionnaires for several reasons. First, self-report questionnaires often ask individuals to report on patterns of behavior over a lengthy period, ranging from days to months, or “in general,” and the accuracy of such reports is questionable due to normal deterioration in memory for events as the recall period lengthens. Furthermore, individuals may not be aware of patterns of affect surrounding binge eating, making it difficult to report on such patterns. This is particularly true with respect to a behavior that may involve mixed emotions: while it has been suggested that binge eating may serve to temporarily relieve negative affect, it is also a behavior that may result in feelings of guilt, self-disgust, physical discomfort, and urges to purge. This complexity may render patterns of affect particularly difficult to report retrospectively. In addition, current state can bias memory for prior events, which may be particularly problematic since retrospective reports of patterns of affect and binge eating are vulnerable to bias resulting
from the person’s current affective state. Affective processes involved in naturalistic binge eating are therefore best studied using EMA procedures because EMA allows for collection of “real-time” data at multiple points throughout the day, reduces recall biases due to length of recall or the effect of current state (e.g., mood) on retrospective self-report, and collects information on temporal sequencing of events, mood, and behavior that may not be accessible via retrospective self-report due to participant recall difficulties or lack of awareness of such patterns.

Binge eating has been shown to follow negative emotional states, and in particular, negative emotional responses to stressful events, in several EMA studies (e.g., Anestis et al., 2010; Engel et al., 2007; Goldschmidt et al., 2014; Hilbert & Tuschen-Caffier, 2007; Smyth et al., 2007). However, the affective consequences of binge eating are less clear. Retrospective studies indicate that many individuals with BN report that binge eating helps to reduce negative emotions (Hawkins & Clement, 1984; Stickney, Miltenberger, & Wolff, 1999; Wedig & Nock, 2010), although results are mixed (e.g., Arnow, Kenardy, & Agras, 1992; Pyle, et al., 1981) and these findings must be interpreted with caution given the limitations of retrospective self-report. EMA studies have also yielded mixed findings, with some reporting improvements in mood following binge eating (e.g., Smyth, et al., 2007) and others reporting deteriorations in mood (e.g., Steiger et al., 2005; for a review, see Wolfe, Baker, Smith, & Kelly-Weeder, 2009). A number of methodological differences may have contributed to the discrepant findings, including differences in the timing of EMA measures, differences in the time frame analyzed, differences in the measurement of affect, and inadequate data collection on compensatory behaviors. Individual differences and moderator variables that have yet to be identified may also
play a role in the discrepant findings across studies; for instance, a re-analysis of the data from Smyth and colleagues’ (2007) study sample found smaller decreases in guilt after binge eating among individuals who habitually engaged in self-induced vomiting after binge eating compared to those who rarely or never engaged in self-induced vomiting (De Young et al., 2013). However, a recent meta-analysis concluded that negative affect does not appear to be reduced following binge eating when results are aggregated across studies (for a review, see Haedt-Matt & Keel, 2011). Negative affect was reduced following purging, but did not drop below pre-binge levels; thus, the authors concluded that “the binge-purge episode does not appear to effectively regulate negative affect in BN” (p. 674). However, it remains unclear whether negative affect is temporarily reduced during the binge episode itself and whether such reductions might be involved in the maintenance of binge eating.

Haedt-Matt and Keel (2011) identified the lack of assessment of specific types of negative affect (e.g., sadness, fear, guilt) as a significant gap in the EMA literature. A recent EMA study attempted to address this gap by examining trajectories of sadness, fear, guilt, and hostility during the hours before and after binge eating (Berg et al., 2013). This study indicated that all four types of negative affect increased during the hours before binge eating and gradually decreased afterwards, but that this pattern was most pronounced for guilt. These results, while intriguing, raise a number of further questions. The study was unable to determine the nature or focus of the guilt; of particular interest is whether participants felt guilt over eating versus some other aspect of their lives (e.g., interpersonal interactions, etc.). The results leave open the possibility that guilt and other negative emotions may have increased prior to the binge due to anticipation that a binge
would soon occur, which would explain the peak in feelings of guilt at the time of the binge. Indeed, there is evidence that many individuals with BN either anticipate or explicitly plan binge episodes (Abraham & Beumont, 1982). Berg and colleagues’ study highlights the fact that the mechanisms of the temporal association between negative affect and binge eating remain unclear. For instance, it is possible that negative affect is an antecedent to binge eating because negative affect produces lapses in inhibitory control, as suggested by escape theory. On the other hand, if binge eating serves as an effective distraction from negative affect and therefore provides even temporary relief, the affective consequences of binge eating might be highly reinforcing.

Potential positive reinforcing effects of binge eating have been little studied; however, there is reason to believe that positive reinforcement processes may be involved in maintaining binge eating. Animal models of binge eating have supported the presence of negative reinforcement processes by documenting that rats stressed by electric shocks or confinement show binge-like eating (Hagan et al., 2002; Inoue et al., 1998); however, animal studies also suggest that positive reinforcement processes are involved. It is possible to produce binge-like eating in rats even without implementing stressful procedures: for instance, when rats are given limited and sporadic access to highly palatable food, binge-like eating develops even in the absence of caloric deprivation (Corwin, Avena, & Boggiano, 2011). Eating is considered to be binge-like in this model when intake of the palatable food among rats with limited access to it exceeds intake of the palatable food among rats with daily access. The fact that rats will binge specifically on highly palatable food, even in the absence of stressful procedures or caloric deprivation, suggests that positive reinforcement related to consumption of palatable food
is involved in binge eating. In addition, animal studies have shown that binge-like eating is associated with repeated release of dopamine and increased opioid receptor binding in reward-related brain regions, including the nucleus accumbens (Avena & Bocarsly, 2012).

Neuroimaging studies indicate that relative to healthy controls, individuals with BN show increased activation in reward regions of the brain in response to viewing food pictures (Brooks et al., 2011) and in response to anticipated consumption of a palatable liquid when in a negative affective state (Bohon & Stice, 2012). In addition, individuals with BN have been shown to have increased availability of cannabinoid receptors, which appear to be involved in reward processes, in the insula (Gerard, Pieters, Goffin, Bormans, & Van Laere, 2011), a region thought to be involved in taste, food reward, and motivation to eat (Kaye & Bailer, 2011). In addition, self-reported sensitivity to the availability of palatable food in the environment has been found to be positively associated with binge eating frequency in BN (Witt & Lowe, 2014). Finally, research in non-clinical populations has shown that consumption of a particular food is associated with a post-consumption decline in the rated pleasantness of that food, a phenomenon known as sensory-specific satiety (Rolls, Hetherington, & Burley, 1988). However, there is evidence that individuals with BN show deficits in sensory-specific satiety: consumption of a food leads to smaller reductions in pleasantness ratings among individuals with BN relative to healthy controls (Hetherington & Rolls, 1989). Taken together, these findings suggest that hedonic appetitive processes among individuals with BN may be over-active. Thus, rather than reducing negative affect, binge eating might actually function to temporarily increase pleasure or other types of positive affect, which might be particularly salient and reinforcing during times of high emotional distress.
Furthermore, it is possible that binge eating on palatable food might be particularly reinforcing when the individual is in an energy-depleted state, either due to acute food restriction, high weight suppression, or both.

**Areas in Need of Further Study.** The strengths of EMA methodology described above render extant EMA research the most informative body of literature relevant to the topic of affect and binge eating. However, a review of the EMA literature suggests two major areas in need of further study: the role of affect during binge episodes and the role of positive affect.

*Affect During Binge Episodes.* As noted above, aggregating the results of a large number of EMA studies suggests that negative affect is not reduced after binge eating, contrary to the predictions of the affect regulation theory of binge eating (Haedt-Matt & Keel, 2011). However, it is possible that affective improvements might occur during the binge episode itself, providing short-term reinforcement that would be difficult to detect in most EMA studies due to the negative feelings that may increase after a binge, such as guilt or disgust. Affect during binge episodes is difficult to investigate empirically, and the small number of studies that have done so have yielded mixed findings. One study (Deaver, Miltenberger, Smyth, Meidinger, & Crosby, 2003) found that a sample of college undergraduate “binge eaters” reported an increase in feelings of pleasure during binge episodes and reductions in pleasure following the binge. In contrast, Johnson and Larson (1982) found that feelings of guilt, shame, and anger increased from before to during the binge among individuals with BN. Similarly, Stickney and Miltenberger (1999) found that in a sample of college undergraduate “binge eaters,” guilt, self-directed anger, and dissatisfaction with weight and shape increased during binge episodes,
although worry, agitation, and frustration did not change. Two studies found no differences in affect ratings from before to during binge episodes among individuals with BN (Hilbert & Tuschen-Caffier, 2007; Powell & Thelen, 1996).

One explanation for the mixed findings in studies that have investigated affect during binge episodes may be the differences in the types of affect assessed. One study assessed feelings of depression and anxiety (Powell & Thelen, 1996), two assessed guilt and anger (Johnson & Larson, 1982; Stickney & Miltenberger, 1999), one used a single-item global measure of mood (Hilbert & Tuschen-Caffier, 2007), and one used a single item assessing pleasure versus displeasure (Deaver, et al., 2003). Due to the small number of studies and the small samples included, however, conclusions about differences in trajectories for these different types of affect would be premature.

In addition, sample characteristics have differed across studies: two studies (Deaver, et al., 2003; Stickney & Miltenberger, 1999) used samples of college students who reported frequent binge eating rather than individuals with BN. As with the differences in types of affect assessed, the small number of studies precludes determination of whether sample differences are associated with systematic differences in results. One study (Deaver, et al., 2003) excluded participants with mood disorders or who were taking antidepressants, an exclusion criterion that reduces external validity given that many individuals with disordered eating also have mood disorders (Brewerton, et al., 1995). Of note, this was the only study that found improvements in affect during binge eating. Furthermore, all of the existing studies included relatively small samples, ranging from 15 to 40 participants who engaged in binge eating. Thus, there is a pressing
need for larger studies of affect during binge episodes among individuals diagnosed with BN.

The timing of measurements completed during binge episodes has also varied across studies. While one study instructed participants to complete ratings every two minutes during each eating episode (Deaver, et al., 2003) another asked participants to complete ratings five minutes after the binge began (Stickney & Miltenberger, 1999), and a third instructed participants to complete measures in the middle of the binge based on prior estimates of the average length of binge episodes for the individual (Powell & Thelen, 1996). The remaining two studies did not report specific instructions on timing for participants (Hilbert & Tuschen-Caffier, 2007; Johnson & Larson, 1982). The timing of assessments is important because affect may shift over the course of the binge: for instance, it is possible that an initial sense of pleasure or enjoyment might give way to increasing feelings of disgust or anxiety as the binge continues. Differences in timing may therefore have contributed to the discrepant findings in previous studies.

Due to the inability of existing studies to assess compliance with the timing of EMA ratings, it remains unclear to what extent affect during binge episodes has been accurately measured. Four of the five studies used paper-and-pencil self-monitoring forms rather than electronic EMA methods and either did not assess compliance with the timing of measure completion or assessed compliance by self-report. While the studies that assessed self-reported compliance obtained favorable compliance ratings (e.g., 85-90%; Deaver, et al., 2003; Powell & Thelen, 1996), it has been found that participants tend to significantly overestimate their compliance with EMA protocols (Shiffman, Stone, & Hufford, 2008). This is a particular concern when investigating research questions that
require completion of EMA ratings to be precisely timed. The one study that included an objective measure of compliance used a combination of computer-generated random signals and paper and pencil measures and was able to assess only the percent of random signals to which the participant responded, but could not assess compliance with the timing of the ratings intended to be completed before, during, and after eating episodes (Hilbert & Tuschen-Caffier, 2007).

A major limitation of studies that have asked participants to self-monitor before, during, and after binge episodes is that in order to complete the “before” rating, participants had to be aware that an eating episode was about to take place and in many cases were likely aware that the episode would be a binge. In fact, in some studies, participants were asked to self-monitor only during binge episodes and not during regular eating episodes (e.g., Stickney & Miltenberger, 1999), meaning that by definition the pre-binge ratings were completed once the participant was aware that a binge would occur. Because awareness of an imminent binge could substantially impact affect and might obscure differences between pre-binge affect and affect during the binge, these findings must be interpreted with caution. In addition, one study reported significantly higher rates of missing data for pre-binge ratings than for other ratings, which the authors suggest may have resulted from participants being unable to anticipate the onset of a binge (Deaver, et al., 2003).

An important goal of EMA is to improve the accuracy of data by reducing the amount of time that has elapsed between the behaviors or feelings of interest and the completion of measures, in addition to eliminating demands on the participant to remember sequences of events (and the resulting likelihood of biases in recall) by
collecting repeated measurements throughout the day. However, this method of assessment also carries the risk of disrupting participants’ naturally occurring behavior. Requiring participants to complete EMA measures during episodes of eating may be particularly intrusive, as this requires the participant to pause during an ongoing behavior in order to reflect and report on his or her emotional state. Escape theory would predict that since binge episodes are thought to result from narrowing of attention (and resulting release of inhibition) as an escape from aversive self-awareness, the increased self-awareness required to complete EMA measures might result in the cessation of eating episodes that would have otherwise become binge episodes. Indeed, one study that investigated this phenomenon found that participants reported engaging in fewer binge episodes as a result of the self-monitoring procedure (Powell & Thelen, 1996).

*Positive Affect.* Considerable debate has arisen in the field regarding whether positive and negative affects are independent dimensions or represent opposite ends of a bipolar dimension (e.g., Green, Goldman, & Salovey, 1993; Watson & Clark, 1997). Further complicating this question is the multidimensional nature of affect: as Russell and Carroll (1999) note, “there is not one but many bipolarity hypotheses. When the topic is the bipolarity of a specific affective state (such as feeling guilty), then its specific semantic opposite (feeling innocent) is the proper target of a test of its bipolarity” (p. 6). Russell and Carroll also note that the timeframe of assessment is critically important in investigating the bipolarity versus independence of positive and negative affect. People may be less likely to endorse feeling two affective states traditionally thought of as opposites (e.g., happy and sad) at the same time, but happiness and sadness may be more likely to be independent of one another (e.g., not inversely correlated) over longer
timeframes (Russell & Carroll, 1999). Given the nature of binge eating, a behavior involving a potentially pleasurable activity that may simultaneously be associated with feelings of guilt, anxiety, anger, or other negative emotions, it appears worthwhile to measure the presence and intensity of a variety of both positive and negative affective states around binge eating. However, many prior EMA studies of binge eating have incorporated measures of positive affect only as the opposing end of a unidimensional measure, for instance a scale ranging from “bored” to “excited” (e.g., Kaye, Gwirtsman, George, Weiss, & Jimerson, 1986), which precludes separate analysis of positive and negative affect. Only a small number of EMA studies have included measures of positive affect, independent of negative affect, around binge eating. However, two of these studies (Steiger, et al., 2005; Steiger, Gauvin, Jabalpurwala, Seguin, & Stotland, 1999) included separate positive affect scales but analyzed positive and negative affect together as a unitary measure of mood. While both studies found that mood was worse prior to a binge relative to mood on non-binge days and that mood deteriorated further after binge episodes, the combined analysis of positive and negative affect obscures any potential differences in trajectories of positive and negative affect.

Lingswiler and colleagues (1989) instructed participants who reported binge eating, approximately half of whom had BN, to rate the degree to which several different positive affect adjectives described their current state immediately after binge eating and one hour later. Affective words included pleasure, high/euphoric, enjoyment, energetic, and relaxed. Results indicated that positive affect declined between the immediate post-binge and 1-hour delayed ratings; unfortunately, no pre-binge ratings of positive affect were made, so this study does not shed light on how positive affect may change from
before to after binge eating. Two studies (Corstorphine, Waller, Ohanian, & Baker, 2006; Sherwood, Crowther, Wills, & Ben-Porath, 2000) have compared positive affect rated immediately before the binge to positive affect immediately after the binge and have found no significant differences using a single-item measure of “happiness/relief” and the positive affect scale of the Positive and Negative Affect Scale (PANAS; Watson, Clark, & Tellegen, 1988), respectively. However, “happiness/relief” was found to increase after vomiting (Corstorphine, et al., 2006). It should be noted that, as with several of the studies mentioned above, in order to make the immediate pre-binge rating participants had to be aware that a binge was about to occur (although in Sherwood and colleagues’ study (2000), participants were asked to rate affect before and after each eating episode, regardless of whether or not it was a binge episode; thus, in this case participants were at a minimum aware that an eating episode was beginning and might have been aware that a binge was about to occur). The pre-binge ratings may therefore reflect affective state concurrent with rather than prior to the binge episode.

Two studies to date have addressed these limitations by using both random signal-contingent and event-contingent monitoring of positive affect in EMA (Smyth, et al., 2007; Wegner et al., 2002). Wegner and colleagues (2002) recruited a sample of college students who engaged in binge eating at least once per week and endorsed significant distress associated with binge eating. In addition to signal-contingent ratings, after each eating episode participants were asked to rate current mood (using the “happy,” “confident,” and “excited” items from the PANAS) and their recalled mood just prior to the eating episode. Results indicated that positive affect was lower overall on days in which binge episodes occurred, but that mean levels of positive affect in the several hours
before the binge did not differ from mean affect ratings in the hours after the binge. Ratings made 30-60 minutes before a binge episode also did not significantly differ from ratings made 30-60 minutes after a binge episode. However, participants reported higher negative affect and lower positive affect immediately after binge episodes than they recalled immediately prior to binge episodes. Smyth and colleagues (2007), in contrast, examined slopes of changes in affect rather than averaging multiple affect ratings before and after binge episodes; results indicated that in a large sample of women with BN, positive affect (measured using the PANAS) decreased over several hours prior to binge eating but recovered in the hours after binge eating, regardless of whether or not vomiting occurred. A meta-analysis of studies that have examined positive affect and binge eating using a variety of EMA methodologies found lower positive affect after binge eating compared to before binge eating (Haedt-Matt & Keel, 2011).

Taken together, results of the studies reviewed above suggest that positive affect decreases prior to binge episodes and may be especially low shortly after the binge episode ends, although one study found that positive affect recovered over the course of the hours after the binge (Smyth, et al., 2007). However, the role of positive affect during binge eating remains unclear, and none of the studies that have investigated affect during binge episodes have assessed positive affect (although Johnson & Larson (1982) assessed feelings of “control” and “adequacy,” these constructs may be more related to cognitive processes than affective states). Thus, it is unclear whether positive affect increases, decreases, or remains unchanged while binge eating is occurring. The studies reviewed above suggest that any increases in positive affect that might occur during binge eating
are likely to be short-lived, as positive affect appears to be low immediately after binge episodes.

The Present Study

Aims. The present study aimed to address gaps in previous literature on affect and binge eating by examining both negative and positive affect before, during, and after binge eating episodes using a two-week EMA protocol in a sample of women with BN. Available data suggest that negative reinforcement via reductions in negative affect is an important maintaining factor in other maladaptive behaviors such as non-suicidal self-injury (e.g., Franklin, et al., 2010; Nock & Prinstein, 2004), and positive reinforcement via increases in desired internal states may be important as well (Nock, 2010). However, despite numerous studies in this area, the role of affect regulation- and positive affect in particular- in the maintenance of binge eating is not well understood.

Specifically, the first aim of the present study was (1) to replicate prior work (Smyth, et al., 2007) by examining (a) trajectories of negative affect and (b) trajectories of positive affect in the hours before and after binge eating. The second aim was (2) to build on prior work by examining positive and negative affect during binge episodes, and to compare positive and negative affect during binge episodes to positive and negative affect before binge episodes. Participants were asked to rate both their present mood and their mood just after the binge began during event-contingent EMA ratings for each binge eating episode. This methodology, while retrospective, involves a shorter recall period in comparison to most retrospective survey studies, and is less likely to produce reactivity to assessment in comparison to protocols that have asked participants to self-monitor during binge episodes. Binge episodes may last for a considerable length of time (e.g., one study...
found an average binge duration of 30 minutes; SE = 10 minutes; Kaye, et al., 1986); however, participants were asked to rate affect just after the binge began because it was hypothesized that negative affective states such as guilt and self-disgust may increase over time as the binge episode continues and more food is consumed. Such an increase in negative affect over the course of the binge might obscure any initial affective improvements during the early part of the binge; thus, asking participants to rate affect just after the binge began was considered to be the optimal way to investigate the current research question.

Due to the lack of clarity in many previous studies concerning whether pre-binge affect ratings may have been affected by knowledge that a binge episode was imminent, and in light of evidence that many individuals with BN report sometimes planning binge episodes (Abraham & Beumont, 1982), an exploratory aim of the present study was (3) to compare positive and negative affect trajectories prior to anticipated versus unanticipated binge episodes, classified by asking participants in the first EMA rating of each day whether they anticipate that a binge will occur that day. An additional exploratory aim was (4) to compare positive and negative affect trajectories prior to and following subjective versus objective binge episodes, as these different types of binge episodes have often not been differentiated in the EMA literature and it is unclear whether they are associated with similar affect trajectories.

**Hypotheses.** *Aim 1.* Based on the findings of Smyth and colleagues (2007), it was expected that on days during which binge episodes occur, (a) negative affect will increase between the first rating of the day and the binge episode and will decrease during the
hours after a binge episode occurs, while (b) positive affect will decrease during the
hours preceding a binge and will increase during the hours after a binge episode occurs.

*Aim 2.* Negative affect was expected to be lower, and positive affect higher,
during binge episodes compared to pre-binge negative and positive affect, respectively.

**Chapter 2: Methods**

**Participants**

Participants were 35 females between the ages of 18 and 45 who met *DSM-5*
criteria for BN, recruited as part of a two-site, grant-funded study of eating behaviors and
metabolic variables in BN at Drexel University and Columbia University. To ensure
generalizability of results to individuals in treatment or seeking treatment, only
prospective participants who were currently receiving outpatient treatment (either
psychotherapy or pharmacotherapy) or who were seeking treatment for their eating
disorder were included. Exclusion criteria for the larger grant-funded study included BMI
less than 18.5 or greater than 30; any signs of menopause; medical instability as
determined by the study physician; current use of atypical antipsychotic medications,
other medications affecting metabolism, or medications affecting hormone levels such as
birth control pills; change in psychotropic medication dosage during the past four weeks
or anticipated change during the next month; history of anorexia nervosa within the past
year; substance abuse or dependence within the past three months; serious psychiatric
problems including bipolar disorders, psychotic disorders, borderline personality
disorder, or active suicidality within the past year; pregnancy; polycystic ovary
syndrome; or non-removable metallic objects in the body. Recruitment took place
between June 2013 and August 2014.
Procedures

**Screening.** Following a telephone screening, participants underwent an in-person screening to confirm eligibility. Informed consent for the screening visit was obtained upon participants’ arrival. The screening visit included a semi-structured interview with a study staff member to assess diagnostic criteria for BN, as well as a medical evaluation. The medical evaluation included measurement of height, weight, vital signs, and a blood draw for serum chemistries (e.g. potassium). It was determined a priori that individuals determined to be medically unstable would be referred for medical treatment and would need to be re-assessed for eligibility if still interested in participating following medical stabilization. However, no prospective participants were determined to be medically unstable within the recruitment timeframe for the current study.

**Laboratory Visits.** Data were collected over the course of three laboratory visits. At the first visit, informed consent for participation was obtained. Next, participants completed self-report questionnaires as part of the larger grant-funded research protocol and were taught to operate the EMA. They then took a smartphone to collect two days of practice EMA recordings. These ratings were checked at the second laboratory visit and, upon successful completion of EMA training, participants were given the device to be used for their 14-day EMA. Participants were given an e-mail address and phone number for laboratory personnel in the event that questions arose during the EMA period. During the third laboratory visit, participants returned the smartphone and received compensation.

**Ecological Momentary Assessment.** Participants were instructed to carry the smartphone with them at all times during the EMA period. The EMA protocol employed
both “event-contingent” recording (participant is instructed to make recordings when a particular event occurs) and “signal-contingent” recording (made throughout the day following the generation of a signal on a semi-random basis). In addition, participants were asked to make recordings just after waking up in the morning and just prior to going to sleep each evening. Participants were instructed to complete event-contingent recordings whenever they experienced an episode of binge eating (objective or subjective) or purging (each was recorded regardless of the occurrence of the other). However, if binge eating and purging occurred consecutively, participants were instructed to treat this as a single “episode” and to complete the event-contingent recording once the full episode was completed. The device was also programmed to emit a signal (a combined audible tone and vibration) at four semi-random times near the following anchor points: 11:00 a.m., 2:00 p.m., 5:00 p.m., and 8:00 p.m. To prevent participants from altering their behavior in anticipation of the signal, signal times were randomly dispersed within 45 minutes of these anchor points. Participants were given 45 minutes from the time of the signal to complete the recording; after 45 minutes, the questionnaires on the smartphone were no longer accessible.

Because previous large EMA studies have found that although there is considerable variability in the timing of binge eating, frequency of binge eating appears to peak around 1pm and again between 7pm and 9pm (Smyth et al., 2009), it was anticipated that this assessment schedule would be adequate to capture most instances of binge eating. However, it should be noted that the likelihood of missing late-night binge episodes in signal-contingent ratings is a limitation of this procedure. This concern was partially addressed by the inclusion of a recording in the evening just prior to going to
sleep, which provided an opportunity to report on any binge eating or purging that was not previously reported.

Signal-Contingent Ratings. Participants were instructed to complete a rating (i.e., answer questions) via the device upon hearing the signal. After each signal, participants were asked to rate their current affective state (described in detail below). Participants were asked to indicate whether they had experienced any binge episodes (as defined for them as part of their EMA training) that they had not recorded since the last signal. When binge episodes were reported, participants were asked whether they had eaten a large amount of food and whether they experienced loss of control over eating (both answered yes or no, as defined during EMA training). Participants were then asked to recall their affective state “just after the binge began” and retrospectively rated their affective state at that time. Participants were then asked if purging occurred and, if so, which form of purging (vomiting, diuretics, laxatives, excessive exercise).

Event-Contingent Ratings. As noted above, participants were instructed to complete EMA ratings after each episode of binge eating. During these ratings, participants rated their current affective state (see detailed description below) and answered questions about the size of the binge and the experience of loss of control, as described above. Next, participants were asked to recall their affective state “just after the binge began,” and retrospectively rated their affective state at that time.

Morning and Evening Recordings. As noted above, participants were asked to complete recordings just after waking up in the morning and just prior to going to sleep each evening. Participants were first asked to rate their current affective state. In the morning recording, participants were asked whether any binge episodes had occurred
after going to bed; in the evening recording, participants were asked whether any binge episodes had occurred since the last signal that had not yet been reported. When binge episodes were reported, participants answered questions about the size of the binge and the experience of loss of control, and then rated their affective state just after the binge began, as described above. In addition, during the morning recording, participants were asked to rate the likelihood of a binge episode occurring that day on a four-point scale ranging from “definitely will not binge” to “will definitely binge.” This item also included an option for “will be unable to binge today” to account for situational limitations on binge eating.

Each rating was estimated to take 2 to 5 minutes to complete based on pilot testing. Participants were told that any rating completed within 45 minutes of the signal would be counted as valid. They were told not to complete ratings in situations in which they could incur harm by doing so (e.g., while driving), and instead to delay (“snooze”) the device and complete the entry as soon as possible. To motivate compliance with the EMA protocol, participants were compensated $2 for each rating completed within 45 minutes of a signal. To maintain participant confidentiality, the smartphones were not labeled with the name or contact information of the participant.

Measures

Eating Disorder Examination (EDE). The EDE is a semi-structured, clinician-administered interview that assesses frequency of binge eating and compensatory behaviors as well as severity of eating disorder psychopathology (Fairburn, 2008). The EDE yields four subscales assessing restraint, eating concern, weight concern, and shape concern, and has demonstrated good inter-rater reliability and convergent and
discriminant validity (Cooper, Cooper, & Fairburn, 1989; Rosen, Vara, Wendt, & Leitenberg, 1990). Information from EDE interviews was used to determine whether prospective participants met proposed DSM-5 criteria for BN. Although EDE scores were not used in the primary analyses, descriptive statistics for the EDE subscales are reported in Table 1 in order to characterize the sample.

**Positive and Negative Affect.** An abbreviated version of the Positive and Negative Affect Scale- Expanded Form (PANAS-X; Watson & Clark, 1994) was used to assess positive and negative affective states in EMA. The PANAS-X consists of a list of adjectives describing different emotional states (e.g., “sad,” “angry”). Participants were asked to indicate the degree to which each item describes their current state (or, in the case of the retrospective ratings, their state just after the binge began) on a five-point Likert scale ranging from 1 (“very slightly or not at all”) to 5 (“extremely”). The PANAS-X yields subscales for general positive and negative affect, which are calculated from the mean of positive and negative affect items, respectively. In addition, the PANAS-X yields subscales for more specific types of positive and negative affect (e.g., fear, sadness). The PANAS was abbreviated in the present study to minimize the burden on participants during the EMA procedure. Items were selected on conceptual grounds to assess a range of different positive and negative affective states thought to be potentially relevant to binge eating. One to two items were selected from each of the basic “lower order” negative emotion scales (Fear, Sadness, Guilt, and Hostility) as well as the Joviality scale (e.g., “happy,” “excited”) and the Serenity scale (“calm”). In addition, the item “distressed” (from the general Negative Affect scale) was included. Because the PANAS is quite commonly abbreviated in this manner and typically retains high
reliability (see for examples Brouer & Harris, 2007; Mikolajczak, Roy, Verstrynge, & Luminet, 2009; Murray, 2007; Stein, Goldman, & Del Boca, 2000), and because the general positive and negative affect scales and the lower order mood scales have shown high internal consistency in validation studies (all alpha’s > .83, with the exception of the Serenity subscale, for which alpha = .76), it was anticipated that the abbreviated measure would be adequately representative of the selected original subscales. Items assessing boredom, feelings of numbness, enjoyment, euphoria, and feeling “upset without knowing why” were added due to clinical anecdotes suggesting that these emotional states might be relevant to binge episodes among participants with BN. Mean scores for positive and negative affect items were calculated in the present study; however, since these groups of items include some that were not originally part of the PANAS-X, internal consistency for each subscale was evaluated as described below.

**Beck Depression Inventory.** The revised Beck Depression Inventory (BDI-1A; Beck & Steer, 1993) is a 21-item self-report measure of depressive symptoms. The BDI-1A has demonstrated good reliability and validity (e.g., Beck, Steer, Ball, & Ranieri, 1996). Although data from the BDI-1A were not included in the primary analyses, descriptive statistics for the BDI-1A are reported in Table 1 in order to characterize the sample.

**Data Analytic Strategy**

For each rating, overall positive affect and negative affect scores were calculated by taking the mean of all positive and negative affect items, respectively. Cronbach’s alpha statistics were calculated to examine internal consistency for each subscale as well as item-total correlations.
Analyses of affect surrounding binge episodes were conducted using two-level linear mixed models, with ratings of affect represented at level 1 and participants represented at level 2. This approach accounts for the non-independence of repeated observations made by the same participant and allows for participants to contribute differing numbers of observations to the analysis. For analyses of affect trajectories (Aims 1, 3, and 4), data from participants who contribute multiple observations of binge episodes (which was the case for all but one participant) were combined to produce average slopes of affect pre-binge and post-binge for each participant, excluding ratings of affect during the binge. Random effects were employed for both intercept and slope, and two-tailed tests were used for all analyses. For each aim described below, models were run separately for the outcome variables of positive affect and negative affect.

The analysis of each aim was conducted in three steps. The first step involved testing the unconditional means model, with no predictors, to test for statistically significant variability in the dependent measure (i.e., significant variability in intercepts). In the second step, time was added to the model, with its corresponding random effect, to test for statistically significant variability in slopes in an unconditional growth curve model. In the third and final step, predictors were added to the model to account for variability in intercepts and slopes.

**Primary Aims.** Aim 1: Trajectories of Affect Before and After Binge Episodes. Participants’ reports of current affective state from signal- and event-contingent ratings were used to examine trajectories of affect before and after binge episodes. On days during which a binge episode was reported, data were included from all ratings of affect completed prior to or following the binge episode. Ratings of affect during the binge
were not included in these analyses. The time of the binge was designated as time 0. Multilevel models included two predictor variables, a continuous variable indicating the absolute value of hours relative to the binge and a dichotomous variable coding whether the rating took place before or after the binge, to allow for examination of affect trajectories before and after binge eating and determine whether trajectories significantly differ before vs. after a binge episode. Linear and quadratic effects of time were tested to determine which model best fit the data. The outcome of the test rested on the significance value for the coefficients representing the effect(s) of time. It was hypothesized that, on average, negative affect would increase linearly prior to a binge and decrease linearly following a binge, while positive affect was expected to decrease linearly prior to a binge and increase linearly following a binge.

*Aim 2: Comparison of Affect Before and During Binge Episodes.* In contrast to the previous analysis that aimed to detect trajectories in affect before and after a binge, the purpose of this analysis was to compare affect ratings before and during a binge. As noted above, the outcome variables of positive and negative affect scores were analyzed separately. In this analysis, the independent variable of time had two levels (before and during the binge) represented by a binary dummy variable. Data from any ratings made during the 3 hours preceding the rating in which a binge was reported were used to calculate pre-binge affect; multiple observations from the same participant over the EMA period were combined to create the most precise estimate of pre-binge positive and negative affect for that participant.

Given that some binges were recorded retrospectively in response to random signal-contingent prompts rather than in event-contingent recordings immediately after a
binge episode, we conducted an additional analysis to determine whether the type of rating (contemporaneous or retrospective) influenced the pattern of results. Rating type was represented by a binary variable, and the main effect of rating type as well as the product term of rating type and the binary time variable (before vs. during the binge) were added to the model.

**Exploratory Aims.** *Aim 3: Affect Trajectories Surrounding Anticipated vs. Unanticipated Binges.* Binge episodes were considered “anticipated” if the participant indicated (at the first rating of the day) that a binge was “likely” or “very likely” to occur. Positive and negative affect trajectories prior to and following binge episodes were modeled as described under Aim 1; however, the additional predictor variable of “type of binge” was represented by a binary dummy variable, with days on which a binge was anticipated coded as 1 and days on which a binge was not anticipated coded as 0. The interaction of this variable with the time variable was examined to determine whether affect trajectories differed for anticipated vs. unanticipated binges.

*Aim 4: Affect Trajectories Surrounding Objective vs. Subjective Binge Episodes.* Subjective binge episodes were identified through participants’ report of experiencing loss of control while eating an amount of food that felt excessive to the participant but was not unusually large (as defined during participants’ EMA training). Positive and negative affect trajectories prior to and following binge episodes were modeled as described under Aim 1; however, the additional predictor variable of “type of binge” was represented by a binary dummy variable with subjective binge episodes coded as 1 and objective binge episodes coded as 0. The interaction of this variable with the time
variable was examined to determine whether affect trajectories differed for subjective vs. objective binges.

For all of the above analyses, in cases in which multiple binge episodes occurred during a single day, only the first binge episode was included in the analyses to avoid possible effects of an earlier binge episode on affect ratings preceding a later binge episode. Following the procedure described by Berg and colleagues (Berg, et al., 2013), only post-binge affect ratings made prior to the second binge episode were included in analyses of affect trajectories (Aims 1, 3, and 4). It should be noted that although we are able to characterize patterns of affect surrounding the first binge episode of the day, we are unable to draw conclusions about patterns of affect surrounding repeated binge episodes occurring within a single day. In addition, overnight binges reported in the morning recording the following day were excluded from the analyses, as there was insufficient data on affect before and after these overnight binge episodes given the EMA assessment schedule.

**Missing EMA data.** Due to the nature of EMA assessment, missing data may occur due to failure to respond to a signal, inability to complete assessments across a given time interval, and attrition from the study. Compliance rates were calculated for each participant, and it was determined a priori that participants with markedly low compliance rates (e.g., < 50%) would be excluded from EMA analyses. Based on prior EMA research, we anticipated that few participants would need to be excluded due to low compliance.

**Power.** Most parameters of the proposed analyses could not be estimated in advance due to a lack of prior research. We initially anticipated a sample size of $N = 50$, 
which was expected to provide adequate power to test our aims given that most EMA studies of BN find statistically significant effects with sample sizes smaller than \( N = 50 \) (Corstorphine, et al., 2006; Hilbert & Tuschen-Caffier, 2007; Lingswiler, et al., 1989; Powell & Thelen, 1996; Sherwood, et al., 2000; Steiger, et al., 2005). Given the nature of the present research questions, the number of observations of binge eating is an important component of the sample size in addition to the number of participants. Based on prior EMA research among participants with BN, it was estimated that binge eating would occur on 28% of days in the sample as a whole. Thus, with \( N = 50 \) and 14 days of EMA per participant, we anticipated \( \geq 166 \) total observations of binge eating with an estimated 85% adherence to the EMA protocol. However, given the high rates of binge eating in this sample and the longer than expected timeframe of recruitment, recruitment was stopped after 35 participants had completed the protocol. A total of 417 episodes of binge eating were reported, 261 of which were the first binge of the day.

**Chapter 3: Results**

**Participant Flow and Characteristics**

Between June 2013 and August 2014, 197 potential participants were screened via telephone. Reasons for exclusion at the phone screen level were: subthreshold frequency of binge eating or purging \( (N = 37) \), BMI less than 18.5 or greater than 30 \( (N = 20) \), use of excluded medications or recent change in psychotropic medication dose \( (N = 17) \), use of hormonal birth control \( (N = 14) \), diagnosis of an excluded psychiatric condition (e.g., bipolar disorder, \( N = 8 \)), age outside the specified age range for the study \( (N = 5) \), diagnosis of AN in the past year \( (N = 4) \), substance abuse or dependence in the last three months \( (N = 3) \), self-reported medical issues (e.g., low heart rate; \( N = 3 \)), menstrual
irregularities ($N = 2$), not in treatment or seeking treatment ($N = 1$), male ($N = 1$). One participant was excluded due to active domestic violence and an unstable home environment, resulting in concerns about her ability to complete study measures. Thirty-nine prospective participants declined interest in the study or did not respond to attempts at contact following the phone screen. Of the 42 participants who completed in-person screening visits, six were excluded because they did not meet the frequency criteria for binge eating and purging, and one was excluded due to having met criteria for AN within the past year. The remaining 35 participants completed the EMA protocol.

The majority of participants (68.6%, $N = 24$) identified as White, 8.6% ($N = 3$) identified as African American, 11.4% ($N = 4$) identified as Asian, and 11.4% ($N = 4$) as another race or ethnicity. Five participants (14.3%) identified as Hispanic. The majority of participants had never been married ($N = 29$, 82.9%). Nine participants (25.7%) were employed full-time, eleven (31.4%) were employed part-time, and 15 participants (42.9%) were unemployed. Descriptive statistics for additional demographic and clinical variables are shown in Table 1.

**EMA Descriptive Statistics and Compliance**

Participants reported at least one binge episode on an average of 43% of days during the EMA period, with multiple binge episodes reported on 15% of days. The average total number of binge episodes per person was $11.9 (SD = 11.5; \text{range } = 0 - 59)$ over the course of the study. Compliance with the EMA protocol was generally high, with participants completing 80% of signal-contingent ratings and time-based (i.e., morning and evening) ratings. Two participants were excluded from analyses due to compliance rates below 50%.
Measure Reliability

Analysis of measure reliability for the positive affect and negative affect scales indicated acceptable internal consistency for positive affect (Cronbach’s $\alpha = .76$) and good internal consistency for negative affect (Cronbach’s $\alpha = .89$).\(^1\) Two items from each scale were considered for exclusion from the scale totals due to relatively low item-total correlations ($r < .6$; “calm” and “euphoric” for positive affect; “bored” and “numb” for negative affect); however, results were unchanged when analyses were re-run with these items excluded from the scales. Consequently, the full positive and negative affect scales were used as the dependent variables in the analyses reported below. The correlation between mean positive and negative affect scores was significant but low ($r = -.26, p < .001$), suggesting that it is meaningful to examine these constructs independently.

Both the positive affect and negative affect scores were highly positively skewed; accordingly, log transformations were conducted to bring the distributions of these variables closer to normality. All analyses were conducted with both log-transformed and non-transformed dependent variables; as the pattern and significance of results were unchanged, the results reported below and in Tables 2 and 3 are from analyses including non-transformed variables.

Primary Aims

As noted in the analytic plan, the analysis of each aim involved a three-step process testing (1) the unconditional means model, (2) the unconditional growth curve model, and (3) a final model incorporating predictors to account for variability in

\(^1\) It should be noted that the use of Cronbach’s $\alpha$ is not ideal due to non-independence of observations in the dataset. However, a detailed psychometric analysis was considered to be outside the scope of the current investigation.
intercepts and slopes. Time was modeled using a linear term (time) and a quadratic term (time²) to account for the possibility of non-linear associations, and the absolute value of time relative to the binge episode was allowed to interact with a binary variable indicating whether the observation took place before or after the binge.

Models were tested using three different covariance structures: a generic covariance structure that makes no assumptions about covariance, a diagonal covariance structure, and an autoregressive structure that assumes that observations that are closer in time are more highly correlated (AR1). The diagonal and autoregressive structures did not improve model fit; accordingly, the generic covariance structure was selected.

**Aim 1: Trajectories of Affect Before and After Binge Episodes.** Results for the final models for Aim 1 analyses are shown in Table 2. The intercepts reported in Table 2 reflect the estimated value of the dependent variable at the time of the binge, the estimate for hours relative to the binge reflects the rate of change in the dependent variable immediately prior to and following the binge, and the estimate for (hours relative to the binge)² reflects the acceleration in rate of change in affect by temporal distance to the binge.

Results from the preliminary unconditional means and growth curve models indicated statistically significant variability in intercepts and slopes for both positive and negative affect. Results from the final models indicated that positive affect decreased during the hours prior to a binge episode and increased during the hours following a binge episode (see Figure 1). The linear and quadratic time variables (hours relative to the binge and hours relative to the binge squared) were both significant predictors of positive affect (see Table 2); accordingly, the quadratic terms were retained in the model.
Results indicated a non-linear (accelerating) decrease in positive affect prior to the binge and a corresponding non-linear increase in positive affect during the hours after the binge. The interaction between the continuous time variable and the dichotomous time variable (before vs. after the binge) was not a significant predictor and including the dichotomous time variable did not improve model fit, indicating that the trajectory of positive affect after binge episodes mirrored the trajectory of positive affect before binge episodes (see Figure 1).

Results for negative affect indicated that both the linear and quadratic time variables (hours relative to the binge and hours relative to the binge squared) were significant predictors of negative affect (both p’s < .001); accordingly, the quadratic terms were retained in the model. However, both the linear and quadratic effects of time variables became non-significant when the dichotomous time variable (before vs. after the binge) was included in the model. Examination of Figure 2 suggested a gradual, non-linear increase in negative affect prior to the binge and a non-linear decrease in negative affect during the hours after the binge, with a steeper slope for changes in negative affect following the binge. The interaction between the continuous linear time variable and the dichotomous time variable (before vs. after the binge) was a significant predictor of negative affect, indicating that the trajectory of negative affect prior to the binge did not mirror the trajectory of negative affect following the binge. Given this asymmetry in the trajectory of negative affect pre- vs. post-binge, we conducted an additional growth curve analysis including only pre-binge affect ratings to determine whether the apparent slight increase in negative affect prior to the binge (see Figure 2) was in fact statistically significant. Results indicated a trend toward a significant linear effect of time, $t = 2.05, p$
= .057. When the quadratic time variable was included in the model, neither the linear nor quadratic effects of time were significant (both p’s ≥ .28).

**Aim 2: Comparison of Affect Before and During Binge Episodes.** In the models comparing affect before and during binge episodes, the dichotomous time variable (before the binge episode within 3 hours vs. during the binge episode) was a significant predictor of both positive and negative affect (see Table 3). Positive affect was significantly lower and negative affect was significantly higher during binge episodes compared to before binge episodes (see Figures 3 and 4). As described above, because some binge episodes were reported retrospectively in response to random signal-contingent prompts, while others were reported in event-contingent ratings immediately after a binge episode, we added a binary variable representing the type of rating in which the binge was recorded (contemporaneous or retrospective) to the model. The main effect of the variable representing contemporaneous vs. retrospective reporting of binges was not significant in either model, but the interaction with the time variable was a significant predictor for both positive and negative affect (see Table 3). Examination of the interaction effect indicated a greater effect of rating type (completed during an event-contingent post-binge rating or captured at the next signal-contingent rating) for during-binge affect ratings, with minimal differences based on rating type for pre-binge affect ratings. Positive affect during the binge was rated as lower and negative affect during the binge was rated as higher in event-contingent ratings compared to signal contingent ratings (see Figures 3 and 4).
Exploratory Aims

**Aim 3: Affect Trajectories Surrounding Anticipated vs. Unanticipated Binge Episodes.** Data on anticipation of binge episodes were available for 231 binge episodes, of which 170 were coded as anticipated and 61 were coded as unanticipated based on the participant’s responses in the morning recording. Positive and negative affect trajectories prior to and following binge episodes were modeled as described under Aim 1. The interaction of “type of binge” (anticipated vs. unanticipated) with the time variable was not a significant predictor of either positive affect \( t = -1.44, p = .151 \) or negative affect \( t = 1.14, p = .254 \), indicating that trajectories of positive and negative affect were unaffected by whether or not the binge was anticipated (or planned) at the time of the morning recording.

**Aim 4: Affect Trajectories Surrounding Objective vs. Subjective Binge Episodes.** Data on the size of binge episodes were available for 247 binge episodes, of which 169 were reported as objective binge episodes and and 78 were reported as subjective binge episodes. Positive and negative affect trajectories prior to and following binge episodes were modeled as described under Aim 1. The interaction of “type of binge” (objective vs. subjective) with the time variable was not a significant predictor of either positive affect \( t = 0.93, p = .352 \) or negative affect \( t = -0.42, p = .674 \), indicating that trajectories of positive and negative affect were unaffected by the size of the binge.

**Chapter 4: Discussion**

The purpose of the present study was to gain a better understanding of the maintenance of binge eating by addressing gaps in the literature on affect and binge eating. In particular, while negative affect is well established as an antecedent to binge
eating, mixed findings have been reported on the impact of binge eating on affect during and after binge episodes, and there has been little research on the relation of positive affect and binge eating. The first aim of the present study was to replicate prior work (e.g., Smyth et al., 2007) by examining trajectories of positive and negative affect in the hours before and after binge eating. The second aim was to compare positive and negative affect during binge episodes to positive and negative affect before binge episodes, to determine whether short-term improvements in affect during binge episodes may serve to reinforce and maintain binge eating. Exploratory aims were to determine whether trajectories of positive and negative affect were affected by anticipation of the binge or by the size of the binge (objectively vs. subjectively large). To address these questions, positive and negative affect were measured before, during, and after binge eating episodes using a two-week EMA protocol among a sample of 35 women with BN. The present study adds to the literature on affect during binge episodes by using a unique assessment procedure in which participants were asked to retrospectively report affect during binge episodes while completing their post-binge EMA recordings. Because we hypothesized that any improvements in affect might take place early on during the binge episode and might diminish as binge eating continues, participants were instructed to rate positive and negative affect just after the binge began. As described previously, this procedure was intended to balance concerns about recall difficulties with concerns about disruption of naturalistic emotions and behaviors. Furthermore, this study is the first to examine positive affect during binge episodes using EMA.
Trajectories of Positive and Negative Affect Before and After Binge Episodes

Consistent with the results of Smyth and colleagues (2007), we found a pattern of decreasing positive affect and increasing negative affect in the hours prior to a binge episode; in the hours following binge episodes, negative affect decreased and positive affect increased. Also consistent with Smyth and colleagues’ findings, the trajectories of positive and negative affect were non-linear, with acceleration in the rate of affective change prior to and following binge episodes. For positive affect, the rate of change in affect did not differ from before to after binge episodes, suggesting a non-linear, accelerating decline in positive affect prior to binge episodes and an equivalent non-linear increase in positive affect after binge episodes.

The pattern of results found for negative affect suggested a very gradual increase in negative affect during the hours prior to a binge episode, although negative affect overall remained low prior to a binge (below a score of 2 on a scale rated from 1 to 5). Following binge episodes, negative affect appeared to decrease sharply starting from a much higher level (see Figure 2), consistent with the finding that negative affect increased from before to during binge episodes. It should be noted that while there was a relatively quick drop in negative affect following binge episodes, it nevertheless remained elevated for some time and did not appear to drop below pre-binge levels until several hours after the binge episode (see Figure 2). This appears consistent with Haedt-Matt and Keel’s (2011) meta-analytic finding that even after purging, negative affect did not drop below pre-binge levels, and raises questions about the efficacy of binge eating in regulating negative affect. One interpretation of the present findings is that they are consistent with affect regulation theory, as positive affect increased and negative affect
decreased following binge episodes, in line with the predictions of affect regulation theory. An alternative interpretation is that binge eating does not effectively regulate positive and negative affect, given the relatively slow affective recovery that took place over several hours after binge episodes. These results also raise questions regarding how rapidly any affective improvements must occur in order to serve a reinforcing function, i.e., whether quick return to a euthymic state is necessary to reinforce a behavior such as binge eating, or whether gradual improvement in affect over several hours is sufficiently reinforcing. This question should be addressed in future research. It is also important to consider the possible role of purging following binge episodes, since it is possible that affective improvements following binge episodes may be at least partially attributable to relief associated with purging.

The pattern of changes in negative affect observed in the present study, in which there appears to be a disconnect in the trajectories of negative affect pre-binge and post-binge (as shown in Figure 2), differs from the pattern found in the Smyth et al. (2007) study, in which negative affect appeared to increase more substantially prior to binge episodes (Smyth et al., 2007, p. 634). Differences in analytic approach may account for this, as Smyth and colleagues obtained a smoother curve by removing the main effect of the dichotomous time variable (before vs. after the binge episode) from the model. This approach forces a common intercept such that the pre-binge and post-binge curves meet at the time of the binge. In contrast, in the present study, all predictor variables were retained in order to characterize differences in pre-binge and post-binge trajectories. Clear methodological differences also existed across the two studies in that Smyth and colleagues did not ask participants to rate affect during binge episodes; however, because
ratings of affect during binge episodes were not included in the present analyses of affect trajectories before and after binge episodes, the inclusion vs. omission of during-binge affect ratings is not a plausible explanation for the differences in findings. Furthermore, when Smyth and colleagues omitted affect ratings completed within 10 minutes of the time of the binge, their pattern of results for affect before and after binge episodes was unchanged, suggesting that the steeper increase in negative affect found in their study is not likely to be attributable to sharp increases in negative affect concurrent with binge episodes.

Prior research on affect and binge eating has raised the question of whether affective trajectories prior to binge episodes are impacted by awareness of an imminent binge or by specific planning of binge episodes. While we did not ask participants about anticipation or planning of binges at each random signal due to concerns that asking these questions repeatedly might produce reactivity to the measurement procedure and possibly increased urges to binge, we did ask participants at the first recording of the day whether they expected to binge that day. Trajectories of positive and negative affect prior to and following binge episodes did not differ based on whether the binge was anticipated at the time of the first recording of the day, suggesting that the affective changes observed were consistent regardless of awareness that a binge would later occur. However, it is important to note that we were unable to conduct a more fine-grained analysis of anticipation or planning of binges that may have begun after the first EMA recording of the day was completed.

Prior research has also raised questions about the distinction between objective binge eating and subjective binge eating, with some studies suggesting that this
distinction may not be clinically useful, as the experience of loss of control over eating may be more important than the actual quantity of food consumed (e.g., Pratt, Niego, & Agras, 1998). The present results suggest that the affective antecedents and consequences of binge eating do not differ according to the size of the binge, supporting the idea that the experience of loss of control may be more clinically important than whether the amount of food consumed is objectively large.

**Comparison of Affect Before and During Binge Episodes**

To address the question of whether short-term improvements in affect during binge episodes may be a factor that serves to maintain binge eating, we compared participants’ ratings of positive and negative affect during binge episodes (“just after the binge began”) to positive and negative affect prior to binge episodes (which included affect ratings completed within 3 hours of the time of the binge episode). Contrary to hypotheses, negative affect was found to be higher and positive affect lower during binge episodes compared to before binge episodes. These results do not support the idea that binge eating is maintained via short-term improvements in mood or distraction from negative emotion during binge episodes. However, results are consistent with those of two prior studies finding increases in negative affect, specifically guilt and anger, during binge episodes (Johnson & Larson, 1982; Stickney & Miltenberger, 1999).

In the present study, it was possible for ratings of affect during binge episodes to be collected either at the next randomly signaled recording or in the event-contingent recording immediately following a binge episode (as noted above, if purging occurred, participants were instructed to wait until after purging to complete the EMA recording). Ratings of affect during the binge systematically differed according to the type of rating
in which the binge episode was reported: positive affect during the binge was rated as lower and negative affect during the binge was rated as higher in event-contingent ratings compared to signal contingent ratings (see Figures 3 – 4). Thus, ratings made closer in time to the binge suggested a greater worsening of mood during binge episodes. It is possible that these event-contingent ratings provide a more accurate estimate of mood during the binge compared to ratings made later; however, it is also possible that the ratings made closer in time to the binge are biased by high negative affect and low positive affect at the time of completing the measures. Nevertheless, the magnitude of the difference based on rating type was small (e.g., approximately one quarter of a point on the five-point scale for negative affect; see Figure 4), suggesting that the clinical significance of this effect is low.

Regardless of rating type, results did not support the hypothesized improvements in affect during binge episodes. Affective theories of binge eating have posited that binge eating is maintained by negative reinforcement (reduction in an aversive state); however, during binge episodes reported in our sample, negative affect increased- and appeared to increase sharply- rather than decreasing. Rather than distracting from negative affect, it appears that binge eating was experienced as aversive in the moment, possibly leading to increased feelings of guilt, shame, anger, and disgust. The current study also did not find support for positive reinforcement functions of binge eating during the binge episode, although it is possible that positive reinforcement may occur in ways not captured by our emotion-focused measures (e.g., more biologically-based reinforcement from eating palatable, energy-dense food). That is, participants may not describe pleasure or reward from eating as a positive emotional state, particularly when experienced in the context of
high negative emotions. The only item in the current study that may have captured positive reinforcement of a less emotional nature was “enjoying myself”; however, exploratory analyses indicated that this item showed the same pattern of results as the full positive affect scale (results not shown). It is possible that using an item such as “pleasure” may have better captured the hypothesized positive reinforcement effects of binge eating, consistent with the results of Deaver and colleagues (2003); it is also possible that this type of positive reinforcement is not well measured via self-report, particularly when participants are experiencing high levels of negative affect. It should also be noted that we did not specifically ask participants to rate their degree of enjoyment or pleasure related to the food they were eating, as opposed to the more general degree to which they were enjoying themselves. Because the consumption of large quantities of food may have quickly produced strong negative affect (e.g., feelings of guilt, shame, or disgust), participants may have been unlikely to rate the generic enjoyment item highly even if short-term pleasure from eating was present.

An additional possibility is that the three-hour pre-binge time window was overly liberal: while this time window was necessary to ensure an adequate number of pre-binge ratings given the assessment schedule in the present study, ratings made further in time from the binge are likely to show lower levels of negative affect and higher positive affect. The inclusion of these ratings may have lowered the aggregated estimate for pre-binge negative affect and may have raised the aggregated estimate for pre-binge positive affect, which would make it difficult to detect any affective improvements from immediately pre-binge to during the binge.
Finally, while the procedure for assessing affect during binge episodes was intended to minimize the recall period while avoiding disruption of naturally occurring emotions and behavior during binge episodes, it is possible that participants were unable to report accurately on their emotions during binge episodes in this retrospective fashion. As noted above, high negative affect and low positive affect at the time of completing the measures may have biased participants in the direction of reporting higher negative affect and lower positive affect when asked to think back to their emotions during the binge episode. It was hoped that first asking participants to report their current emotional state and then asking participants to think back to how they were feeling just after the binge began would prompt participants to distinguish their current and recalled mood states, but it is possible that participants may have been unable to make this distinction. Thus, although results did not support the hypothesized improvements in affect, we are unable to rule out the possibility that short-term improvements in affect may occur during binge episodes.

**General Discussion**

Taken together, the results of this study support the idea that increases in negative affect and decreases in positive affect are antecedents to binge eating, but raise questions about the theory that binge eating is maintained through the regulation of affect. During binge episodes, mood appeared to worsen; while improvement in mood occurred after binge episodes, the fact that the recovery of positive and negative affect to pre-binge levels took several hours raises questions about the role of affect regulation in reinforcing binge eating, as well as the necessary speed at which affective improvement must occur in order to serve a reinforcing function. The current results appear to be fairly consistent
with theories suggesting that binge eating results from lapses in inhibitory control associated with low mood (for instance, escape theory, which does not specify that binge eating functions to improve affect). Interestingly, however, the increase in negative affect prior to binge episodes was more gradual than expected, and negative affect was rated as quite low overall prior to binge episodes. Given the questionable clinical significance of these low levels of negative affect and the small magnitude of the pre-binge changes in negative affect, the present findings raise the possibility that the sharp pre-binge decline in positive affect is an important contributor to binge eating, above and beyond the slight increase in negative affect. While the present results could be interpreted either as supporting or not supporting negative reinforcement or positive reinforcement functions of binge eating in the affective domain depending on the timeframe being considered (as discussed above), it is also possible that binge eating is reinforced in ways that could not be adequately assessed by the present methodology.

Furthermore, it is important to consider individual variability in functions of binge eating, particularly in light of the lack of clear evidence that binge eating serves to regulate affect. It is possible that binge eating may serve to regulate emotions for some individuals but not others; for instance, it is possible that binge eating might serve an emotion regulation function for those with high levels of emotion dysregulation, but might be more related to dietary factors, cravings, or restrictive eating among individuals with lower levels of emotion dysregulation. As emotion dysregulation was not measured in the current study, it is not possible to examine emotion dysregulation as a moderator of the relation between affect and binge eating; this is an important direction for future research.
The present methodology does not allow for conclusions about causality; thus, an additional possibility is that an impending binge episode produces increased negative affect, rather than the reverse. While we attempted to address this question by comparing trajectories of positive and negative affect for binges that were anticipated vs. unanticipated as of the first EMA recording of the day, as discussed above, this procedure was likely not sufficiently sensitive to examine the relation between awareness of an impending binge and changes in affect. However, the fact that a large proportion (74%) of binge episodes were anticipated as early as the first EMA recording of the day may be evidence against the causal role of later affective changes in producing binge episodes (although it is also possible that worsening mood does causally contribute to binge episodes and that the individual is simply able to predict that this pattern will occur based on past experience). The present findings that the increase in negative affect prior to the binge was very gradual (and perhaps of questionable clinical significance) and that negative affect increased significantly during the binge appear to be consistent with the perspective that the increase in negative affect was generated by the binge episode. The fact that both negative and positive affect were slow to recover after binge episodes is also consistent with the idea that binge episodes produce negative emotional states.

It is also possible that there is no causal relation between the increase in negative affect or decrease in positive affect and the subsequent occurrence of a binge episode. As noted above, there may be other variables aside from positive and negative affect that play a causal role in producing binge eating, including diet- and weight-related variables identified in prior research (e.g., highly restrictive eating or weight suppression). Based on the present results, we cannot rule out the possibility that a third variable (e.g., food
deprivation) is causally related to both increasing dysphoria and to the occurrence of binge eating.

The present study has several clinical implications. While the present results do not provide strong support for the idea that increases in negative affect trigger binge episodes, we are also unable to rule out the possibility that increases in negative affect have a disinhibiting effect that contributes to binge eating. Thus, it appears prudent to use strategies to intervene or alter behavior as early as possible when negative affect begins to rise. Secondly, although we did not find support for positive reinforcement during binge eating, we were also unable to rule out the presence of positive reinforcement during or following binge eating, for the reasons discussed above. Thus, possible positively reinforcing functions of binge eating should be carefully evaluated for each patient, and alternative behaviors to provide positive reinforcement may need to be considered. If it is correct that binge eating is maintained via positive reinforcement from food, this would support the use of interventions that allow for more regular, moderate reinforcement from food, such as the regular eating intervention in cognitive behavioral therapy for eating disorders (Fairburn, 2008). Overall, the present findings suggest the importance of idiographic functional analysis, as variation may exist in the factors maintaining binge eating for any given individual.

Strengths of this study include the clinical sample, the use of EMA to reduce recall bias and assess behaviors and emotions during participants’ daily lives, and the collection of data on a large sample of binge episodes. Furthermore, when participants are asked to complete measures prior to every eating episode or are specifically asked to complete measures before binge eating, differences between pre-binge and during-binge
affect may be obscured due to the participant’s awareness that a binge is imminent. This issue was addressed in the current study by collecting ratings of affect before binge episodes using a random signaling procedure. In addition, as has been discussed above, the assessment of affect during binge episodes was less intrusive and less likely to disrupt naturalistic behavior and emotions compared to the assessment procedures in studies that have asked participants to complete measures during binge episodes.

Limitations of the study included the possibility of limited generalizability given some of the exclusion criteria for the parent study such as the limited age range, exclusion of participants taking hormonal birth control, and the exclusion of participants with certain severe psychiatric disorders such as bipolar disorder, borderline personality disorder, and current or recent substance use disorders. This may have resulted in participants with more severe emotion dysregulation being excluded from the study, although the observed high rates of binge eating and elevated depressive symptoms suggest significant severity of psychopathology in this sample. An addition limitation is the restricted number of items assessing positive and negative affect that could be included in the EMA assessments given concerns about minimizing burden on participants and the requirements of the parent study. While subscale reliability was adequate to good for positive and negative affect, the limited number of items assessing each type of emotion rendered us unable to conduct separate analyses for different specific emotional states. Particularly given some research suggesting a specific association between guilt and binge eating (Berg et al., 2013; De Young et al., 2013), it would be interesting to examine specific emotional states during binge eating in addition to general positive and negative affect.
In addition, while the use of randomly signaled ratings to assess pre-binge affect is a strength of the study for the reasons described above, the fact that the pre-binge ratings represent an aggregate of ratings over a 3-hour period is also a limitation, as we are unable to provide a precise estimate of positive and negative affect just prior to binge eating. Furthermore, while participants were instructed to complete EMA ratings just after binge eating or purging, the actual length of time between the conclusion of each binge and/or purge episode and the completion of an event-contingent rating is unknown. Finally, as mentioned previously, the assessment schedule for the EMA means that late-night binges may not be well represented in the present results, as they were surrounded by fewer EMA ratings; in addition, we examined only the first binge episode in a given day to avoid confounding the affective consequences of the first binge episode with the affective antecedents of later binge episodes. Thus, we are unable to characterize patterns of affect before, during, or after binge episodes that were preceded by another binge episode earlier in the day. Given that the majority of participants (74%) reported at least one day with multiple binge episodes during the two-week EMA period, it appears clinically important to gain a better understanding of the relation of changes in positive and negative affect to repeated binge episodes occurring within a day.

The present findings suggest several additional directions for future research aimed at better understanding the maintenance of binge eating. First, inclusion of a broader range of items assessing emotional states as well as other states such as pleasure might help to clarify any reinforcing functions of binge eating. Inclusion of additional affect items would also allow for separate examination of changes in different types of affective states (e.g., guilt vs. anger), which was not done in the current study due to
concerns about unreliability of analyses using single items as dependent variables. While we did not find evidence for reduction in negative affect during binge eating, it is possible that binge eating, although seemingly aversive, serves as a distraction from other aversive situations in the individual’s life. Thus, it is possible that while the individual’s overall level of distress is not reduced during binge eating (as measured by the negative affect scale), binge eating may be reinforced because it serves as a distraction from other sources of distress that the individual might for some reason find more difficult to cope with. This possibility should be tested in future research. In addition, while the present study focused on affective factors involved in the maintenance of binge eating, it is also possible that expectancies related to binge eating (e.g., the expectation that binge eating will help to relieve negative mood states or distract from stressors) may serve to perpetuate binge eating independent of its actual distress-reducing effect. Future research examining this type of potential interaction between affective and cognitive factors would be informative. As mentioned above, future research examining potential moderators of the relation between affective changes and binge eating (e.g., emotion dysregulation or diet- and weight-related variables) is important to help understand individual variability in the functions of binge eating.

Finally, given the inherent difficulties with self-report, even when using EMA procedures, studies using objective physiological or brain imaging methods may help to shed light on possible positive and negative reinforcement functions of binge eating. Physiological research has proven useful in understanding the maintenance of behaviors such as non-suicidal self-injury using analog procedures in the laboratory (e.g., Franklin et al., 2010), and has the potential to be similarly useful in understanding the maintenance
of binge eating. While use of brain imaging during eating episodes has presented challenges because of the movements involved in eating, newer technologies such as functional near-infrared spectroscopy (fNIR) have the potential to provide valuable information about neurobiological processes during increasingly naturalistic eating paradigms. As the results of the current study highlight, binge eating is a complex behavior that should be investigated using multiple levels of analysis in order to better understand the persistence of the behavior.
References


Table 1

*Sample Characteristics*

<table>
<thead>
<tr>
<th></th>
<th>Minimum</th>
<th>Maximum</th>
<th>$M$</th>
<th>$SD$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>18</td>
<td>43</td>
<td>24.7</td>
<td>6.4</td>
</tr>
<tr>
<td>Age of BN onset</td>
<td>10</td>
<td>26</td>
<td>15.9</td>
<td>3.4</td>
</tr>
<tr>
<td>Years of education</td>
<td>12</td>
<td>19</td>
<td>15.1</td>
<td>2.2</td>
</tr>
<tr>
<td>BMI</td>
<td>18.4</td>
<td>34.7</td>
<td>23.3</td>
<td>4.0</td>
</tr>
<tr>
<td>Weight suppression (lbs)</td>
<td>0.0</td>
<td>164.5</td>
<td>23.0</td>
<td>31.8</td>
</tr>
<tr>
<td>BDI-1A</td>
<td>2.0</td>
<td>42.0</td>
<td>19.9</td>
<td>11.0</td>
</tr>
<tr>
<td>EDE Restraint</td>
<td>0.2</td>
<td>5.4</td>
<td>3.4</td>
<td>1.3</td>
</tr>
<tr>
<td>EDE Eating Concern</td>
<td>0.0</td>
<td>4.4</td>
<td>2.1</td>
<td>1.1</td>
</tr>
<tr>
<td>EDE Weight Concern</td>
<td>0.8</td>
<td>5.8</td>
<td>3.5</td>
<td>1.5</td>
</tr>
<tr>
<td>EDE Shape Concern</td>
<td>0.8</td>
<td>6.0</td>
<td>3.8</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Note: BDI-1A = revised Beck Depression Inventory; BMI = body mass index; BN = bulimia nervosa; EDE = Eating Disorder Examination
### Table 2

Multilevel Models for Positive and Negative Affect Before and After Binge Episodes (Aim 1)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Positive Affect</th>
<th>Negative Affect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td>SE</td>
</tr>
<tr>
<td>Intercept</td>
<td>1.73</td>
<td>.07</td>
</tr>
<tr>
<td>Hrs relative to binge</td>
<td>.05</td>
<td>.01</td>
</tr>
<tr>
<td>(Hrs relative to binge)$^2$</td>
<td>-.002</td>
<td>.001</td>
</tr>
<tr>
<td>Before vs. after binge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before vs. after binge* Hrs relative to binge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before vs. after binge* (Hrs relative to binge)$^2$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variance terms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>.13</td>
<td></td>
</tr>
<tr>
<td>Slope</td>
<td>.001</td>
<td></td>
</tr>
<tr>
<td>Residual</td>
<td>.26</td>
<td></td>
</tr>
</tbody>
</table>

Note: The table shows the best-fitting models for each dependent variable. For positive affect, the final model included only hours relative to the binge and its quadratic term as predictors; adding the dichotomous time variable did not improve model fit.
Table 3

*Multilevel Models for Positive and Negative Affect Before vs. During Binge Episodes (Aim 2)*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Positive Affect</th>
<th></th>
<th></th>
<th></th>
<th>Negative Affect</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td>SE</td>
<td>t</td>
<td>p</td>
<td>Estimate</td>
<td>SE</td>
<td>t</td>
<td>p</td>
</tr>
<tr>
<td>Intercept</td>
<td>1.89</td>
<td>.09</td>
<td>20.93</td>
<td>&lt;.001</td>
<td>1.90</td>
<td>.14</td>
<td>13.50</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Time*</td>
<td>-.31</td>
<td>.07</td>
<td>-4.14</td>
<td>&lt;.001</td>
<td>.65</td>
<td>.08</td>
<td>8.38</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Rating type**</td>
<td>-.06</td>
<td>.10</td>
<td>-.57</td>
<td>.569</td>
<td>.05</td>
<td>.11</td>
<td>.43</td>
<td>.668</td>
</tr>
<tr>
<td>Time*rating type</td>
<td>.23</td>
<td>.11</td>
<td>2.01</td>
<td>.046</td>
<td>-.37</td>
<td>.12</td>
<td>-3.14</td>
<td>.002</td>
</tr>
</tbody>
</table>

Variance terms

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>SE</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>.12</td>
<td>.001</td>
<td>.47</td>
<td></td>
</tr>
<tr>
<td>Residual</td>
<td>.23</td>
<td>&lt;.001</td>
<td>.24</td>
<td></td>
</tr>
</tbody>
</table>

*Before vs. during binge episodes*

**Binge reported at event-contingent rating following binge vs. reported at next signal-contingent rating*
Figure 1. Trajectories of positive affect before and after binge episodes.
Figure 2. Trajectories of negative affect before and after binge episodes.
Figure 3. Positive affect before vs. during binge episodes, by rating type (binge reported during an event-contingent rating vs. reported at the next signal-contingent recording).
Figure 4. Negative affect before vs. during binge episodes, by rating type (binge reported during an event-contingent rating vs. reported at the next signal-contingent recording).
Vita

Ashley Anne Witt

EDUCATION

Clinical Psychology Internship Training Program
Veterans Affairs Palo Alto Health Care System
Palo Alto, CA
August 2014 – present

Doctoral Candidate in Clinical Psychology
Drexel University
Philadelphia, PA
Ph.D. expected June 2015

Master of Science in Clinical Psychology
Drexel University
Philadelphia, PA
December 2012

Bachelor of Arts summa cum laude in Psychology
Harvard University
Cambridge, MA
June 2008

PUBLICATIONS


HONORS AND AWARDS

International Travel Award, Drexel University, 2013
Provost’s Fellow, Drexel University, 2010-2011 and 2011-2012
Phi Beta Kappa, Harvard University, 2008
National Merit Scholar, 2004