



The ecological validity of trait-level rumination measures among women with binge eating symptoms

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Abstract

Purpose Cognitive rumination is a transdiagnostic construct that has been increasingly studied in the context of eating disorders (EDs). While this literature has consistently linked trait-level general and ED-specific forms of rumination to ED psychopathology, it is not clear whether trait-level measures are independently related to symptoms in daily life. Therefore, the present study used ecological momentary assessment (EMA) to assess the ecological validity of trait measures of general rumination and ED-specific rumination, and assess the degree to which ruminative brooding and reflection were differentially related to relevant momentary affective, cognitive, and behavioral processes.

Methods Forty women completed baseline measures (Ruminative Response Scale [RRS] and Ruminative Response Scale for Eating Disorders [RRSED]) followed by a 10-day EMA protocol.

Results Generalized estimating equations indicated trait-level ED-specific rumination was related to momentary general and ED-specific rumination, and trait-level general and ED-specific rumination were related to momentary affect and concentration difficulties. Trait-level general rumination was related to momentary self-discrepancy, while higher trait-level ED-specific rumination was related to greater loss of control eating, overeating, and body dissatisfaction. Lastly, trait levels of ruminative brooding, compared to reflection, were more consistently related to maladaptive momentary symptoms (i.e., general rumination, negative affect, concentration problems, body dissatisfaction).

Conclusion Together these findings support the ecological validity of the RRSED and identify shared and unique momentary correlates of the RRS and RRSED. Results also highlight the importance of measuring and addressing trait- and state-level ruminative processes that are both general and specific to ED psychopathology in research and clinical work.

Level of evidence Level V, observational descriptive study.

Keywords Ecological validity · Rumination · Eating disorders · Ecological momentary assessment

These results have not been previously presented in publication, conference presentation, or online formats.

This article is part of topical collection on Personality and eating and weight disorders.

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Introduction

Rumination refers to repetitive, self-focused thoughts concerning one's distress and the meaning of this distress [1]. While initial research on rumination predominantly focused

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on its role in perpetuating depressive symptoms, subsequent studies have established ruminative thinking as a transdiagnostic construct that is linked to a range of psychiatric symptoms, including eating disorder (ED) psychopathology [2, 3]. Across studies, individuals with EDs show heightened rumination compared to non-ED control groups, and higher levels of rumination have been specifically linked to greater binge eating symptoms and lower body satisfaction [3]. In addition, some research has suggested that the association between rumination and binge eating does not appear to vary based on race/ethnicity, though rumination may be more strongly related to binge eating among women versus men [4, 5]. Together, this literature has given rise to increased focus on integration of rumination into theoretical models of psychopathology, including EDs, and the development of interventions that specifically target maladaptive repetitive negative thought processes [6–8].

Given the growing recognition that rumination is relevant to EDs and ED-related comorbidities (e.g., depression, anxiety), it is imperative that measures of rumination that are commonly used in clinical research adequately reflect real-world, momentary ruminative processes. Ecological validity reflects the degree to which a measure reflects the way a construct is experienced in daily life [9]. Ensuring the ecological validity of measures is important given the potential for recall biases with self-report questionnaires [10] and because the evaluation of theoretical models and intervention targets rests on the fundamental assumption that self-report measures of constructs serve as accurate indicators of real-world, momentary phenomena. This is especially relevant for rumination measures, as the processes by which rumination relates to symptoms are thought to be momentary in nature. For example, the Emotional Cascade Model suggests that momentary rumination and negative affect evidence reciprocal, compounding relationships that potentiate impulsive behaviors [11]. In a similar manner, Control Theory posits that momentary discrepancies between one's goals and an actual situation lead to increased states of rumination [12]. In sum, evaluating the ecological validity of self-report rumination measures will inform the extent to which these measures can be used as meaningful indicators of this construct and their potential clinical utility in ED populations.

To date, the Ruminative Response Scale (RRS) remains one of the most commonly used self-report measures of rumination, including in ED studies. Factor analysis of the RRS has identified two distinct facets of rumination—brooding and reflection [13], which demonstrate differential relations to maladaptive and adaptive outcomes. Specifically, reflection, which refers to attempts to understand the reasons for one's symptoms, does not consistently relate to psychopathology symptoms, and, in some studies, is associated with increases in adaptive outcomes or decreases in negative

affect over time [13]. In contrast, brooding, or the tendency to dwell on negative symptoms, is related to a range of maladaptive psychological outcomes [14]. However, based on the findings of a recent meta-analysis, it is not clear whether ruminative brooding and reflection are differentially associated with ED psychopathology [3].

It also important to consider that in addition to ruminating about negative emotional experiences, individuals with EDs may ruminate about disorder-specific content (i.e., repetitive concerns about weight, shape, and eating). ED-specific rumination can be measured by the Ruminative Response Scale for EDs (RRSED), which also includes brooding and reflection subscales [15]. Extant evidence suggests that ED-specific rumination measured by the RRSED is more strongly associated with ED psychopathology than general measures of rumination [3].

However, while the majority of research on rumination in relation to ED symptoms has relied on the RRS and RRSED, no research has examined whether these trait-based rumination assessments capture distinct types of momentary ruminative experiences of individuals with EDs. In addition, it is unclear whether trait-level ruminative brooding and reflection tendencies differentially relate to momentary symptoms, or whether the RRSED is a stronger predictor of *momentary* ED symptoms compared to the RRS, as suggested by prior findings [3]. Clarifying these issues will inform how trait rumination measures can be most appropriately used in future research.

Therefore, the current study sought to evaluate the ecological validity of the RRS and RRSED using ecological momentary assessment (EMA) among a sample of women with regular binge eating. First, we examined the extent to which these measures uniquely predicted state-level general and ED-specific rumination. Second, we assessed the degree to which trait-level ruminative brooding and reflection measures were related to momentary cognitive and affective symptoms that are conceptually and empirically related to rumination in the broader literature, including affective state, self-discrepancy (i.e., differences between the attributes that an individual believes she or he actually possesses and those that he or she strives to possess), and difficulties with concentration. These variables were chosen in light of prior research and theoretical models indicating rumination is related to affect (e.g., Emotional Cascade Theory [11]), goal discrepancies (e.g., Control Theory [12]) and self-discrepancies [16], and interference with executive functioning [17]. Last, we examined whether the RRSED was more strongly related to real-time ED symptoms compared to the RRS. Symptoms of binge eating (i.e., loss of control eating and overeating) and body satisfaction were chosen as ED-related outcomes given they are transdiagnostic features that are relevant to a range of ED presentations, and prior trait-level ED research has shown specific associations between

these variables and rumination [3]. However, to date, no EMA research in EDs has examined rumination in relationship to these constructs.

We hypothesized that (1) trait-level ED and general rumination (RRSED and RRS, respectively) would be positively associated with respective state-level measures of these constructs; (2) elevated trait-level ruminative brooding (on both ED-specific and general measures), as compared to trait-level reflective rumination, would be more strongly linked to low momentary positive affect and high momentary negative affect, self-discrepancy, and concentration difficulties, and (3) trait-level ED rumination (RRSED), and particularly ED-specific ruminative brooding, would be uniquely associated with state-level ED symptoms (i.e., body dissatisfaction, loss of control eating, overeating), more so than general rumination (RRS). Given that depressive symptoms are also associated with rumination, analyses adjusted for trait-level depression to mitigate this confound.

Methods

Participants

The present study recruited 40 women (87.5% Caucasian, $M_{\text{BMI}} = 34.30 \pm 9.84 \text{ kg/m}^2$; $M_{\text{age}} = 34.70 \pm 15.59$) from clinical and community settings (i.e., a local ED treatment center and university) who reported recurrent binge eating. The study was advertised via a university email listserv (distributed to both students and staff), flyers, and in-person meetings with clinical research staff, and was described as a research study on mood, cognition, and eating behavior. To be eligible for the study, participants were required to report regular binge eating (i.e., \geq once/week over the past 3 months) as determined by the Structured Clinical Interview for DSM-5, Research Version (SCID-5-RV) [18], self-identify as female, and fall between the ages of 18 and 65. Exclusionary criteria were: (1) inability to read/speak English; (2) current psychiatric or medical instability; (3) severe cognitive impairment; (4) currently pregnant or breastfeeding; (5) changes to ED treatment in the past 4 weeks; (6) history of bariatric surgery; or (7) body mass index (BMI) $< 18.0 \text{ kg/m}^2$. In the current sample, 29 participants were diagnosed with binge eating disorder (BED), 9 with bulimia nervosa, 1 with anorexia nervosa binge-purge subtype (DSM-5 mild severity category: $17.5 < \text{BMI} < 18.5$) [19], and 1 with Other Specified Feeding or Eating Disorder (OSFED, subthreshold BED presentation).

Procedure

Following a phone screen, interested participants attended a study visit, which included the informed consent process,

assessment of vital signs and anthropometric measures, structured interviews, computerized tasks, and self-report questionnaires. Participants also received training on the EMA protocol using the Momentary Assessment Tool (MAT) system, which was administered on Samsung Galaxy tablets provided by the researchers. During the EMA protocol, participants were asked to make 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. During each day of the EMA protocol, participants received five semi-random signal-contingent prompts distributed around anchor points from 8:30 a.m. to 9:00 p.m. Participants were also asked to complete event-contingent recordings after eating episodes. 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. All participants provided informed consent, and study procedures received IRB approval.

Trait-level measures

Center for Epidemiologic Studies Depression Scale (CES-D; present study $\alpha = 0.83$) [20]. The CES-D is a 10-item, widely used self-report instrument of depressive symptoms. Respondents are asked to indicate how often they experienced depressive symptoms over the past week (e.g., I felt that everything I did was an effort) on a Likert-type scale ranging from 0 (less than 1 day) to 3 (5–7 days), with total scores ranging from 0 to 30. The scale has demonstrated good reliability and validity in a range of populations [21].

Ruminative Response Scale (RRS) [13]

The RRS is a 22-item self-report measurement of rumination. Respondents are asked to indicate what they generally do when they feel down, sad, or depressed (e.g., *Think about how sad you feel*). Each item is rated on a Likert-type scale from 1 (*almost never*) to 4 (*almost always*). The scale has been widely used in research on rumination, has demonstrated good psychometric properties [13], and has two subscales: reflection (RRS-R; $\alpha = 0.83$) and brooding (RRS-B; present study $\alpha = 0.77$). The 5-item RRS-R and 5-item RRS-B subscale scores each range from 5 to 20, with higher scores indicating greater ruminative tendencies.

Ruminative Response Scale for Eating Disorders (RRSED)

[15]

The RRSED measures ED-specific rumination and was adapted using items from the original RRS. Respondents are asked to indicate what they would generally do when they were concerned about controlling their eating, weight and shape (e.g., Think ‘why can’t I handle my eating better?’). Each item is rated on a Likert-type scale from 1 (*almost never*) to 4 (*almost always*). The scale has previously demonstrated acceptable reliability and validity [15]. Similar to the RRS, the RRSED has two subscales: reflection (RRSED-R; 3 items) and brooding (RRSED-B; 6 items); present study $\alpha=0.78$ and $\alpha=0.82$, respectively. The RRSED-R subscale score ranges from 3 to 12, while the RRSED-B subscale score ranges from 6 to 24.

EMA measures

Momentary general rumination was assessed at EMA signals by the following items, which were based on the RRS and previous EMA research: [22–24]. 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 (present study $\alpha=0.92$), with possible scores ranging from 1 to 5.

Momentary ED-specific rumination was assessed by the following items based on the RRSED-B subscale: 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 (present study $\alpha=0.93$), with possible scores ranging from 1 to 5.

Momentary negative and positive affects were assessed at EMA signals using the 10-item Positive and Negative Affect Schedule Short Form (PANAS-SF) [25], with the addition of guilt, given its relevance to negative affect in EDs [26]. Participants rated the extent to which they were currently experiencing each affective state (e.g., *nervous*; *inspired*) on a Likert-type scale ranging from 1 (*not at all*) to 5 (*extremely*).

Ratings were summed to create composite negative and positive affect scores at each EMA signal (present study $\alpha=0.88$ and $\alpha=0.87$, respectively). The total possible negative affect score ranged from 6 to 30, while the total possible positive affect score ranged from 5 to 25.

Momentary concentration difficulties were assessed by the following item: Since the last recording, to what extent have you had difficulty concentrating or focusing your attention? Responses were rated on a 5-point Likert-type scale ranging from 1 (*not at all*) to 5 (*extremely*), with possible scores ranging from 1 to 5.

Momentary self-discrepancy was assessed by the following items, each of which was rated on a 5-point Likert-type scale (1 = *not at all*; 5 = *extremely*): At this moment, how much do you feel you are the person you ideally wish to be?; At this moment, how much do you feel you are the person others want you to be? The items have been used in prior EMA research [27] and were averaged to create a measure of overall self-discrepancy at each signal, with possible scores ranging from 1 to 5. Higher scores indicate *less* self-discrepancy (i.e., a *greater* match between the individual’s desired self and perceived current self; present study $\alpha=0.85$).

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 [26] and were rated a Likert-type scale ranging from 1 (*not at all*) to 5 (*extremely*). Scores on the loss of control eating and overeating items were averaged to create composite scores for each domain, with each possible score ranging from 1 to 5. Internal consistencies of the loss of control eating and overeating composites were excellent ($\alpha=0.90$ and $\alpha=0.94$, respectively). Momentary body satisfaction was assessed analogously to prior EMA studies (e.g., Peterson et al., under review): Right now, I am satisfied with my weight; Right now, I am satisfied with my body shape. Responses were rated on a 5-point Likert-type scale (1 = *not at all*; 5 = *extremely*), with higher scores reflecting greater weight and shape satisfaction. The two items were averaged to assess overall body satisfaction at each EMA signal (present study $\alpha=0.95$), with possible scores ranging from 1 to 5.

Statistical analyses

Generalized estimating equations (GEEs) were used to examine the unique associations between trait-level measures of general rumination (RRS-B and RRS-R) and ED-specific

rumination (RRSED-B, RRSED-R) and momentary (EMA-measured) variables. Each GEE included RRS and RRSED subscale scores as independent variables; age, BMI, and depressive symptomatology (CES-D total) were included as covariates. Independent variables were grand-mean centered. Each GEE employed an AR1 covariance structure to account for autocorrelations within the EMA data, as well as a gamma link function to account for non-normal distributions of dependent variables. False discovery rate (FDR) significance was used to correct for multiple comparisons [28]. The p values from the main effects of interest (i.e., RRS-B, RRS-R, RRSED-B, RRSED-R) in the models were used to calculate adjusted p values. The FDR significance level was set at 0.10, which has been recommended for exploratory research [29].

Results

There were a total of 2239 signals completed during the EMA protocol, with a 90.3% compliance rate for signal-contingent recordings. Descriptive statistics and bivariate correlations among trait-level measures and EMA-measured variables are shown in Table 1. There were significant correlations between trait-level general and ED-specific rumination RRSED-R subscales ($r=0.40$ to 0.64 , $p<0.001$) as well as between EMA-measured general and ED-specific rumination ($r=0.64$, $p<0.001$). Results of GEEs are shown in Table 2; the pattern of findings remained the same after FDR correction.

Hypothesis 1 Our first hypothesis suggested the trait-level ED and general rumination measures would converge with their respective state-level measures. This hypothesis was largely supported, as higher trait-level general ruminative brooding (RRSED-B) was related to higher momentary general rumination. In addition, higher trait-level ED-specific brooding and reflective rumination (RRSED-R and RRSED-B) were independently related to higher momentary ED-related rumination.

Hypothesis 2 It was expected that higher trait-level ruminative brooding (both ED-specific and general), as compared to trait-level reflective rumination, would be more strongly linked to high negative affect/low positive affect, self-discrepancy, and concentration difficulties. Higher general and ED-specific ruminative brooding (RRS-B and RRSED-B) was related to higher levels of momentary negative affect, while higher general ruminative reflection (RRS-R) was related to *higher* momentary positive affect. Higher ED-specific ruminative brooding (RRSED-B) was also associated with greater momentary difficulties with concentration. Both general ruminative brooding and reflection (RRS-R

and RRS-B) were associated with momentary self-discrepancy, albeit in opposite directions: higher general ruminative reflection was related to *less* momentary self-discrepancy (i.e., greater endorsement that individuals were the person they ideally wished to be or the person others want them to be), while higher general ruminative brooding was related to *greater* momentary self-discrepancy.

Hypothesis 3 Consistent with the expectation that trait-level ED rumination would be more strongly associated with state-level ED symptoms than general rumination, higher ED-specific ruminative brooding (RRSED-B) related to lower momentary body satisfaction and higher loss of control eating, and higher ED-specific ruminative reflection (RRSED-R) was related to higher overeating. In addition, *higher* general ruminative reflection (RRS-R) was related to lower momentary overeating and loss of control eating.

Discussion

The current investigation examined the ecological validity of trait-level rumination measures among women with recurrent binge eating. The first hypothesis was partially supported, in that trait-level ED-specific rumination demonstrated associations with momentary general and ED-specific rumination. Specifically, trait-level ED-specific brooding was positively associated with both momentary general and ED-specific rumination, and trait-level ED-specific reflection was positively associated with momentary ED-specific rumination. In contrast, trait levels of general rumination were not associated with momentary levels of either type of rumination. Altogether, these findings suggest that trait-level ED-specific rumination may be a stronger indicator of momentary ruminative processes in this population.

However, both general and ED-specific forms of rumination were relevant in predicting momentary affective symptoms, self-discrepancy, and cognitive processes. In line with the second hypothesis, trait-levels of general and ED-specific brooding but not reflection predicted greater momentary negative affect, and ED-specific brooding but not reflection was related to greater concentration difficulties. This generally converges with prior findings suggesting brooding is the more maladaptive subtype of rumination, and adds to the currently equivocal literature differentiating these subtypes in EDs [3]. Interestingly, the trait-level tendency to ruminate on ED-specific content in a brooding manner was more strongly associated with impaired momentary cognitive focus compared to general ruminative tendencies. It may be that ED-related thoughts are experienced as more intrusive and/or disruptive in this population, and thus the tendency to ruminate on such thoughts in a brooding

Table 1 Descriptive statistics and zero-order correlations between EMA measures (aggregated within person) and trait-level measures ($N=40$)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. RRS-R	–	0.64**	0.40**	0.53**	0.57**	0.39*	0.27	0.17	–0.01	–0.22	0.36*	0.32*	–0.04	0.02
2. RRS-B		–	0.48**	0.52**	0.73**	0.53**	0.52**	–0.11	0.21	0.03	0.49**	0.44**	–0.48**	–0.20
3. RRS-D			–	0.48**	0.43**	0.56**	0.54**	–0.03	0.45**	0.39*	0.50**	0.58**	–0.32*	–0.20
4. RRS-R				–	0.34*	0.39*	0.21	–0.11	0.43**	0.33*	0.25	0.47**	–0.11	0.11
5. CES-D					–	0.65**	0.45**	–0.01	0.29	0.08	0.44**	0.49**	–0.40*	–0.28
6. Concentration difficulties (EMA)						–	0.63**	0.03	0.61**	0.35*	0.67**	0.78**	–0.25	–0.09
7. Negative affect (EMA)							–	0.02	0.33*	0.29	0.85**	0.64**	–0.46**	–0.16
8. Positive affect (EMA)								–	–0.17	–0.32*	0.14	–0.03	0.55**	0.41**
9. Overeating (EMA)									–	0.85**	0.36*	0.73**	–0.17	–0.07
10. Loss of control eating (EMA)										–	0.23	0.54**	–0.23	–0.17
11. General rumination (EMA)											–	0.64**	–0.37*	–0.11
12. ED rumination (EMA)												–	–0.27	–0.11
13. Self-discrepancy (EMA)													–	0.64**
14. Body satisfaction (EMA)														–
<i>M</i>	10.45	12.13	18.45	5.88	12.03	2.25	10.85	12.90	2.16	2.07	2.35	2.20	1.97	1.49
<i>SD</i>	3.97	3.44	3.65	2.37	5.70	0.77	3.91	2.47	0.71	0.65	0.83	0.80	0.69	0.65
Minimum	5.00	6.00	11.00	3.00	2.00	1.04	6.12	8.00	1.00	1.08	1.12	1.00	1.00	1.00
Maximum	19.00	19.00	24.00	12.00	27.00	4.40	20.61	17.18	3.97	3.65	4.12	4.36	3.23	3.05

EMA ecological momentary assessment, RRS Ruminative Response Scale, RRS-ED Ruminative Response Scale for Eating Disorders, R reflection subscale, B brooding subscale, CES-D Center for Epidemiologic Studies Depression Scale, ED eating disorder

* $p < 0.05$

** $p < 0.001$

^aHigher ratings indicate lower self-discrepancy

Table 2 Generalized estimating equations examining trait-level rumination measures as predictors of momentary (EMA-measured) processes

	EMA general rumination							EMA ED-specific rumination						
	<i>B</i>	SE	Lower	Upper	Wald χ^2	<i>p</i>	BH <i>p</i>	<i>B</i>	SE	Lower	Upper	Wald χ^2	<i>p</i>	BH <i>p</i>
Intercept	0.81	0.05	0.72	0.90	295.46	< 0.001	–	0.72	0.04	0.65	0.79	420.22	< 0.001	–
Age	< 0.01	< 0.01	< 0.01	0.01	0.46	0.498	–	< 0.01	< 0.01	< 0.01	0.01	0.06	0.802	–
BMI	< 0.01	< 0.01	– 0.01	0.01	0.01	0.937	–	– 0.01	< 0.01	– 0.02	< 0.01	3.34	0.068	–
CES-D	< 0.01	0.02	– 0.03	0.03	< 0.01	0.985	–	0.03	0.01	0.01	0.04	10.97	0.001	–
RRS-R	< 0.01	0.01	– 0.02	0.03	0.05	0.823	0.847	– 0.01	0.01	– 0.03	0.01	1.96	0.161	0.265
RRS-B	0.04	0.03	– 0.02	0.09	1.75	0.185	0.266	< 0.01	0.02	– 0.05	0.04	0.01	0.905	0.905
RRSED-R	– 0.02	0.02	– 0.06	0.02	0.85	0.357	0.476	0.05	0.02	< 0.01	0.09	4.4	0.036	0.091
RRSED-B	0.04	0.02	< 0.01	0.08	4.29	0.038	0.091	0.03	0.01	0.01	0.05	8.38	0.004	0.023
	EMA negative affect							EMA positive affect						
	<i>B</i>	SE	Lower	Upper	Wald χ^2	<i>p</i>	BH <i>p</i>	<i>B</i>	SE	Lower	Upper	Wald χ^2	<i>p</i>	BH <i>p</i>
Intercept	2.34	0.04	2.27	2.42	3329.23	< 0.001	–	2.56	0.03	2.51	2.61	9073.37	< 0.001	–
Age	< 0.01	< 0.01	< 0.01	0.01	0.43	0.511	–	< 0.01	< 0.01	< 0.01	0.01	4.64	0.031	–
BMI	< 0.01	< 0.01	– 0.01	0.01	0.54	0.463	–	< 0.01	< 0.01	– 0.01	< 0.01	1.43	0.231	–
CES-D	< 0.01	0.01	– 0.02	0.02	0.01	0.906	–	< 0.01	0.01	– 0.02	0.01	0.3	0.587	–
RRS-R	– 0.02	0.01	– 0.04	0.01	2.00	0.158	0.265	0.02	0.01	< 0.01	0.03	6.77	0.009	0.029
RRS-B	0.05	0.02	0.01	0.09	7.14	0.008	0.029	– 0.01	0.01	– 0.04	0.02	0.33	0.568	0.682
RRSED-R	– 0.02	0.02	– 0.07	0.03	0.48	0.486	0.603	< 0.01	0.01	– 0.03	0.02	0.06	0.808	0.847
RRSED-B	0.04	0.02	0.01	0.08	7.86	0.005	0.023	< 0.01	0.01	– 0.02	0.01	0.18	0.671	0.755
	EMA concentration difficulties							EMA self-discrepancy ^a						
	<i>B</i>	SE	Lower	Upper	Wald χ^2	<i>p</i>	BH <i>p</i>	<i>B</i>	SE	Lower	Upper	Wald χ^2	<i>p</i>	BH <i>p</i>
Intercept	0.75	0.03	0.69	0.82	490.52	< 0.001	–	0.65	0.04	0.57	0.74	218.59	< 0.001	–
Age	< 0.01	< 0.01	< 0.01	< 0.01	0.04	0.847	–	< 0.01	< 0.01	– 0.01	0.01	< 0.01	0.965	–
BMI	< 0.01	< 0.01	– 0.01	0.01	0.24	0.626	–	– 0.01	< 0.01	– 0.02	< 0.01	1.70	0.192	–
CES-D	0.03	0.01	0.01	0.05	12.13	< 0.001	–	– 0.02	0.01	– 0.04	0.01	2.24	0.135	–
RRS-R	– 0.01	0.01	– 0.03	0.01	1.84	0.175	0.266	0.04	0.01	0.02	0.07	9.48	0.002	0.018
RRS-B	< 0.01	0.02	– 0.03	0.04	0.05	0.817	0.847	– 0.06	0.02	– 0.09	– 0.02	8.97	0.003	0.022
RRSED-R	0.02	0.02	– 0.02	0.06	0.77	0.379	0.487	0.03	0.02	– 0.01	0.06	1.76	0.185	0.266
RRSED-B	0.03	0.01	0.01	0.05	10.13	0.001	0.012	– 0.02	0.02	– 0.06	0.01	1.54	0.214	0.296
	EMA body satisfaction							EMA overeating						
	<i>B</i>	SE	Lower	Upper	Wald χ^2	<i>p</i>	BH <i>p</i>	<i>B</i>	SE	Lower	Upper	Wald χ^2	<i>p</i>	BH <i>p</i>
Intercept	0.37	0.05	0.27	0.47	49.66	< 0.001	–	0.70	0.04	0.62	0.79	263.16	< 0.001	–
Age	< 0.01	< 0.01	– 0.01	< 0.01	1.19	0.275	–	< 0.01	< 0.01	– 0.01	< 0.01	0.36	0.546	–
BMI	– 0.01	< 0.01	– 0.02	< 0.01	7.37	0.007	–	– 0.01	0.01	– 0.02	< 0.01	1.50	0.22	–
CES-D	– 0.02	0.02	– 0.05	0.01	1.71	0.191	–	0.03	0.01	0.01	0.05	9.56	0.002	–
RRS-R	0.03	0.02	– 0.01	0.07	2.21	0.138	0.261	– 0.03	0.01	– 0.06	< 0.01	5.14	0.023	0.069
RRS-B	– 0.01	0.03	– 0.07	0.05	0.19	0.663	0.755	– 0.03	0.02	– 0.07	< 0.01	2.97	0.085	0.180
RRSED-R	0.04	0.03	– 0.02	0.09	1.96	0.162	0.265	0.06	0.02	0.02	0.10	7.42	0.006	0.024
RRSED-B	– 0.05	0.02	– 0.08	– 0.02	8.05	0.005	0.023	0.02	0.01	< 0.01	0.05	2.96	0.085	0.180
	EMA loss of control eating													
	<i>B</i>	SE	Lower	Upper	Wald χ^2	<i>p</i>	BH <i>p</i>							
Intercept	0.65	0.04	0.57	0.73	267.52	< 0.001	–							
Age	< 0.01	< 0.01	– 0.01	< 0.01	0.24	0.624	–							
BMI	< 0.01	0.01	– 0.01	0.01	0.49	0.483	–							
CES-D	0.02	0.01	< 0.01	0.04	5.72	0.017	–							

Table 2 (continued)

	EMA loss of control eating				Wald χ^2	<i>p</i>	BH <i>p</i>
	<i>B</i>	SE	Lower	Upper			
RRS-R	− 0.04	0.01	− 0.07	− 0.02	12.04	0.001	0.012
RRS-B	− 0.04	0.02	− 0.08	0.01	2.8	0.094	0.188
RRSED-R	0.06	0.02	0.02	0.10	10.12	0.001	0.012
RRSED-B	0.03	0.01	< 0.01	0.06	4.69	0.030	0.083

Bolded text indicates statistical significance. All independent variables were grand-mean centered

EMA ecological momentary assessment-measured variable, BH Benjamini–Hochberg adjusted *p* value, RRS-R Ruminative Response Scale Reflection subscale, RRS-B Ruminative Response Scale Brooding subscale, RRSED-R Ruminative Response Scale for Eating Disorders Reflection subscale, RRSED-B Ruminative Response Scale for Eating Disorders Brooding subscale, BMI body mass index, CES-D Center for Epidemiologic Studies Depression Scale total score

^aHigher EMA ratings indicate less self-discrepancy

manner (reflected by the RRSED-B) could be particularly detrimental to concentration abilities.

Notably, general rumination was independently related to momentary self-discrepancy. Greater ruminative brooding predicted higher self-discrepancy, suggesting that a passive, negative cognitive style may maintain and/or exacerbate negative self-concept, and/or that self-discrepancy may give rise to ruminative brooding. Irrespective of directionality, these findings generally converge with the tenets of Control Theory [12] and the results of a recent meta-analysis showing relationships between measures of general rumination and self-discrepancy [16]. The lack of associations between self-discrepancy and ED-specific rumination could also indicate that the nature of the momentary self-discrepancy endorsed by participants was largely unrelated to eating domains and instead reflected broader sense of self-evaluation (e.g., general low self-esteem rather than failing to meet eating or weight-related standards).

In line with the second hypothesis, the opposite effect emerged for reflective rumination, indicating that neutrally valenced, insight-oriented thought processes may facilitate problem-solving aimed at resolving goal discrepancies. Further, general reflective rumination was positively associated with momentary positive affect. Together the associations between general reflective rumination, less self-discrepancy, and higher positive affect are consistent with research indicating reflection represents a more adaptive form of rumination [13].

With respect to the third hypothesis, ED-specific rumination demonstrated some specificity of associations with ED symptomatology compared to general rumination measures. That is, there were more significant effects observed for the RRSED with respect to body satisfaction, overeating, and loss of control eating compared to the RRS, and putatively maladaptive associations between trait rumination and momentary ED symptoms were only observed using the RRSED. Specifically, greater ED-specific, but not general,

ruminative brooding was associated with greater momentary loss of control eating and lower body satisfaction, and greater ED-specific ruminative reflection was associated with greater loss of control eating and overeating. In contrast, higher general reflective rumination was related to lower overeating and loss of control eating, suggesting possible benefits of general self-reflection on ED symptoms. In line with the self-discrepancy finding, it may be that some types of self-reflection that are not directly linked to ED symptoms could promote adaptive coping and problem-solving, which in turn may indirectly mitigate risk of dysregulated eating. However, when a reflective cognitive style was directed to ED content, ED-related reflective rumination was positively associated with overeating and loss of control eating. Thus, there may be no benefit of ED-specific rumination in clinical ED populations.

Strengths of the current study include the use of validated measures to assess trait-level general and ED-specific rumination, as well as the use of EMA to assess state rumination and associated symptoms in the natural environment. However, the study is limited by the relatively small sample size and restricted sample demographics—i.e., all participants were adult women who engaged in binge eating and who were mostly Caucasian. Future studies are warranted to examine these processes in larger samples, other ED presentations, and in more diverse demographic groups, particularly samples including men given previously documented gender differences in rumination [30]. Given that prior research has found the relationship between rumination and binge eating was stronger among women [5], the RRS and RRSED could be less predictive of momentary binge eating among men. While other research has not found differences in the association between rumination and binge eating across Caucasian and African-American groups, it would also be informative for future research to explore potential differences in other racial/ethnic groups [4]. In addition, momentary

ED-specific rumination items were based on the RRSED-B, and thus there was a lack of EMA items to assess state ED-specific reflection. Future work should examine reflective forms of momentary ED-related rumination, as well as the convergence between trait and state measures of rumination in larger and more diverse samples.

Despite these limitations, the current study extended past work by examining the ecological validity of trait-based rumination measures using EMA, which has important implications for future clinical research. Most importantly, these findings highlight the independent utility of each trait-based measure, as both general and ED-specific rumination demonstrated unique associations with relevant affective, cognitive, and ED symptoms in daily life. Specifically, the RRSED may serve as a better indicator of overall ruminative processes and may be a stronger predictor of ED symptoms; however, the RRS uniquely related to general self-evaluation, and both general and ED-specific measures independently related to negative affect. In addition, these results demonstrate the importance of differentiating between ruminative brooding and reflection, as the momentary correlates of trait-level rumination differed across these subtypes and further depended on the nature of ruminative thought content (i.e., general vs. ED-specific). Collectively, findings suggest investigators should carefully consider their research questions and underlying constructs of interest when selecting trait-level measures of rumination for use in ED samples.

In addition to informing measure selection, these results highlight other potential theoretical and clinical implications. For instance, the majority of research on rumination in EDs has been cross-sectional, which limits our understanding of how rumination, *and which aspects of rumination* (e.g., trait vs. state, general vs. ED-specific, brooding vs. reflection), should be integrated in etiological and maintenance models of EDs. For instance, in line with transdiagnostic conceptualizations of rumination [6], it is possible that trait-level ruminative tendencies reflect a predisposing risk factor for EDs; in addition, states of rumination may operate at a momentary level to maintain and exacerbate ED symptomatology, as suggested by the Emotional Cascade Model [11]. As such, future longitudinal and intensive longitudinal (i.e., EMA) research will be vitally important to advance our understanding of this construct as it relates to ED theory. Lastly, no research to date has examined trait-level rumination measures as possible predictors or moderators of treatment outcome in EDs. Given that rumination-focused interventions have shown promise outside of EDs (e.g., cognitive bias modification, rumination-focused and mindfulness-based cognitive behavioral therapies [7]), rumination may serve as a viable treatment target if future research indicates that rumination has prognostic relevance in the context of ED treatment.

What is already known on this subject?

Rumination is a salient process across many forms of psychopathology, including eating disorders (EDs). To date, the majority of research on rumination in EDs relies on trait-level questionnaires such as the Ruminative Response Scale (RRS) and Ruminative Response Scale for Eating Disorders (RRSED). However, it is yet unknown the extent to which these measures of general and ED-specific rumination (RRS and RRSED, respectively) capture real-time symptomatology.

What does this study add?

Through the use of ecological momentary assessment, the present study adds to the current literature by showing that trait-level ED-specific rumination (RRSED) is related to momentary general and ED-specific rumination, and is associated with greater momentary ED symptoms. Both general and ED-specific trait-level rumination (RRS and RRSED) are relevant in predicting momentary affective symptoms, self-discrepancy, and cognitive processes. Together these findings support the ecological validity of the RRSED and demonstrate distinct momentary correlates of the RRS and RRSED.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional review board (Sanford IRB CR00000857) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent All participants provided informed consent, and study procedures received IRB approval.

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