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Examining prospective mediational relationships between momentary rumination, negative affect, and binge eating using ecological momentary assessment*

Kathryn E. Smith^{a,*}, Tyler B. Mason^b, Erin E. Reilly^c, Vivienne M. Hazzard^d, Skylar L. Borg^d, Robert Dvorak^e, Ross D. Crosby^d, Stephen A. Wonderlich^d

^aDepartment of Psychiatry and Behavioral Sciences, University of Southern California, 2250 Alcazar Street, #2200, Los Angeles, CA 90033, United States

^bDepartment of Preventive Medicine, University of Southern California, Los Angeles, California, United States

^cDepartment of Psychology, Hofstra University, Hempstead, New York, United States

^dSanford Center for Bio-Behavioral Research, Sanford Health, Fargo, North Dakota, United States

^eDepartment of Psychology, University of Central Florida, Orlando, Florida, United States

Abstract

Background: Rumination is linked to negative affect (NA), and there is accumulating support for an association between rumination and eating disorder (ED) behaviors. However, no research has examined the dynamic interrelationships between negative affect, rumination, and binge eating in naturalistic settings.

Methods: The present study used ecological momentary assessment (EMA) to assess the hypotheses that momentary rumination would mediate relationships between NA and binge eating, and momentary NA would mediate relationships between rumination and binge eating. Given that rumination may be focused on weight, shape, and food in ED samples, models were examined separately for general and ED-specific rumination. Forty women completed a 10-day EMA protocol that included measures of NA, general and ED-specific rumination, and binge eating.

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*Corresponding author. ksmith41@usc.edu (K.E. Smith).

CRedit author contribution statement

Kathryn Smith: Conceptualization, Methodology, Investigation, Data curation, Formal analysis, Writing- Original draft preparation, Review & Editing, Project administration; Tyler Mason: Conceptualization, Methodology, Writing- Original draft preparation, Review, & Editing; Erin Reilly: Conceptualization, Methodology, Writing- Original draft preparation, Review, & Editing; Vivienne Hazzard: Writing- Original draft preparation, Review, & Editing; Skylar Borg: Writing- Original draft preparation, Review, & Editing; Robert Dvorak: Methodology, Software, Resources, Writing- Review & Editing; Ross Crosby: Methodology, Validation, Formal analysis, Writing- Review & Editing; Stephen Wonderlich: Supervision, Writing- Review & Editing.

All authors have approved the final article should be true and included in the disclosure.

Declaration of Competing Interest

The authors declare no conflicts of interest.

Results: Multilevel mediation models indicated significant within-subjects indirect effects, such that momentary general rumination mediated the association between NA and binge eating, and NA also mediated the association between general but not ED-specific rumination and binge eating. Between-subjects effects indicated women with higher overall NA reported greater ED-specific rumination, which was associated with greater binge eating.

Limitations: The study was limited by a modest sample size, and the design precludes causal inferences.

Conclusions: Results highlight the momentary interplay between rumination and NA as a mechanism underlying binge eating, as well as the specificity of ruminative thought content in relationship to binge eating. Future work is needed to address the construct of rumination in the context of eating disorder interventions.

Keywords

Binge eating; Eating disorders; Rumination; Negative affect; Ecological momentary assessment

1. Introduction

Binge eating is defined as excessive caloric intake accompanied by a sense of loss of control and is a transdiagnostic characteristic of several eating disorders (EDs), including binge eating disorder (BED), bulimia nervosa (BN), and anorexia nervosa binge-purge subtype (AN-BP; American Psychiatric Association [APA], 2013). Further, binge eating is associated with numerous psychiatric and medical comorbidities, lower quality of life, and functional impairment (Schmidt et al., 2016). Unfortunately, treatment outcomes for binge eating remain suboptimal, as only 35–50% of individuals achieve abstinence from binge eating across a range of treatment modalities (Linardon, 2018; Linardon and Wade, 2018). This highlights the need to enhance treatment efficacy by identifying and interrupting processes that provoke and perpetuate binge eating.

Momentary processes are particularly important to study as potential treatment targets for binge eating, as affect regulation frameworks suggest that binge eating serves to reduce momentary negative emotional states, which maintains the behavior via negative reinforcement (Hawkins and Clement, 1984; Heatherton and Baumeister, 1991; Wonderlich et al., 2008). These theoretical tenets have been supported by a wealth of research demonstrating that individuals with binge eating evidence emotion regulation difficulties (Lavender et al., 2015), and at the momentary level, heightened negative affect reliably precedes binge episodes (Haedt-Matt and Keel, 2011). However, while the association between negative affect and binge eating is well established, less is known regarding the dynamic mechanisms by which negative affect precipitates these episodes at the momentary level.

Rumination is one aspect of maladaptive emotion regulation that may be particularly relevant for understanding momentary processes that potentiate binge eating. Rumination refers to repetitive, passive thoughts on the meaning, causes, and consequences of negative emotions and upsetting situations (Nolen-Hoeksema, 1991). Importantly, rumination is

considered to be a transdiagnostic construct that confers risk for a range of psychopathology (Aldao et al., 2010; Nolen-Hoeksema and Watkins, 2011), as well as for EDs specifically (Smith et al., 2018).

Across studies of EDs, rumination was both concurrently and prospectively associated with ED psychopathology, and in research exploring the specific link between rumination and binge eating, individuals who endorse binge eating also report exhibit greater levels of rumination compared to those without binge eating (Smith et al., 2018). In addition, the content of rumination may differ among individuals with EDs. While general rumination is defined by repetitive concerns about meaning, causes, and repercussions of negative emotions (Nolen-Hoeksema, 1991), ED-specific rumination is defined by repetitive concerns about weight, shape, and eating (Cowdrey and Park, 2011), and evidence suggests that ED-specific rumination is more strongly associated with ED psychopathology than general rumination (Smith et al., 2018).

Although rumination has often been conceptualized and studied as a trait-like style of responding, rumination and the processes by which it gives rise to adverse outcomes are inherently state-based (i.e., momentary) in nature. States of rumination and negative affect are thought to exhibit a reciprocal, mutually amplifying relationship. That is, rumination about negative emotions and situations leads to increased negative affect; in turn, negative affect leads to mood-congruent perseverative cognitions such as rumination. This is consistent with the Emotional Cascade Model (Selby et al., 2008), which suggests that negative affect and rumination reciprocally aggravate each other in an “emotional cascade” until an affective state is reached that is extremely aversive and difficult to tolerate. As a result, individuals are likely to resort to dysregulated behaviors (e.g., binge eating) to stop the cascade and escape from such emotions (Selby et al., 2008).

The use of ecological momentary assessment (EMA) has been particularly helpful to elucidate the nature of such momentary relationships. EMA involves repeated measurement of variables in natural environments, which allows for enhanced ecological validity, reduced retrospective recall bias, and examination of micro-temporal ordering of variables (Shiffman et al., 2008). Thus far, EMA research has supported the Emotional Cascade Model, documenting reciprocal, synergistic associations between momentary rumination and negative affect (e.g., Ruscio et al., 2015; Selby et al., 2016). In addition, rumination was found to mediate the momentary relationship between stress and increases in negative affect (Ruscio et al., 2015).

Despite the existing body of EMA rumination research and the relevance of rumination to EDs (Smith et al., 2018), few studies have examined momentary rumination in the context of EDs. One study of individuals with AN found concurrent associations between momentary negative affect and rumination about weight, shape, and food; in addition, rumination about weight and shape predicted subsequent increases in negative affect, but not vice versa (Seidel et al., 2016). Another EMA study of individuals undergoing ED treatment found that higher momentary repetitive negative thinking (a broader construct under which rumination is subsumed) was associated with increases in weighing and bodychecking (Sala et al., 2019). However, no EMA studies have examined associations between rumination and binge

eating, assessed the mechanisms by which negative affect and rumination together potentiate binge eating, or explored whether such mechanisms may differ for general versus ED-specific ruminative processes.

Taken together, there are reciprocal, synergistic relationships between rumination and negative affect at the momentary level, which in turn may increase risk for psychopathology symptoms. Relatively little EMA research has explored these processes in EDs, and no studies have directly assessed binge eating. Therefore, the goal of this study was to use EMA to examine the role of rumination in momentary mechanisms underlying binge episodes, which could yield important information to refine affect regulation theories and inform clinical targets. Based on the tenets of the Emotional Cascade Model and prior research, it was expected that there would be bi-directional associations between negative affect and rumination, and that each of these processes (i.e., negative affect leading to increased rumination, and rumination leading to increased negative affect) would explain momentary increases in binge eating. To examine these hypotheses, multilevel mediation models were conducted to assess (1) momentary rumination as a mediator of the relationship between negative affect and subsequent binge eating, and (2) momentary negative affect as a mediator of the relationship between rumination and subsequent binge eating. As an exploratory aim, the specificity of these associations for general and ED-specific rumination was examined by conducting each model separately for general and ED-specific measures of rumination.

2. Methods

2.1. Participants

Participants were adult women drawn from a study that has been previously reported (Smith et al., 2020a, 2020b, 2020c). Participants (87.5% Caucasian, $M_{\text{BMI}} = 34.30 \pm 9.84 \text{ kg/m}^2$, range: 18.21–59.16, $M_{\text{age}} = 34.70 \pm 15.59$, range: 19–64) were recruited from clinical and community settings who reported binge eating at least once per week over the past three months as determined by the Structured Clinical Interview for DSM-5, Research Version (SCID-5-RV; First et al., 2015), self-identified as female, and were 18–65 years old. Exclusion criteria were (1) inability to read/speak English; (2) current psychosis; (3) current mania; (4) acute suicidality; (5) medical instability as determined by vital signs and blood pressure at the study visit; (6) severe cognitive impairment or intellectual disability; (7) currently pregnant or breastfeeding; (8) inpatient or partial hospitalization in the past 4 weeks; (9) changes to ED treatment in the past four weeks; (10) history of bariatric surgery; or (11) body mass index (BMI) $< 18.0 \text{ kg/m}^2$. The resulting sample was comprised of 40 women (87.5% Caucasian, $M_{\text{BMI}} = 34.30 \pm 9.84 \text{ kg/m}^2$; $M_{\text{age}} = 34.70 \pm 15.59$ years), of whom 29 were diagnosed with BED, 9 with BN, 1 with AN-BP (DSM-5 mild severity category: $17.5 < \text{BMI} < 18.5$; American Psychiatric Association, 2013), and 1 with Other Specified Feeding or Eating Disorder (OSFED, subthreshold BED presentation). Initial screening data indicated that over the prior 6 months, 62.5% of participants attended individual psychotherapy, 12.5% had attended group psychotherapy, and 10.0% had attended community support groups. In addition, 40.0% reported taking medication for eating, mood, or weight.

2.2. Procedure

Eligibility screening was conducted via telephone. During the first study visit, participants completed the informed consent process, assessment of vital signs and anthropometric measures, structured interviews (including the SCID-5-RV to determine diagnoses), computerized tasks, and questionnaires. Participants also received EMA training using the Momentary Assessment Tool system, which was administered on Samsung Galaxy tablets provided by the researchers. Following the first study visit, participants completed the EMA protocol, which involved making signal-contingent and event-contingent recordings for the next 11 days. The first day was a practice day and not included in analyses. Participants received a call from study staff after the first practice day to answer questions related to the protocol. If there were no concerns, participants proceeded to complete the 10-day EMA data collection period that included signal- and event-contingent recordings. Signal-contingent recordings were made in response to EMA prompts, such that during each day of the EMA protocol, participants received 5 semi-random signal-contingent prompts distributed around anchor points between 8:30 a.m. and 9:00 p.m. In addition to signal-contingent recordings, participants were asked to complete event-contingent recordings, which were initiated after participants engaged in a target behavior (i.e., any time they ate). If participants forgot to record an episode, they could also report this information at the next semi-random signal. After the EMA protocol, participants attended a second study visit to return the tablet and receive payment for participation. Participants could receive up to \$250 for participation depending on EMA compliance. All study procedures received IRB approval.

2.3. Measures

2.3.1. Baseline questionnaires—Prior to the EMA protocol participants completed questionnaire assessments, including the Eating Disorder Examination Questionnaire (EDE-Q; Fairburn and Beglin, 2008), 10-item Center for the Epidemiological Studies of Depression Short Form (CES-D-10), and 7-item Generalized Anxiety Disorder scale (GAD-7; Spitzer et al., 2006), which were used for descriptive purposes in the present study. Based on previously suggested cut-off scores, a total score of 10 or more on the CES-D-10 and GAD-7 was considered indicative of a likely depression and GAD diagnosis, respectively (Björgvinsson et al., 2013; Spitzer et al., 2006).

2.3.2. EMA measures—Momentary general rumination was assessed at EMA signals by the following items, which were based on the Ruminative Response Scale (RRS; Treynor et al., 2003) and previous EMA research (e.g., Ruscio et al., 2015; Selby et al., 2016): *To what extent are you currently thinking about your mistakes, failures, or losses?*; *To what extent are you currently thinking about something negative that happened?*; *To what extent are you currently thinking about an upsetting problem?*; *To what extent are you currently thinking about your emotions?* Each item was rated on a 5-point Likert-type scale ranging from 1 (*not at all*) to 5 (*extremely*). The four items were averaged at each signal to create a composite measure of general momentary rumination ($\alpha = 0.92$).

Momentary ED-specific rumination was assessed at EMA signals by the following items based on the brooding subscale of the Ruminative Response Scale for Eating Disorders

(RRS-ED; Cowdrey and Park, 2011): *To what extent are you currently thinking about why you can't handle your eating better?; To what extent are you currently thinking about why you react the way you do around food?; To what extent are you currently thinking about a recent meal you wished had gone better?; To what extent are you currently thinking about why you have problems with your eating, weight, and/or body shape?* Each item was rated on a 5-point Likert-type scale ranging from 1 (*not at all*) to 5 (*extremely*). The four items were averaged at each signal to create a composite measure of momentary ED-specific rumination ($\alpha = 0.93$).

Momentary negative affect was assessed at EMA signals using six items, five of which came from the Positive and Negative Affect Schedule Short Form (PANAS-SF; Thompson, 2007). Guilt was added as a sixth item, given its relevance to negative affect in EDs (Berg et al., 2013). Participants rated the extent to which they were currently experiencing each affective state on a Likert-type scale ranging from 1 (*not at all*) to 5 (*extremely*). Items were summed at each signal to create a composite negative affect score ($\alpha = 0.88$).

Momentary binge eating symptoms were measured at each eating episode with questions assessing loss of control eating (While you were eating, to what extent did you: feel a sense of loss of control?; feel that you could not stop eating once you started?; feel disconnected [e.g., numb, zoned out, on auto-pilot]?) and overeating (To what extent do you: feel that you overate?; think that others would consider what you ate to be an unusual or excessive amount of food?). These items were based on previous EMA research in EDs (e.g., Berg et al., 2013) and were rated a Likert scale ranging from 1 (not at all) to 5 (extremely). Scores on the loss of control eating and overeating items were averaged to create a composite score. Internal consistencies of the loss of control eating and overeating items were excellent ($\alpha = 0.90$ and $\alpha = 0.94$, respectively).

2.4. Analytic plan

Multilevel structural equation modeling (MSEM; Preacher et al., 2010) with Mplus version 7.3 was used to test the proposed mediation models. A 1–1–1 MSEM was used, which means that the independent variable, mediating variable, and dependent variable were all used as Level 1 within-person variables. Two sets of mediation models were run. In the first set, the independent variable was momentary negative affect at Time 1 (T1), the mediating variable was momentary rumination at Time 2 (T2), and the dependent variable was binge eating at Time 3 (T3). In the second set, the independent variable was momentary rumination at T1, the mediating variable was momentary negative affect at T2, and the dependent variable was binge eating at T3. T3 reflects the time when binge eating occurred, T2 represents the most proximal momentary rating of rumination or negative affect preceding binge eating, and T1 represents the momentary rating of rumination or negative affect prior to the T2 rating. In both sets of models, general rumination and eating-related rumination were examined separately. In the mediation models, T1 levels of rumination or negative affect were included as covariates predicting T2 rumination or negative affect (the mediator), respectively. This allowed us to address whether change in momentary rumination or negative affect precede binge eating symptoms. Level 2 between-person mediation models were also examined in each respective analysis. Formal tests of the

direct and indirect effects were conducted. Significance testing was conducted using 95% Bayesian credible intervals (BCIs), with BCIs not including 0 considered significant.

3. Results

There were a total of 2239 EMA signals completed during the EMA protocol, with a 90.3% compliance rate to random signals. Across the 10 days of EMA, the mean number of binge episodes reported per participant was 5.82 ± 5.56 ($Md = 4.00$; Range: 0–22). The mean EDE-Q global score was 3.31 ± 1.03 (range: 0.62–5.45), which is on par with norms reported for samples of individuals seeking treatment for an eating disorder (Aardoom et al., 2012; Smith et al., 2017). The mean CES-D-10 and GAD-7 total scores were 12.02 ± 5.70 (range: 2–27) and 8.53 ± 5.57 (range: 0–21), respectively. Based on suggested cut-offs for the CES-D-10 and GAD-7 (Björgvinsson et al., 2013; Spitzer et al., 2006), 62.5% of participants had a likely depression diagnosis and 37.5% had a likely GAD diagnosis.

3.1. Rumination as a mediator between negative affect and binge eating

The fitted mediation model of general rumination as a mediator between negative affect and binge eating is displayed in Fig. 1. Direct and indirect path estimates for models with rumination as a mediator are displayed in Table 1. T1 within-person negative affect significantly predicted T2 within-person general rumination controlling for T1 within-person general rumination, and T2 within-person general rumination significantly predicted greater binge eating symptoms at T3. The formal test of the within-subjects indirect effect was significant, such that general rumination mediated the association between negative affect and binge eating. Women who reported greater momentary negative affect at T1 had increased momentary general rumination at T2, and in turn, greater momentary general rumination at T2 predicted greater binge eating symptoms at T3. The within-subjects direct effect between T1 negative affect and T3 binge eating was negative, such that after accounting for the indirect effect through rumination, greater within-person negative affect at T1 predicted lower binge eating symptoms at T3. Between-person negative affect and general rumination were positively related, but there were no between-person associations with binge eating.

The fitted mediation model of ED-specific rumination as a mediator between negative affect and binge eating is displayed in Fig. 2. T1 within-person negative affect was unrelated to T2 within-person ED-specific rumination controlling for T1 within-person ED-specific rumination. T2 within-person ED-specific rumination significantly predicted greater binge eating symptoms at T3. The formal test of the within-subjects indirect effect was nonsignificant, as was the within-subjects direct effect between T1 negative affect and T3 binge eating. Between-subjects negative affect was positively associated with greater ED-specific rumination, and ED-specific rumination was positively associated with binge eating. The formal test of the between-subjects indirect effect was significant, such that ED-specific rumination mediated the association between negative affect and binge eating. Women with higher negative affect over the course of EMA reported greater ED-specific rumination, which in turn, was associated more binge eating.

3.2. Negative affect as a mediator between rumination and binge eating

The fitted mediation model of negative affect as a mediator between general rumination and binge eating is displayed in Fig. 3. Direct and indirect path estimates for models with negative affect as a mediator are displayed in Table 2. T1 within-person general rumination significantly predicted T2 within-person negative affect controlling for T1 within-person negative affect, and T2 within-person negative affect significantly predicted greater likelihood of binge eating at T3. The formal test of the within-subjects indirect effect was significant, such that negative affect mediated the association between general rumination and binge eating. Women who reported greater momentary general rumination at T1 had increased momentary negative affect at T2, and in turn, greater momentary negative affect at T2 predicted greater likelihood of binge eating at T3. The within-subjects direct effect between T1 general rumination and T3 binge eating was nonsignificant. Between-person negative affect and general rumination were positively related, but there were no between-person associations with binge eating.

The fitted mediation model of negative affect as a mediator between ED-specific rumination and binge eating is displayed in Fig. 4. T1 within-person ED-specific rumination was unrelated to T2 within-person negative affect controlling for T1 within-person negative affect. T2 within-person negative affect significantly predicted greater likelihood of binge eating at T3, and T1 ED-specific rumination was unrelated to T3 binge eating. The formal test of the within-subjects indirect effect was nonsignificant, as was the within-subjects direct effect between T1 ED-specific rumination and T3 binge eating. Between-subjects ED-specific rumination was positively associated with greater negative affect, and ED-specific rumination was positively associated with binge eating. The formal test of the between-subjects indirect effect was nonsignificant.

4. Discussion

Accumulating work supports the relevance of both general and symptom-specific rumination in EDs (Smith et al., 2018). However, past research on transdiagnostic repetitive thought has primarily used retrospective, trait-based self-report measurements, and the small number of studies exploring rumination in EDs using real-time assessment have not tested links between this cognitive process and binge eating. Therefore, the current study evaluated temporal associations between rumination, negative affect, and binge eating using EMA. Overall, results from the investigation supported hypothesized temporal associations between both general and ED-specific rumination and later binge eating, as well as theoretical links between general rumination, negative affect, and later binge eating. On the other hand, contrary to expectations, results did not suggest that ED-specific rumination related to binge eating by way of negative affect, supporting the possibility of unique effects for differing types of rumination on ED behaviors.

First, we aimed to explore temporal associations between rumination, negative affect, and binge eating. Past transdiagnostic work has consistently supported the assertion that rumination increases negative affectivity (e.g., Kirkegaard Thomsen, 2006; Moberly and Watkins, 2008), and depending on the particular sample being studied, associations between this negative affectivity and later engagement in dysregulated behaviors (Nicolai et al., 2016;

Selby et al., 2013). Our results from models exploring general rumination were consistent with this work, as rumination was associated with later significant increases in negative affect, which related to engagement in binge eating. In a reciprocal manner, negative affect was associated with increases in rumination, which predicted increases in binge eating. These findings are consistent with theoretical accounts of synergistic relationships between rumination and negative affect, such as the Emotional Cascade Model (Selby et al., 2008); they also provide support for generalized rumination as an important cognitive mechanism through which individuals engage in dysregulated behaviors, extending past work in other samples to include women that engage in binge eating.

Notably, findings from mediation analyses were not consistent for general and ED-specific rumination. Specifically, momentary ED-specific rumination did *not* predict increases in negative affect, and negative affect did not predict increases in ED-specific rumination. These results are notable given that, in our sample, ED-specific rumination *did* proximally relate to binge eating. These results are consistent with the possibility that there may be other mechanisms through which engagement in ED-specific rumination promotes binge eating. It may be that the measure of negative affect in the present study did not capture the specific nature of self-criticism or distress that is linked to ED-specific rumination, and/or that the schedule of EMA prompts was not consistent with the timescale during which temporal associations between negative affect and ED-specific rumination are observed. Our findings are also surprising given past data supporting links between ED-specific rumination and subsequent negative affect (Seidel et al., 2016). However, it could also be that our findings are secondary to the characteristics of our sample or the measurements used, as Seidel and colleagues (2016) used a broader measure of disorder-specific repetitive negative thinking and was exploring links between repetitive thought and affect in AN, rather than EDs characterized by binge eating. The one other study exploring repetitive thought in an ED sample used another measure of repetitive thought that focused specifically on mealtimes, and these researchers did not assess negative affect or binge eating behaviors (Sala et al., 2019). In addition, it is important to consider that some of the momentary ED-specific rumination items may be more strongly related to affective changes *following* binge episodes (e.g., *To what extent are you currently thinking about a recent meal you wished had gone better?*). Altogether, given the limited data exploring disorder-specific rumination in EDs and its associations with negative affect and other behaviors, as well as lack of consistent methodology and samples in existing work, future research replicating our findings and exploring the mechanisms through which repetitive thought may precipitate engagement in ED symptoms is necessary.

While our hypotheses focused on momentary (within-subjects) effects, it is worth noting that at the between-subjects level, negative affect was associated with general rumination, which replicates prior work demonstrating trait-level associations between these variables (e.g., Kirkegaard Thomsen, 2006). Further, there was a significant between-subjects mediational effect for ED-specific rumination, such that women with higher overall negative affect reported greater ED-specific rumination, which in turn was associated with more frequent binge eating. Given that this mediation effect was not significant at the momentary level, and there were not significant momentary relationships between negative affect and ED-specific

rumination, further work is necessary to explore the timescale over which these trait-level relationships unfold.

There are also important limitations that should be noted. The sample size was modest and consisted of women who were primarily Caucasian; thus, future research is needed to explore these questions in a larger population with a wider range of demographics, including mixed samples of men and women. Due to the sample size, diagnostic differences were not assessed as a moderator in the present study. Given the lack of observed associations with ED-specific rumination, in future research it would be important to explore whether these momentary mechanisms are more relevant for particular diagnoses (e.g., AN and BN vs. BED). Overeating was also assessed via self-report questions, which may limit the accuracy of the measurement of the objective nature of binge episodes. Our study only focused on one of many maladaptive emotion regulation strategies (i.e., rumination) that are associated with binge eating; consequently, future research should also explore momentary associations with other emotion regulation strategies. It should also be noted that the present analyses focused on times at which participants reported binge eating and not when they experienced urges to binge eat. This precludes examination of moments when participants successfully resisted urges to binge when experiencing rumination and negative affect. As such, future research should address how rumination and negative affect relate to binge urges, and which factors may buffer or exacerbate the likelihood that rumination will lead to binge eating when experiencing urges. While multilevel mediation analyses lend insight into potential mechanisms that precipitate binge eating, it is important to note that such effects do not confirm causality. Lastly, while the sample size precluded multilevel autoregressive cross-lagged analyses, such an approach would be useful to apply in future research in order to examine contemporaneous, autoregressive, and prospective associations among these variables simultaneously.

This study was the first to test momentary bidirectional mechanisms by which rumination predicts binge eating, which expands existing models of affect regulation in EDs and highlights the importance of perseverative cognition. Further research is warranted to explore the biobehavioral processes that underlie this mechanism, as prior EMA studies have shown momentary rumination is linked to aberrant neurobiological functioning (Putnam and McSweeney, 2008; Seidel et al., 2018), neuroendocrine changes (Fürtjes et al., 2018), and stress-related physiological responses (Cropley, Rydstedt, Devereux, & Middleton, 2013). In addition, results indicate repetitive negative thought may serve as a potent intervention target to disrupt mechanisms that maintain binge eating. As such, more work is needed to develop strategies of addressing negative affect as well as the perseverative nature of thought processes in ED treatment. For instance, Integrative Cognitive Affective Therapy (ICAT; Wonderlich et al., 2015) and other emotion-focused interventions may help target negative affective states that precipitate general rumination. In addition, outside of EDs, rumination-focused interventions have shown promise (e.g., cognitive bias modification, rumination-focused and mindfulness-based cognitive behavioral therapies; Watkins, 2015), which may be able to be integrated in the context of binge eating to enhance outcomes of existing ED treatments.

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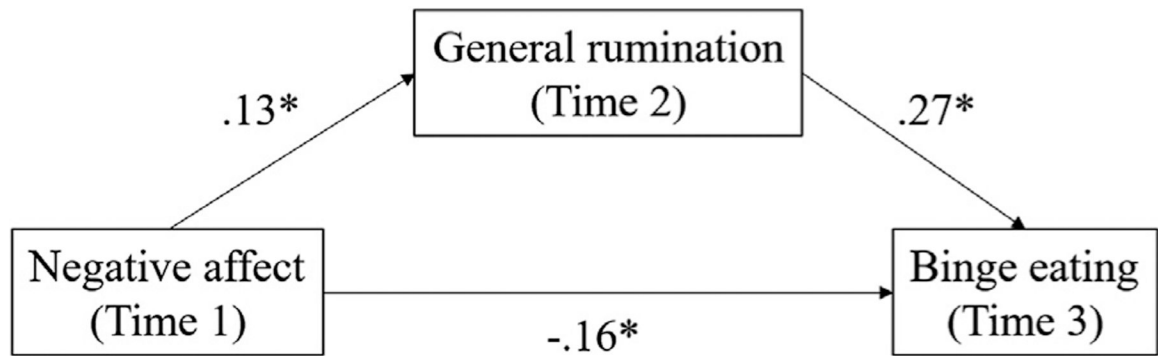


Fig. 1. Momentary general rumination as a mediator of the relationship between negative affect and binge eating (within-subjects results displayed). * $p < .05$. Indirect within-subjects effect = 0.03, $p < .001$.

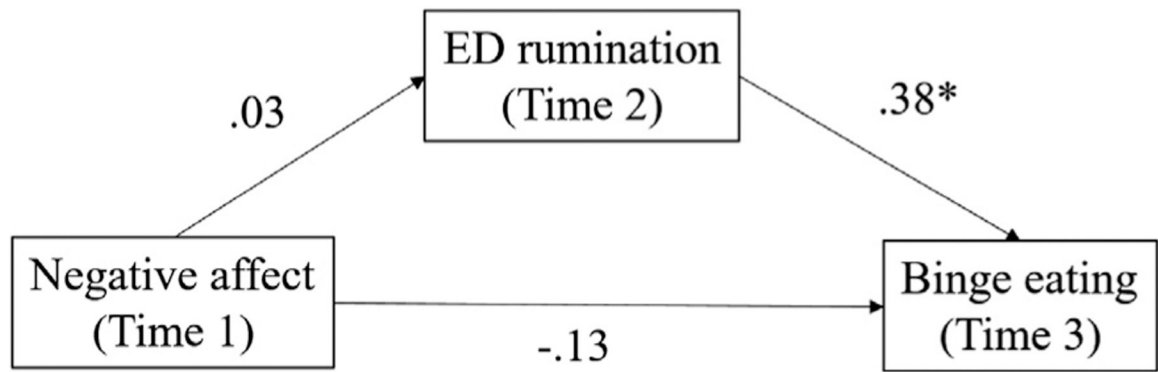


Fig. 2. Momentary eating disorder (ED) specific rumination as a mediator of the relationship between negative affect and binge eating (within-subjects results displayed). * $p < .05$. Indirect within-subjects effect = 0.01, $p > .05$.

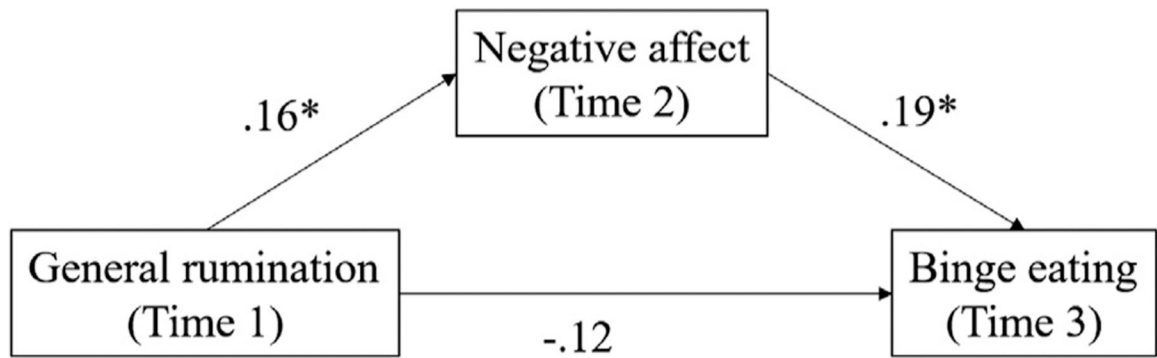


Fig. 3. Momentary negative affect as a mediator of the relationship between general rumination and binge eating (within-subjects results displayed). * $p < .05$. Indirect within-subjects effect = 0.03, $p = .003$.

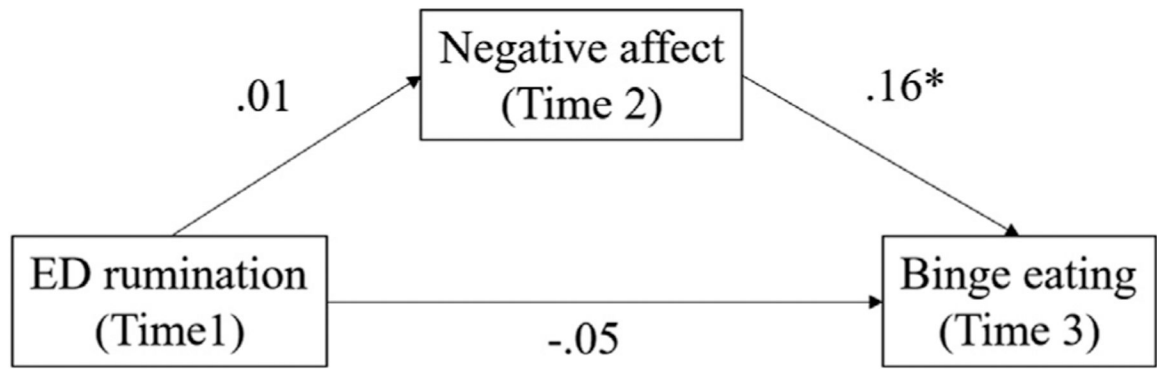


Fig. 4. Momentary negative affect as a mediator of the relationship between eating disorder (ED) specific rumination and binge eating (within-subjects results displayed). * $p < .05$. Indirect within-subjects effect < 0.01 , $p > .05$.

Unstandardized path estimates of multilevel structural equation models of rumination as a mediator of negative affect and binge eating.

Table 1

Path	General Rumination			Eating-related Rumination		
	Estimate	SE	95% BCI	Estimate	SE	95% BCI
Within-subjects						
<i>Direct effects</i>						
T1 NA → T2 Rumination	0.13	0.03	[0.05, 0.18]	0.03	0.03	[-0.03, 0.08]
T1 NA → T3 Binge Eating	-0.16	0.09	[-0.36, -0.02]	-0.13	0.09	[-0.32, 0.02]
T1 Rumination → T2 Rumination	0.34	0.03	[0.28, 0.40]	0.29	0.03	[0.22, 0.35]
T2 Rumination → T3 Binge Eating	0.27	0.07	[0.12, 0.40]	0.38	0.06	[0.27, 0.49]
<i>Indirect effect</i>						
T1 NA → T2 Rumination → T3 Binge Eating	0.03	0.01	[0.01, 0.06]	0.01	0.01	[-0.01, 0.03]
Between-subjects						
<i>Direct effects</i>						
NA → Rumination	0.74	0.08	[0.60, 0.91]	0.53	0.11	[0.33, 0.75]
NA → Binge Eating	0.20	0.34	[-0.65, 0.89]	-0.16	0.17	[-0.48, 0.15]
Rumination → Binge Eating	0.18	0.40	[-0.45, 0.93]	0.96	0.20	[0.57, 1.34]
<i>Indirect effect</i>						
NA → Rumination → Binge Eating	0.13	0.30	[-0.53, 0.75]	0.49	0.15	[0.25, 0.81]

Note. 95% Bayesian credible intervals (BCIs) were used for significant testing. If 0 is not included, then the path is significant; *T* = time; NA = negative affect.

Table 2

Unstandardized path estimates of multilevel structural equation models of negative affect as a mediator of rumination and binge eating.

Paths	General Rumination			Eating-related Rumination		
	Estimate	SE	95% BCI	Estimate	SE	95% BCI
<i>Within-subjects</i>						
<i>Direct effects</i>						
T1 Rumination → T2 NA	0.16	0.04	[0.08, 0.23]	0.01	0.02	[-0.04, 0.06]
T1 Rumination → T3 Binge Eating	-0.12	0.09	[-0.27, 0.06]	-0.05	0.07	[-0.17, 0.07]
T1 NA → T2 NA	0.35	0.03	[0.28, 0.41]	0.43	0.02	[0.38, 0.47]
T2 NA → T3 Binge Eating	0.19	0.07	[0.05, 0.32]	0.16	0.07	[0.01, 0.28]
<i>Indirect effect</i>						
T1 Rumination → T2 NA → T3 Binge Eating	0.03	0.02	[0.01, 0.07]	0.002	0.004	[-0.01, 0.01]
<i>Between-subjects</i>						
<i>Direct effects</i>						
Rumination → NA	1.01	0.10	[0.83, 1.22]	0.77	0.16	[0.46, 1.00]
Rumination → Binge Eating	0.17	0.40	[-0.67, 0.91]	0.90	0.20	[0.47, 1.29]
NA → Binge Eating	0.20	0.35	[-0.44, 0.90]	-0.16	0.17	[-0.44, 0.18]
<i>Indirect effect</i>						
Rumination → NA → Binge Eating	0.21	0.36	[-0.46, 0.90]	-0.10	0.14	[-0.36, 0.16]

Note. 95% Bayesian credible intervals (BCIs) were used for significant testing. If 0 is not included, then the path is significant; T = time; NA = negative affect.