

Original Article

Cite this article: Smith KE *et al* (2022). Micro-level de-coupling of negative affect and binge eating in relationship to macro-level outcomes in binge eating disorder treatment. *Psychological Medicine* **52**, 140–148. <https://doi.org/10.1017/S0033291720001804>

Received: 3 January 2020
Revised: 2 April 2020
Accepted: 15 May 2020
First published online: 29 June 2020


Key words:

Binge eating disorder; ecological momentary assessment; emotion regulation

Author for correspondence:

Kathryn E. Smith,
E-mail: ksmith41@usc.edu

Micro-level de-coupling of negative affect and binge eating in relationship to macro-level outcomes in binge eating disorder treatment

Kathryn E. Smith¹ , Tyler B. Mason², Lauren M. Schaefer³, Lisa M. Anderson⁴, Vivienne M. Hazzard³, Ross D. Crosby^{3,5}, Scott G. Engel^{3,5}, Scott J. Crow^{4,6}, Stephen A. Wonderlich^{3,5} and Carol B. Peterson^{4,6}

¹Department of Psychiatry and Behavioral Sciences, University of Southern California, Los Angeles, California, USA; ²Department of Preventive Medicine, University of Southern California, Los Angeles, California, USA; ³Center for Bio-behavioral Research, Sanford Research, Fargo, North Dakota, USA; ⁴Department of Psychiatry and Behavioral Sciences, University of Minnesota, Minneapolis, Minnesota, USA; ⁵Department of Psychiatry and Behavioral Science, University of North Dakota School of Medicine and Health Sciences, Fargo, North Dakota, USA and ⁶The Emily Program, Saint Paul, Minnesota, USA

Abstract

Background. While negative affect reliably predicts binge eating, it is unknown how this association may decrease or ‘de-couple’ during treatment for binge eating disorder (BED), whether such change is greater in treatments targeting emotion regulation, or how such change predicts outcome. This study utilized multi-wave ecological momentary assessment (EMA) to assess changes in the momentary association between negative affect and subsequent binge-eating symptoms during Integrative Cognitive Affective Therapy (ICAT-BED) and Cognitive Behavior Therapy Guided Self-Help (CBTgsh). It was predicted that there would be stronger de-coupling effects in ICAT-BED compared to CBTgsh given the focus on emotion regulation skills in ICAT-BED and that greater de-coupling would predict outcomes.

Methods. Adults with BED were randomized to ICAT-BED or CBTgsh and completed 1-week EMA protocols and the Eating Disorder Examination (EDE) at pre-treatment, end-of-treatment, and 6-month follow-up (final $N=78$). De-coupling was operationalized as a change in momentary associations between negative affect and binge-eating symptoms from pre-treatment to end-of-treatment.

Results. There was a significant de-coupling effect at follow-up but not end-of-treatment, and de-coupling did not differ between ICAT-BED and CBTgsh. Less de-coupling was associated with higher end-of-treatment EDE global scores at end-of-treatment and higher binge frequency at follow-up.

Conclusions. Both ICAT-BED and CBTgsh were associated with de-coupling of momentary negative affect and binge-eating symptoms, which in turn relate to cognitive and behavioral treatment outcomes. Future research is warranted to identify differential mechanisms of change across ICAT-BED and CBTgsh. Results also highlight the importance of developing momentary interventions to more effectively de-couple negative affect and binge eating.

Introduction

The goal of many therapeutic approaches is not only to dampen symptom severity, but also to ‘un-link’ or de-couple functional relationships between cognitive, emotional, and behavioral variables that contribute to psychopathology. For example, emotion-focused interventions aim to decrease the momentary association between negative affect and eating disorder (ED) behaviors by helping individuals to utilize more adaptive emotion regulation skills, which is thought to disrupt key maintaining mechanisms. However, analytic approaches that have been previously applied to examine mechanisms of change in EDs have insufficiently captured the nuanced dynamics of these processes, which could enhance our understanding of treatments and refine targets of intervention.

Affect regulation models of EDs

Negative affectivity and emotion dysregulation are central factors in the onset and maintenance of EDs (Lavender *et al.*, 2015; Stice, 2002). Extensive research shows EDs characterized by binge eating are associated with heightened negative affect intensity and difficulties tolerating and regulating aversive emotions. This is consistent with theoretical and empirical work suggesting that binge-eating functions escape from or regulate negative affective states

(Haedt-Matt & Keel, 2011; Heatherton & Baumeister, 1991). Thus, the *momentary coupling* of negative affect and symptoms forms the basis of affect regulation models of EDs.

Binge eating disorder (BED) is one ED characterized by recurrent binge eating (i.e. consumption of an objectively large amount of food with a sense of loss of control over eating) in the absence of regular compensatory behaviors (American Psychiatric Association, 2013). Similar to other EDs, BED is associated with emotion regulation difficulties and range of psychiatric and medical morbidities (Lehr et al., 2015; Mitchell, 2016). Despite the significance of this disorder, treatment outcomes remain less than optimal (Grilo, 2017; Linardon, 2018). Identifying interventions that disrupt momentary affect-binge-eating associations is therefore of utmost importance.

Emotion-focused interventions

Across psychopathology and treatment frameworks, converging research indicates that improvement in emotion regulation is a key mechanism of change (Gratz & Tull, 2010; Gratz, Bardeen, Levy, Dixon-Gordon, & Tull, 2015; Mennin & Fresco, 2010; Slee, Spinhoven, Garnefski, & Arensman, 2008). In brief, emotion-focused treatments, which are included in the broader category of 'third-wave' behavioral and cognitive therapies, are based on the tenet that symptom reduction occurs through changing the context and function of internal events and behavior, rather than changing their form and frequency (Hayes, Villatte, Levin, & Hildebrandt, 2011; Kahl, Winter, & Schweiger, 2012). In other words, emotion-focused treatments help individuals adaptively *cope* with negative affect and distress via emotion regulation strategies, rather than attempting to *eliminate or suppress* aversive emotional states. As a result, the momentary associations between negative affect and maladaptive symptoms should weaken as a result of increases in adaptive coping; however, this has yet to be empirically examined.

Notably, several ED treatments have been developed that specifically address emotion regulation, which shows promise in reducing symptoms (Berg & Wonderlich, 2013; Linardon, Gleeson, Yap, Murphy, & Brennan, 2019). One such treatment is Integrative Cognitive Affective Therapy (ICAT), which targets momentary affective processes that trigger binge eating (Wonderlich et al., 2014, 2015). While ICAT for bulimia nervosa (BN) demonstrated comparable efficacy to cognitive behavior therapy enhanced (CBT-E; Fairburn, 2008; Wonderlich et al., 2014), ICAT-BN was shown to be more effective than CBT-E for individuals who experienced high levels of affective lability, which is thought to be indicative of emotion dysregulation (Accurso et al., 2016). Such findings are consistent with the tenets of this framework and suggest ICAT could be particularly effective in enhancing emotion regulation by de-coupling previously learned associations between high negative affect states and binge eating. Recently, ICAT has also been applied to the treatment of BED (Peterson et al., *in press*), which showed treatment outcomes for ICAT-BED were comparable to Cognitive Behavioral Therapy Guided Self-Help (CBTgsh; Fairburn, 2013). However, no studies have examined the extent to which momentary associations between affect and behavior change during ICAT.

Despite evidence indicating improved emotion regulation is an important mechanism of symptom change, methodological approaches have largely precluded nuanced examination of how temporal associations between affect and symptoms change over the course of treatment and whether individual differences in

these micro-level changes relate to macro-level outcomes. Investigating these temporal dynamics using person-specific analytic approaches would allow for a more precise assessment of these momentary processes and individual differences underlying behavior change. Although most ecological momentary assessment (EMA) studies apply multilevel modeling approaches that aggregate data across individuals to describe average dynamic patterns at the *group level* (e.g. the extent to which momentary negative affect generally predicts binge eating in a sample), person-specific approaches capture each *individual's* temporal dynamics based on his/her own time-series data (e.g. the extent to which momentary negative affect predicts binge eating for a particular person). In the context of BED, such an approach would shed light on how the strength of association between momentary negative affect and subsequent binge-eating symptoms decreases or de-couples during treatment, and whether *individuals* who evidence greater momentary de-coupling fare better over the course of treatment and at follow-up, perhaps as a result of increased capacity to employ adaptive emotion regulation skills.

The present study

To better understand hypothesized processes driving symptom change within ICAT-BED (i.e. de-coupling of negative affect and ED symptoms), we aimed to utilize multi-wave EMA data to assess (1) decrease in the association between momentary negative affect and subsequent binge-eating symptoms (i.e. de-coupling) over treatment, (2) differences in this de-coupling between treatment groups (i.e. ICAT-BED, which emphasizes emotion regulation skills, *v.* CBTgsh, which does not explicitly target emotion), and (3) the extent to which the magnitude of de-coupling is related to treatment outcomes. It was hypothesized that (1) the strength of the momentary association between negative affect and subsequent binge-eating symptoms would decrease during and after treatment; (2) there would be a stronger de-coupling effect in ICAT-BED compared to CBTgsh; and (3) lesser de-coupling would be associated with lesser improvement in treatment outcomes at end-of-treatment and follow-up. As an exploratory aim, we examined the potential that the association between de-coupling and treatment outcomes may differ across treatment groups.

Methods

Participants

Participants were drawn from an initial sample of 112 adults who met full criteria for DSM-5 BED (American Psychiatric Association, 2013). A priori exclusion criteria were: unable to read English; body mass index (BMI) < 21; lifetime history of psychotic symptoms or bipolar disorder; substance use disorder within 6 months of enrollment; medically or psychiatrically unstable (e.g. acute suicidality); purging behavior more than once per month for the previous 3 months; current diagnosis of BN; medical condition impacting eating or weight; the history of gastric bypass surgery; currently pregnant or lactating; currently receiving weight loss or ED treatment; use of medication impacting eating or weight; or psychotropic medication changes in the 6 weeks prior to enrollment.

The present study was limited to participants who completed the end-of-treatment EMA protocol given that analyses depended

on the calculation of change in momentary associations between baseline and end-of-treatment (see Statistical analyses). Due to attrition, this resulted in a final analytic sample of 78, the majority of whom identified as female (86.4%). The mean age of the sample was 40.01 ± 13.21 years (range: 18–64), and the mean BMI was 34.14 ± 8.69 kg/m² (range: 21.41–61.12). Most participants were non-Hispanic Caucasian (92.6%), with the remaining identifying as Hispanic (1.2%), Asian American (1.2%), or ‘Other’ (4.9%). The majority had completed at least a bachelor’s degree (54.3%), and the median household income was \$ 50 000–74 999.

Procedure

Participants were recruited from ED clinics, community advertisements, and social media postings at two sites in the Midwest United States. Following an eligibility screening, participants completed a baseline assessment comprised of semi-structured clinical interviews and a 7-day EMA.

After the baseline assessment, participants were randomized to ICAT-BED or CBTgsh. ICAT-BED (Wonderlich, Peterson, & Smith, 2015) consisted of 21, 50-min individual sessions occurring over 17 weeks. Treatment included four phases, which emphasized motivational enhancement, psychoeducation, and self-monitoring (Phase 1); meal planning and emotional awareness (Phase 2); identifying precipitants of negative affect, possible functionality of binge-eating behavior, and implementation of skills (Phase 3); and relapse prevention and healthy lifestyle planning (Phase 4). CBTgsh utilized ‘Overcoming Binge Eating’ (Fairburn, 2013), an empirically supported self-help intervention emphasizing consistent self-monitoring, the development of regular eating patterns, identification of alternative activities to avoid binge eating, problem-solving, and relapse prevention. Consistent with previous studies of CBTgsh (Wilson, Wilfley, Agras, & Bryson, 2010), participants attended ten individual sessions (one initial 60-min session and nine 30-min sessions) occurring over the course of 17 weeks. During these sessions, participants met with a non-ED specialist who provided support and encouraged participants to progress through the self-help book at their own pace. ICAT-BED was delivered by doctoral-level psychologists and graduate students who received an initial all-day didactic training along with weekly group clinical supervision. CBTgsh was delivered by master’s level clinicians who received a 2-h didactic training and weekly to biweekly group phone supervision. Supervision was provided by two authors with extensive experience delivering psychotherapy for EDs (authors S.A.W. and C.B.P.) to ensure treatment fidelity. At end-of-treatment and 6-month follow-up, participants again completed 7-day periods of EMA and outcome assessments. Institutional review board approval was obtained at each site.

Measures

The eating disorder examination 16.0 (EDE)

The EDE (Fairburn, 2008; Fairburn & Cooper, 1993) is a semi-structured interview that was administered at pre-treatment, end-of-treatment, and follow-up by trained assessors to evaluate BED diagnoses and ED symptoms. In the present study, cognitive symptoms were assessed as the EDE Global score, which comprised four symptom domains (i.e. restraint, eating concern, shape concern, and weight concern), while behavioral symptoms were operationalized as the frequency of objective binge episodes (OBEs) over the past 28 days. Reliability across assessors was

excellent for diagnoses (κ coefficient = 1.0); intraclass correlation coefficients (ICCs) for the EDE scales were also excellent (ICC = 0.84–0.98).

EMA measures

Each EMA protocol utilized both signal and interval contingent recordings (Wheeler & Reis, 1991). Specifically, participants were prompted to complete assessments throughout the day in response to five semi-random signals, which were distributed around five anchor points between 8 am and 10 pm. In addition, participants completed a final assessment at the end of the day (i.e. bedtime). For each recording, participants were asked to rate their current mood and to report any eating behaviors that had not yet been recorded.

Binge-eating behavior. Participants indicated the extent to which each recorded eating episode was characterized by overeating and loss of control over eating using a Likert-type scale ranging from 1 (*not at all*) to 5 (*extremely*). To assess overeating, participants rated the items: (a) ‘To what extent do you feel that you overate?’, and (b) ‘To what extent do you feel that you ate an excessive amount of food?’. To assess the loss of control, participants rated the following questions: (a) ‘While you were eating, to what extent did you feel a sense of loss of control?’, (b) ‘While you were eating, to what extent did you feel that you could not resist eating?’, (c) ‘While you were eating, to what extent did you feel that you could not stop eating once you had started?’, and (d) ‘While you were eating, to what extent did you feel driven or compelled to eat?’. The overeating and loss of control items were averaged ($\alpha = 0.83$ and 0.93 , respectively) and summed together to provide an index of binge-eating symptoms at each eating episode.

Negative affect. The five-item Negative Affect subscale of the International Positive and Negative Affect Schedule Short Form (I-PANAS-SF; Thompson, 2007) was used to measure momentary negative affect. At each recording, participants rated the degree to which they were currently experiencing each of the five affective states (afraid, nervous, upset, ashamed, and hostile) on a scale ranging from 1 (*not at all*) to 5 (*extremely*). The internal consistency for the negative affect subscale was 0.80.

Statistical analyses

Person-specific changes in momentary negative affect – binge-eating associations

Analyses were based on available data without imputation. To derive person-specific estimates of the momentary association between negative affect and subsequent binge-eating symptoms, momentary negative affect scores were first grand-mean and person-mean centered within each EMA wave (pre-treatment, end-of-treatment, follow-up). That is, grand-mean centered variables reflect the degree to which an individual’s average level of a variable differs from the sample mean (i.e. between-person effect), whereas person-mean centered variables reflect the degree to which an individual’s momentary level of a variable differs from his/her own average level of that variable (i.e. within-person effect). To establish temporal relationships between momentary negative affect and binge eating, the within-person negative affect ratings were utilized, which were lagged from the prior EMA signal but not lagged across persons or days. That is, the lagged negative affect ratings (time $t-1$) reflect the intensity of momentary negative affect (relative to an individual’s own average) that occurred before eating episodes (time t) reported on the same

day. Then, separate random coefficients models were conducted at each EMA wave using PROC MIXED (SAS 9.4) to extract person-specific regression coefficients, which reflected the within-person association between lagged negative affect ratings (person-mean centered) and subsequent binge-eating symptoms. Each model included a single fixed effect of negative affect and random effects on the intercept and negative affect slope, which indicated the deviation from the overall intercept and slope for each participant. The person-specific deviations were then used to calculate each participant's intercept and slope values at each EMA wave, and the negative affect slope values were saved for subsequent analyses (i.e. higher individual slope values reflected stronger associations between momentary negative affect and subsequent binge-eating symptoms).

Aims 1–2

A repeated measures general linear model was conducted to assess changes in the association between momentary negative affect and binge-eating symptoms (i.e. changes in negative affect slope values; Aim 1) and differences in these changes across ICAT-BED and CBTgsh (Aim 2). The model included time (pre-treatment, end-of-treatment, follow-up) as a within-subjects factor, group (ICAT-BED *v.* CBTgsh) as a between-subjects factor and their interaction.

Aim 3

To assess the degree to which the magnitude of de-coupling of momentary negative affect and binge-eating symptoms predicted treatment outcomes, the residual change in negative affect slope indices from pre-treatment to end-of-treatment was calculated, with *higher* values indicating *lesser* declines (i.e. less de-coupling) between pre-treatment and end-of-treatment. Residual change was calculated rather than a raw change score given that pre-post change scores are highly correlated with baseline levels. Next, generalized linear models were conducted to examine each participant's residual change as a predictor of EDE Global scores and OBE frequency at end-of-treatment and follow-up, controlling for pre-treatment EDE Global score and OBE frequency, respectively. Models examining EDE Global scores used a gamma link function, and models examining OBE frequency employed a negative binomial function in order to account for skewed distributions of these continuous and count variables, respectively. Models also adjusted for age, BMI and treatment group. Last, to examine the exploratory aim, we added the interaction between the treatment group and residual change scores to models. Analyses were conducted using SPSS 25 and SAS 9.4.

Results

EMA data and compliance

The average number of signals completed per person during each EMA period demonstrated adequate compliance to the protocol [pre-treatment: $M = 30.28 \pm 8.77$ signals/person (68.9% including eating episode reports); end of treatment: $M = 25.99 \pm 8.39$ signals/person (68.4% including eating episode reports); follow-up: $M = 27.52 \pm 8.48$ signals/person (66.0% including eating episode reports)]. Descriptive statistics for variables across assessments are shown in Table 1.

Table 1. Descriptive statistics

	Pre-treatment			End-of-treatment			Follow-up					
	Mean	SD	Minimum	Maximum	Mean	SD	Minimum	Maximum	Mean	SD	Minimum	Maximum
Negative affect	1.51	0.47	1.01	3.58	1.33	0.39	1.00	3.04	1.34	0.40	1.00	2.98
Loss of control eating	2.60	0.82	1.13	4.55	1.76	0.67	1.00	3.75	1.87	0.74	1.00	3.81
Overeating	2.36	0.76	1.03	4.80	1.67	0.52	1.00	3.44	1.76	0.56	1.00	3.76
Binge-eating	4.96	1.49	2.38	9.35	3.43	1.14	2.00	7.16	3.63	1.23	2.00	6.95
EDE Global	2.65	0.83	0.28	4.29	0.68	0.82	0.00	3.60	1.46	0.82	0.06	4.06
EDE OBE	15.80	10.78	3.00	53.00	1.22	3.07	0.00	19.00	2.18	4.51	0.00	28.00
Negative affect slope	0.19	0.04	0.11	0.31	0.27	0.24	-0.09	1.19	-0.06	0.29	-0.83	0.33

EDE, Eating Disorder Examination.

Note. Binge-eating reflects the sum of the loss of control eating and overeating composites.

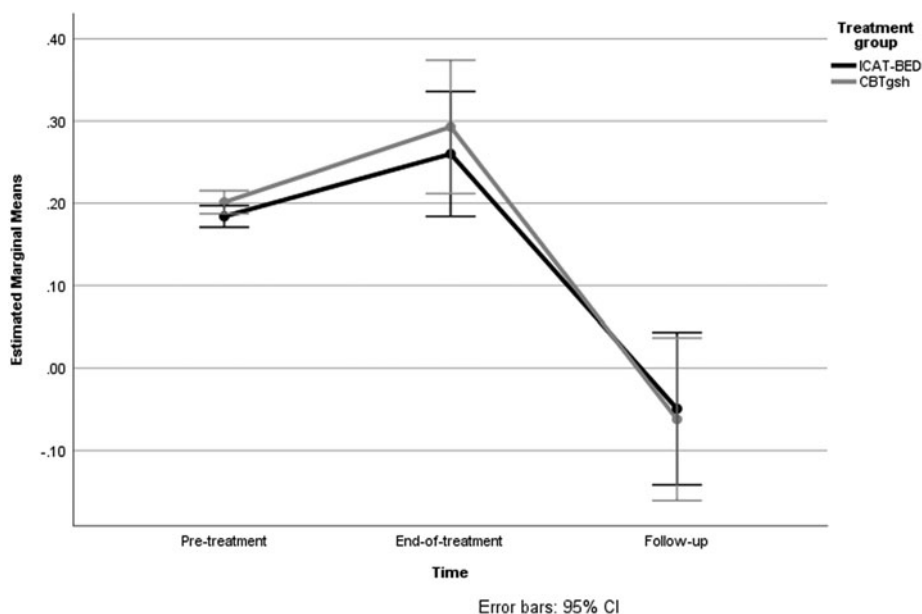


Fig. 1. Estimated marginal means of individuals' slope of negative affect at pre-treatment, end-of-treatment, and follow-up.

Aims 1-2

Results of the repeated measures general linear model indicated a significant effect of time, $F_{(2)} = 38.69$, $p < 0.001$, but no significant effect of group, $F_{(1)} = .28$, $p = 0.598$, or time \times group interaction, $F_{(2)} = 0.18$, $p = 0.830$. As depicted in Fig. 1, pairwise comparisons showed that across groups, there were significant increases in the negative affect slope from pre-treatment to end-of-treatment ($p = 0.003$), followed by significant decreases at follow-up, such that the slope at follow-up was lower compared to pre-treatment and end-of-treatment levels ($ps < 0.001$). Thus, while there were initial increases in the strength of association between momentary negative affect and binge-eating symptoms, the magnitude of this association dropped below pre-treatment levels by the 6-month follow-up, in partial support of the Aim 1 hypothesis. In contrast, the lack of interaction with the group did not support the Aim 2 hypothesis, in that the magnitude of de-coupling did not significantly differ by treatment type.

Exploratory analyses

As exploratory analyses, we also examined the degree to which starting slope values may have impacted the degree of de-coupling within each treatment. To do so, we categorized participants into groups based on treatment condition and quartiles of pre-treatment slope values (ICAT-BED quartile 1-4; CBTgsh quartile 1-4). We then re-ran the repeated measures ANOVA described in Aim 2 using this revised grouping (see details in online supplementary material). Results revealed those with the highest pre-treatment slope values (4th quartile subgroups, reflecting stronger negative-affect binge-eating associations) appeared to experience increases in the coupling of negative affect and binge eating at the end of treatment, yet steeper declines by follow-up. However, the differences between the ICAT-BED and CBT 4th quartile subgroups were minimal across timepoints. Thus, it does not appear that those with higher starting slopes who received ICAT-BED necessarily experienced greater de-coupling compared to those with higher starting slopes who received CBTgsh.

Aim 3

As shown in Table 2, generalized linear model results indicated that less de-coupling (i.e. more positive residual change values) was associated with higher EDE Global scores at end-of-treatment ($B = 0.48$, $s.e. = 0.24$, $p = 0.046$) and higher OBE frequencies at follow-up ($B = 1.55$, $s.e. = 0.59$, $p = 0.008$), controlling for age, BMI, treatment group, and pre-treatment levels of outcome variables. There were no significant effects of residual change scores for EDE Global at follow-up or OBE frequency at end-of-treatment. When the interactions between the treatment group and residual change scores were added to the models, no significant effects emerged for EDE Global scores or OBE frequency at end-of-treatment or follow-up ($ps = 0.303-0.877$); therefore, the more parsimonious models without these terms are presented in Table 2.

Discussion

The current study used a person-specific modeling approach to investigate whether this association was de-coupled, or weakened, following two specific BED treatments. Specifically, the magnitude of changes in the micro-level (momentary) association between negative affect and subsequent binge-eating symptoms was calculated for each individual and then used as a predictor of macro-level treatment outcomes. Consistent with expectations, there was a significant decrease or 'de-coupling' effect at follow-up across the sample, such that the momentary association between negative affect and binge-eating symptoms was significantly weaker compared to pre-treatment and end-of-treatment; however, contrary to hypotheses, the magnitude of this change did not significantly differ between ICAT-BED and CBTgsh. Furthermore, across treatment groups, individuals who experienced less de-coupling between pre-treatment and end-of-treatment evidenced lesser improvement in cognitive ED symptoms (as indexed by the EDE Global score) at end-of-treatment and lesser improvement in binge-eating frequency at follow-up. Together, these findings illustrate how

Table 2. Generalized linear models examining the de-coupling of associations between negative affect and binge-eating as predictors of treatment outcomes

Outcome: EDE-G	End-of-treatment						Follow-up					
	<i>B</i>	S.E.	95% CI		Wald χ^2	<i>p</i>	<i>B</i>	S.E.	95% CI		Wald χ^2	<i>p</i>
			Lower	Upper					Lower	Upper		
Intercept	-1.15	0.32	-1.78	-0.52	12.90	<0.001	-1.50	0.40	-2.29	-0.71	13.79	<0.001
EDE-G (pre-treatment)	0.18	0.07	0.05	0.31	7.01	0.008	0.29	0.08	0.14	0.45	13.59	<0.001
Age	0.01	0.00	0.00	0.02	5.86	0.015	0.01	<0.01	<0.01	0.02	7.10	0.008
BMI	0.02	0.01	0.01	0.03	7.97	0.005	0.02	0.01	<0.01	0.03	5.10	0.024
Treatment group	0.05	0.11	-0.16	0.27	0.26	0.610	-0.05	0.13	-0.30	0.20	0.15	0.703
NA slope change	0.48	0.24	0.01	0.95	4.00	0.046	0.38	0.28	-0.18	0.93	1.76	0.184
Outcome: EDE OBE												
Intercept	0.63	0.87	-1.08	2.34	0.52	0.471	-1.69	0.76	-3.18	-0.21	4.98	0.026
EDE OBE (pre-treatment)	<0.01	0.02	-0.03	0.04	0.06	0.809	0.03	0.02	-0.01	0.07	2.70	0.100
Age	0.03	0.01	0.01	0.05	6.78	0.009	0.03	0.01	0.01	0.05	7.58	0.006
BMI	-0.06	0.02	-0.11	-0.02	8.59	0.003	0.01	0.02	-0.02	0.05	0.63	0.428
Treatment group	0.52	0.34	-0.15	1.19	2.34	0.126	0.07	0.36	-0.63	0.78	0.04	0.843
NA slope change	0.02	0.68	-1.31	1.36	<0.01	0.971	1.55	0.59	0.40	2.70	6.95	0.008

EDE, Eating Disorder Examination; EDE-G, Global score; OBE, objective binge-eating frequency over the past 28 days; BMI, body mass index; NA slope change, residual change in the slope of momentary negative affect predicting binge eating from pre-treatment to end-of-treatment (higher score = less decline in slope).

Bold values indicate $p < 0.05$.

Note: Treatment group was coded such that ICAT-BED was the reference category.

changes in micro-temporal dynamics are linked to macro-level symptom change and further highlight the need to account for individual variability in momentary processes.

While the overall de-coupling effect was consistent with hypotheses, it was notable that this effect emerged only at follow-up, and that the momentary association between negative affect and binge-eating symptoms strengthened somewhat between pre-treatment and end-of-treatment. These findings are nevertheless consistent with prior EMA research in EDs (Haedt-Matt & Keel, 2011) and suggest that heightened negative affect remains a proximal predictor of binge eating at the end-of-treatment in BED. That is, although the primary outcome study showed that individuals' binge eating and negative affect generally decreased over the course of treatment (see Peterson *et al.*, *in press*), when individuals experienced states of high negative affect, albeit less frequently overall, they were more likely to report subsequent binge-eating symptoms. It is possible that both treatments may have facilitated increased emotional awareness and clarity, particularly with respect to affective states that trigger binge eating. This is supported by the broader literature showing lower levels of emotional awareness and clarity among individuals with EDs (Lavender *et al.*, 2015), as well as research from this sample and other studies indicating that emotion regulation improves over the course of ED treatments such as ICAT and CBT (Bodell *et al.*, 2019; Peterson *et al.*, 2019; Wonderlich *et al.*, 2014). This may have resulted in response bias in the present study. That is, compared to the pre-treatment EMA, during the end of treatment EMA participants may have more accurately reported the type and intensity of their negative affective states. This could lead to greater consistency in high negative affect ratings occurring prior to binge eating, contributing to an apparent increase in coupling. However, these interpretations are speculative and should be considered tentative until further replication in other samples. Further, it is also possible that there is an increased coupling between negative affect and more adaptive coping over the course of treatment, which would be useful to explore in future studies.

Despite this unexpected finding, there was a significant de-coupling effect by follow-up, indicating that states of high negative affect less reliably predicted subsequent binge-eating symptoms. In line with the tenets of third-wave therapies, it may be that individuals were able to more adaptively cope with aversive emotional states following treatment, and were thus less likely to resort to binge eating in the face of heightened negative affect. While it is unclear why there was a delay in this effect, one possibility is that the initial decreases in symptoms experienced at end-of-treatment facilitated continued improvements and skill acquisition and utilization over the course of follow-up.

Although such findings would ostensibly support the use of interventions that target negative affect and emotion dysregulation to reduce binge eating, it was unexpected that there were no differences between ICAT-BED and CBTgsh groups in the magnitude of de-coupling of negative affect and binge-eating symptoms. One of the main goals of ICAT-BED is to target momentary affective processes that precipitate binge eating by helping patients use adaptive emotion regulation skills (Wonderlich *et al.*, 2015). However, these results indicate that CBTgsh is associated with a similar degree of decoupling. This is somewhat consistent with the previous treatment trial comparing ICAT to CBT for BN, which found improvements in emotion regulation were linked to ED symptom improvement across both treatments (Peterson *et al.*, 2017). It could also be that a more

potent dose of treatment would be needed to observe reliable differences in decoupling during treatment.

It is therefore important to consider other potential mechanisms driving de-coupling across both ICAT-BED and CBTgsh. Both ICAT-BED and CBTgsh are integrative treatments share a common focus on planning and self-monitoring, regular eating, and relapse prevention, and these components may similarly contribute to the de-coupling effect in each treatment. For example, by increasing eating consistency and self-regulatory strategies via self-monitoring, individuals in both treatments may have increased their ability to abstain from binge-eating symptoms when experiencing heightened negative affect. Another possible mechanism that is posited to contribute to health behavior change and which is particularly relevant for eating behavior is that of habit processes (Gardner, 2015; van Riet, Sijtsema, Dagevos, & de Bruijn, 2011). For instance, both ICAT-BED and CBTgsh include components that may have effectively targeted learned stimulus-response associations via altering situational cues (e.g. negative affective states) and inhibiting habitual binge-eating responses to such cues (e.g. identifying alternatives that are incompatible with binge eating).

Lastly, and perhaps most importantly, *individuals* who evidenced less de-coupling by end-of-treatment experienced less improvement in symptoms at the end-of-treatment and follow-up. Juxtaposed with the trend in group-level changes in negative affect slope values, these results underscore the utility of examining individual differences in micro-temporal changes. That is, averaging time series data can fail to capture meaningful symptom dynamics at the person-level. It may be that lesser de-coupling was an indirect indicator of broader emotion regulation problems, such that individuals experiencing less change in the association between negative affect and binge-eating symptoms lacked or had difficulty implementing effective strategies to manage aversive emotions. Consequently, such individuals may be likely to continue to resort to binge eating when experiencing negative affect, which in turn could impede longer-term improvement in symptoms.

The finding that individuals' change in momentary affect-behavior associations was linked to cognitive change (i.e. cognitive restraint and concerns about eating, weight, and shape, as measured by the EDE Global score) is notable, although directionality cannot be inferred given that these changes were observed concurrently between pre-treatment and end-of-treatment. Nevertheless, research has shown positive associations between implicit and explicit emotion dysregulation and EDE scores in BED (e.g. Robinson, Safer, Austin, and Etkin, 2015), and that emotion dysregulation prospectively predicts higher EDE Global scores in other EDs (Racine & Wildes, 2015). Together this suggests maladaptive regulation of affect is an important factor maintaining cognitive ED symptoms such as preoccupation with weight and shape. This may account for why individuals who evidenced more consistent associations between negative affect and binge-eating symptoms during treatment (i.e. less de-coupling, perhaps reflecting greater emotion regulation difficulties) experienced less concomitant improvement in ED-related cognitions.

Although individuals' degree of de-coupling was associated with the change in EDE Global scores at end-of-treatment, the most durable effect was observed at follow-up with respect to OBE frequency. This finding is consistent with the possibility that individuals with BED who learn to effectively implement adaptive coping skills and/or disrupt habitual cue-response associations (i.e. negative affect-binge eating) at the momentary level

are less likely to engage in binge eating over time. Conversely, greater consistency in the strength of the relationship between negative affect and binge-eating symptoms was prospectively associated with higher OBE frequency, suggesting that a lack of de-coupling may contribute to the maintenance of binge-eating behavior and perhaps increase relapse risk. It would, therefore, be useful for future research to explore internal and external factors that influence changes in momentary affect-behavior associations.

Limitations

Despite several strengths of the study (e.g. multi-wave EMA across the delivery of two empirically supported therapies, use of well-validated measures and therapy protocols, and use of a novel statistical approach), there are notable limitations. The treatments varied in length considerably, which was intentional to test a new treatment with the current standard treatment. In addition, only signal-contingent EMA recording was used in this study, which may have resulted in missing binge-eating episodes. However, missing data are also a problem with an event-contingent recording (i.e. having participants complete surveys when a binge-eating episode occurs; see Smyth et al., 2007), and the use of event-contingent recordings may increase participant burden. Further, the 1-week protocol may have reduced the ability to capture all relevant data points and eating behaviors. The study also did not include a non-treatment control group, and thus it is unclear the extent to which decoupling of negative affect and binge-eating symptoms was specifically due to treatment-related processes or other factors (e.g. passage of time and regression to the mean). Finally, the sample was rather homogeneous with regard to race, ethnicity, and sexual orientation, limiting the generalizability of the study findings to other groups.

Conclusions and future directions

Despite these limitations, findings provide novel insights into the association between micro- and macro-level processes underlying symptom change in BED treatment. Both of the therapies examined were associated with de-coupling of momentary affect-behavior associations in daily life, which is a meaningful clinical target in ED populations. Moreover, the magnitude of individuals' de-coupling was linked to treatment outcomes. As implied by affect regulation frameworks, this study lends further evidence that the micro-temporal association between affect and binge eating is an important mechanism to target in order to reduce symptoms and relapse risk. These data also demonstrate the utility of applying statistical approaches that can provide a more nuanced understanding of person-specific symptom dynamics, in line with precision medicine initiatives to develop personalized interventions (Kan, Cardi, Stahl, & Treasure, 2019). In addition, it is crucial to develop novel interventions that may help to more effectively de-couple negative affect and binge eating, as group-level effects were only observed at follow-up. One emerging type of intervention is technology-enhanced interventions that intervene on momentary processes in patients' daily life (e.g. just-in-time adaptive interventions; Juarascio, Parker, Lagacey, and Godfrey, 2018). In light of the suboptimal outcomes seen in BED (Linardon, 2018), going forward it will be important to explore such approaches and integrate person-specific assessments to enhance outcomes, prevent relapse, and minimize patient cost and burden.

Supplementary material. The supplementary material for this article can be found at <https://doi.org/10.1017/S0033291720001804>

Acknowledgements. This research was supported by the National Institute of Mental Health (C.B.P., grant number R34MH099040-01A1; S.A.W., grant number R34MH098995; L.M.A. and V.M.H., grant number T32MH082761).

Conflict of interest. None.

Ethical standards. The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

References

- Accurso, E. C., Wonderlich, S. A., Crosby, R. D., Smith, T. L., Klein, M. H., Mitchell, J. E., ... Peterson, C. B. (2016). Predictors and moderators of treatment outcome in a randomized clinical trial for adults with symptoms of bulimia nervosa. *Journal of Consulting and Clinical Psychology, 84*(2), 178. doi: 10.1037/ccp0000073
- American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Washington, DC: Author.
- Berg, K. C., & Wonderlich, S. A. (2013). Emerging psychological treatments in the field of eating disorders. *Current Psychiatry Reports, 15*(11), 407. doi: 10.1007/s11920-013-0407-y
- Bodell, L. P., Pearson, C. M., Smith, K. E., Cao, L., Crosby, R. D., Peterson, C. B., ... Berg, K. C. (2019). Longitudinal associations between emotion regulation skills, negative affect, and eating disorder symptoms in a clinical sample of individuals with binge eating. *Eating Behaviors, 32*, 69–73.
- Fairburn, C. G. (2008). *Cognitive behavior therapy and eating disorders*. New York: Guilford Press.
- Fairburn, C. G. (2013). *Overcoming binge eating: The proven program to learn why you binge and how you can stop* (2nd ed.). New York, NY: Guilford Press.
- Fairburn, C., & Cooper, Z. (1993). The eating disorder examination. In C. G. Fairburn & G. T. Wilson (Eds.), *Binge eating: Nature, assessment, and treatment* (pp. 317–360). New York, NY: Guilford Press.
- Gardner, B. (2015). A review and analysis of the use of 'habit' in understanding, predicting and influencing health-related behaviour. *Health Psychology Review, 9*(3), 277–295.
- Gratz, K. L., Bardeen, J. R., Levy, R., Dixon-Gordon, K. L., & Tull, M. T. (2015). Mechanisms of change in an emotion regulation group therapy for deliberate self-harm among women with borderline personality disorder. *Behavior Research and Therapy, 65*, 29–35. doi: 10.1016/j.brat.2014.12.005
- Gratz, K. L., & Tull, M. T. (2010). Emotion regulation as a mechanism of change in acceptance- and mindfulness-based treatments. Assessing mindfulness and acceptance processes in clients: Illuminating the theory and practice of change, pp. 107–133.
- Grilo, C. M. (2017). Psychological and behavioral treatments for binge-eating disorder. *The Journal of Clinical Psychiatry, 78*, 20–24. doi: 10.4088/JCP.sh16003su1c.04
- Haedt-Matt, A. A., & Keel, P. K. (2011). Revisiting the affect regulation model of binge eating: A meta-analysis of studies using ecological momentary assessment. *Psychological Bulletin, 137*(4), 660. doi: 10.1037/a0023660
- Hayes, S. C., Villatte, M., Levin, M., & Hildebrandt, M. (2011). Open, aware, and active: Contextual approaches as an emerging trend in the behavioral and cognitive therapies. *Annual Review of Clinical Psychology, 7*, 141–168. doi: 10.1146/annurev-clinpsy-032210-104449
- Heatherton, T. F., & Baumeister, R. F. (1991). Binge eating as escape from self-awareness. *Psychological Bulletin, 110*(1), 86–108.
- Juarascio, A. S., Parker, M. N., Lagacey, M. A., & Godfrey, K. M. (2018). Just-in-time adaptive interventions: A novel approach for enhancing skill utilization and acquisition in cognitive behavioral therapy for eating disorders. *International Journal of Eating Disorders, 51*(8), 826–830. doi: 10.1002/eat.22924

- Kahl, K. G., Winter, L., & Schweiger, U. (2012). The third wave of cognitive behavioural therapies: What is new and what is effective? *Current Opinion in Psychiatry*, 25(6), 522–528. doi: 10.1097/YCO.0b013e328358e531
- Kan, C., Cardi, V., Stahl, D., & Treasure, J. (2019). Precision psychiatry—what it means for eating disorders? *European Eating Disorders Review*, 27(1), 3–7. doi: 10.1002/erv.2651
- Lavender, J. M., Wonderlich, S. A., Engel, S. G., Gordon, K. H., Kaye, W. H., & Mitchell, J. E. (2015). Dimensions of emotion dysregulation in anorexia nervosa and bulimia nervosa: A conceptual review of the empirical literature. *Clinical Psychology Review*, 40, 111–122. doi: 10.1016/j.cpr.2015.05.010
- Leehr, E. J., Krohmer, K., Schag, K., Dresler, T., Zipfel, S., & Giel, K. E. (2015). Emotion regulation model in binge eating disorder and obesity—a systematic review. *Neuroscience & Biobehavioral Reviews*, 49, 125–134.
- Linardon, J. (2018). Rates of abstinence following psychological or behavioral treatments for binge-eating disorder: Meta-analysis. *International Journal of Eating Disorders*, 51(8), 785–797. doi: 10.1002/eat.22897
- Linardon, J., Gleeson, J., Yap, K., Murphy, K., & Brennan, L. (2019). Meta-analysis of the effects of third-wave behavioural interventions on disordered eating and body image concerns: Implications for eating disorder prevention. *Cognitive Behavior Therapy*, 48(1), 15–38. doi: 10.1080/16506073.2018.1517389.
- Mennin, D. S., & Fresco, D. M. (2010). Emotion regulation as an integrative framework for understanding and treating psychopathology. In A. M. Kring, & D. M. Sloan (Eds.), *Emotion regulation and psychopathology: A transdiagnostic approach to etiology and treatment* (pp. 356–379). The Guilford Press.
- Mitchell, J. E. (2016). Medical comorbidity and medical complications associated with binge-eating disorder. *International Journal of Eating Disorders*, 49(3), 319–323. doi: 10.1002/eat.22452
- Peterson, C. B., Berg, K. C., Crosby, R. D., Lavender, J. M., Accurso, E. C., Ciao, A. C., ... Wonderlich, S. A. (2017). The effects of psychotherapy treatment on outcome in bulimia nervosa: Examining indirect effects through emotion regulation, self-directed behavior, and self-discrepancy within the mediation model. *International Journal of Eating Disorders*, 50(6), 636–647. doi: 10.1002/eat.22669
- Peterson, C., Engel, S., Crosby, R. D., Crow, S., Smith T., Klein, M., ... Wonderlich, S.A. (2019, September). A randomized comparison of ICAT-BED and CBT-GSH to treat binge eating disorder using standard and naturalistic momentary outcome measures. Paper presented at the Annual Meeting of the Eating Disorders Research Society, Chicago, IL.
- Peterson, C. B., Engel, S. G., Crosby, R. D., Strauman, T., Smith, T. L., Klein, M., ... Wonderlich, S. A. (in press). Comparing Integrative Cognitive-Affective Therapy and guided selfhelp cognitive-behavioral therapy to treat binge eating disorder using standard and naturalistic momentary outcome measures: A randomized controlled trial. *International Journal of Eating Disorders*.
- Racine, S. E., & Wildes, J. E. (2015). Dynamic longitudinal relations between emotion regulation difficulties and anorexia nervosa symptoms over the year following intensive treatment. *Journal of Consulting and Clinical Psychology*, 83(4), 785. doi: 10.1037/ccp0000011
- Robinson, A., Safer, D. L., Austin, J. L., & Etkin, A. (2015). Does implicit emotion regulation in binge eating disorder matter? *Eating Behaviors*, 18, 186–191. doi: 10.1016/j.eatbeh.2015.05.011
- Slee, N., Spinhoven, P., Garnefski, N., & Arensman, E. (2008). Emotion regulation as mediator of treatment outcome in therapy for deliberate self-harm. *Clinical Psychology & Psychotherapy*, 15(4), 205–216. doi: 10.1002/cpp.577
- Smyth, J. M., Wonderlich, S. A., Heron, K. E., Sliwinski, M. J., Crosby, R. D., Mitchell, J. E., & Engel, S. G. (2007). Daily and momentary mood and stress are associated with binge eating and vomiting in bulimia nervosa patients in the natural environment. *Journal of Consulting and Clinical Psychology*, 75(4), 629.
- Stice, E. (2002). Risk and maintenance factors for eating pathology: A meta-analytic review. *Psychological Bulletin*, 128(5), 825. doi: 10.1037/0033-2909.128.5.825
- Thompson, E. R. (2007). Development and validation of an internationally reliable short-form of the Positive and Negative Affect Schedule (PANAS). *Journal of Cross-Cultural Psychology*, 38(2), 227–242. doi: 10.1177/0022022106297301
- Van Riet, J., Sijtsema, S. J., Dagevos, H., & De Bruijn, G. J. (2011). The importance of habits in eating behaviour. An overview and recommendations for future research. *Appetite*, 57(3), 585–596.
- Wheeler, L., & Reis, H. T. (1991). Self-recording of everyday life events: Origins, types, and uses. *Journal of Personality*, 59, 339–354. doi: 10.1111/j.1467-6494.1991.tb00252.x
- Wilson, G. T., Wilfley, D. E., Agras, W. S., & Bryson, S. W. (2010). Psychological treatments of binge eating disorder. *Archives of General Psychiatry*, 67, 94–101. doi: 10.1001/archgenpsychiatry.2009.170
- Wonderlich, S. A., Peterson, C. B., Crosby, R. D., Smith, T. L., Klein, M. H., Mitchell, J. E., & Crow, S. J. (2014). A randomized controlled comparison of integrative cognitive-affective therapy (ICAT) and enhanced cognitive-behavioral therapy (CBT-E) for bulimia nervosa. *Psychological Medicine*, 44(3), 543–553. doi: 10.1017/S0033291713001098
- Wonderlich, S. A., Peterson, C. B., & Smith, T. L. (2015). *Integrative cognitive-affective therapy for bulimia nervosa: A treatment manual*. New York: Guilford Publications.