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The Role of Affective Instability in Loss of Control Eating in Youth with Overweight/Obesity Across Development: Findings from Two EMA Studies

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Keywords: emotion, eating disorders, adolescence

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Abstract

Affective instability is common during adolescence, but at high levels it is associated with a variety of internalizing and externalizing disorders, including eating disorders. Although most models focus on affective intensity as a mechanism for explaining eating disorders in adults, affective instability may be more developmentally relevant at predicting eating behaviors in youth. Using ecological momentary assessment, this manuscript explored the association between loss of control over eating (LOC), a key component of dysregulated eating in youth, and affective instability in youth with overweight/obesity in two separate studies, one with youth in middle childhood and early adolescence (Study 1: ages eight to 13) and one in youth in early through middle adolescence (Study 2: ages 12-17). Overall, there was no association between affective instability and LOC in Study 1, but in Study 2, age moderated the association between positive affective instability and LOC, such that greater between-person positive affective instability (i.e., relative to peers) was associated with lower average LOC for youth earlier in adolescence and higher average LOC for those later in adolescence. Negative affective instability was also associated with LOC in Study 2, such that on days when youth reported less within-person negative affective instability (i.e., relative to their own average), they also reported greater average LOC. Findings across the two studies indicate that the association between affective instability and LOC may not emerge until adolescence, and when it does, both positive and negative affective instability may be important to consider.

Keywords: emotion regulation, eating disorders, adolescence

Emotion dysregulation is a risk factor for the development of psychopathology during adolescence (Gilbert, 2012). Although adolescents experience dynamic emotional shifts throughout the day in response to salient stimuli, experiencing high levels of affective instability may be problematic over time (Heller & Casey, 2016). Affective intensity can be described as the absolute strength of an emotional experience, while affective instability represents acute and marked fluctuation in affective intensity, which may include fluctuation in positive affect (PA) or negative affect (NA) (Renaud & Zacchia, 2013). Although affective instability has been traditionally thought of as a hallmark feature of borderline personality disorder (BPD) (Domes et al., 2009), and an important prognostic marker for youth at risk for developing bipolar disorder (Howes et al., 2011), a growing body of research indicates that it may also be relevant for youth with a variety of other conditions, from depression (Silk et al., 2011) to oppositional defiant disorder (Becker et al., 2006). However, despite both theoretical and empirical evidence demonstrating a link between emotion dysregulation and the development of eating disorders (Fairburn et al., 2003), affective instability has gone largely unstudied in youth with disordered eating. Nevertheless, recent evidence suggests that affective instability may be salient to youth who report experiencing a loss of control (LOC) over their eating (Egbert et al., 2020).

LOC is defined as the experience of not being able to control what one is eating or to be able to stop eating (Tanofsky-Kraff et al., 2020). It is a central component of binge-eating disorder and bulimia nervosa (American Psychiatric Association, 2013). Although both bulimia nervosa and binge-eating disorder often manifest during young adulthood (i.e., the average age of onset for bulimia nervosa is 18 and for binge-eating disorder is after age 20) (Mussell et al., 1995; Volpe et al., 2016), youth as early as age eight report experiencing LOC, regardless of the objective amount of food consumed (Tanofsky-Kraff et al., 2005). LOC occurs in approximately

23% of youth across the weight spectrum, one-third of youth with obesity (He et al., 2017; Schlüter et al., 2016), and 50% of youth in treatment for obesity (Glasofer et al., 2007). LOC is associated with decreased quality of life, increased depressive symptoms, and higher levels of interpersonal problems (see Goldschmidt, 2017 for a review). Empirical studies have validated the importance of LOC in youth, regardless of episode size, demonstrating that LOC is associated with increased risk for developing a full-threshold eating disorder in the future (Hilbert, Hartmann, et al., 2013; Tanofsky-Kraff et al., 2011).

Much of the current research on LOC and affect has focused on the importance of NA intensity. Drawn from adult models, a widely accepted theory explaining LOC is the affect regulation model, which asserts that binge eating, and by extension LOC, may occur as a way to modulate NA (Polivy & Herman, 1993). Although the adult literature suggests that, across eating disorder diagnoses, binge eating is preceded by higher levels of NA intensity than seen prior to normal eating episodes (see Haedt-Matt & Keel, 2011 for a review) which may decrease after the binge eating episode is complete (Berg et al., 2017), ecological momentary assessment (EMA) research in youth suggests that these momentary associations may not yet be present. EMA is an ideal mechanism for the study of both emotion and eating behaviors because it minimizes reliance on retrospective recall and allows for reporting in near real-time. Additionally, by taking many repeated measurements each day, EMA captures both between-person differences in affective states (i.e., how does one person's affective state differ overall in comparison to their peers) and within-person differences (i.e., how does the same person differ at a particular moment in time in comparison with their own average level of emotion. Of the three studies to date that have examined the association between emotion and LOC in youth using EMA, all have found that momentary NA intensity is no higher in the context of LOC episodes as compared

with regular eating episodes or no higher in youth with LOC than in youth without LOC, whether between- or within-person differences were considered (Goldschmidt et al., 2018; Hilbert et al., 2009; Ranzenhofer et al., 2014). These studies have examined youth from middle childhood and early adolescence (i.e., ages 10-14) to middle adolescence (i.e., ages 15-17), with obesity and across the weight spectrum (Goldschmidt et al., 2018; Hilbert et al., 2009; Ranzenhofer et al., 2014).

Despite the lack of evidence from EMA studies, both laboratory and traditional retrospective studies indicate that non-overweight youth with LOC, ranging in age from six to 17, experience overall higher levels of NA than their peers without LOC (Shomaker et al., 2010), specifically experience higher levels of NA than their peers prior to eating a test meal (Vannucci et al., 2013), and that youth across the weight spectrum, including those seeking weight loss treatment, report NA prior to LOC episodes (Tanofsky-Kraff et al., 2007). Therefore, NA appears to be an important component of LOC in youth and there may be different processes occurring in the moment that influence absolute ratings of NA in EMA studies. One such process that has gained attention in the adult eating disorder literature is affective instability.

From a developmental perspective, increased affective instability is normative in certain periods of youth. Specifically, adolescents tend to have heightened affective instability as compared with both adults and children, likely due to changes in brain structure that occur during puberty as well as shifts in social contexts (Casey et al., 2008). Nevertheless, prolonged periods of heightened emotion intensity and high variability in emotion may be linked to emotional dysregulation (Beauchaine, 2015). In adults, there is evidence that when binge eating leads to fluctuations in NA, the resulting NA instability may in turn exacerbate binge eating behavior (Berner et al., 2017). However, no studies to date have examined the association between LOC

and NA instability in youth, therefore it is unclear whether it may be an explanation for the emotion dysregulation seen in adolescents with LOC, either in conjunction with or above and beyond the role of affective intensity. Examining affective instability in relation to LOC eating across development could inform understanding of mechanisms underlying LOC and binge eating behaviors.

In the adult literature, two studies to date have assessed NA instability in women with eating disorders (i.e., bulimia nervosa), both using EMA. Berner et al. (2017) found that NA instability was higher on days where women with bulimia nervosa engaged in binge eating or purging as compared with days where binge/purge episodes did not occur, and that these women had higher levels of NA instability prior to binge/purge episodes than they did after them. Santangelo et al. (2014) examined affective instability on a bipolar scale instead of measuring PA and NA separately. They found that women with bulimia nervosa were as likely to experience shifts from very positive to very negative affect as women with BPD and that they were more likely to experience those shifts than were healthy control (Santangelo et al., 2014). These findings indicate some support for a link between LOC and NA instability. However, little is known about how NA instability may be associated with binge eating in the absence of compensatory behaviors, despite the fact that binge eating is independently associated with emotion dysregulation (Munsch et al., 2012). Additionally, elucidating whether there is an association between NA instability and LOC in youth may help to explain some of the discrepant findings between EMA and more traditional research methods.

Although the role of PA is less understood than that of NA in relation to disordered eating behaviors, it may also be important to consider. Findings are mixed as to whether PA intensity is positively or negatively associated with LOC. For example, retrospective research

indicates that LOC often occurs during events associated with higher levels of PA, such as social events and parties (Tanofsky-Kraff et al., 2007). However, EMA research lends support to the idea that youth with LOC may be vulnerable to eating in response to low mood, as Hilbert et al (2009) found that youth ages eight to 13 with LOC reported lower levels of PA intensity than healthy controls prior to either LOC or regular eating episodes than they did when measured at random. The role of PA instability in the context of disordered eating, and of youth psychopathology in general, is also unclear. It appears that in some cases, higher levels of PA instability may be associated with better mental health outcomes, such that PA instability may be viewed as flexibility in interpreting and responding to emotions, whereas in other contexts, it may be associated with impulsive behavior and increased psychopathology (Spindler et al., 2016).

To date, only one study has examined affective instability in youth with LOC, and it focused on PA instability. Using EMA in a sample of youth with overweight/obesity, Egbert et al. (2020) found that the association between LOC and PA instability was moderated by pubertal status: for youth in mid-late puberty, youth reported more LOC on days when they experienced greater PA instability and for youth in pre-early puberty, there was no association between PA instability and LOC. These findings raise the possibility that youth who experience large fluctuations in PA may use eating to regulate their emotions. They also indicate that the association between PA instability and LOC is complex and may not manifest until later in development. However, given the overall discrepant findings for the association between PA and LOC, more research is needed to elucidate the salience of both PA intensity and instability and whether links between affect and LOC may be different as youth get older.

Therefore, the current study sought to examine the association between affect and LOC comprehensively, with a focus on both PA and NA instability, using samples from two studies of youth of different ages, to capture developmental differences (Hilbert et al., 2009; Ranzenhofer et al., 2014). For the purposes of the current study, we included only youth from Hilbert et al., 2009 who endorsed LOC at baseline and had overweight/obesity given the higher levels of LOC in this population (e.g., Goldschmidt et al., 2018; Goldschmidt, Smith, Lavender, Engel, & Haedt-Matt, 2019) and to be consistent in methodology with Ranzenhofer et al., 2014. Hypotheses for each study are detailed below.

Study 1

The aim of Hilbert et al. (2009) was to utilize EMA to examine LOC eating in the everyday lives of children across the weight spectrum and understand the psychological and emotional factors that maintain such behavior. Drawing participants with overweight/obesity from Hilbert et al. (2009) sample, Study 1 sought to examine whether NA and PA instability were associated with LOC in a pre-early adolescent sample, and whether that association differed by age, while accounting for levels of PA and NA intensity. Leveraging the multiple data points collected through EMA, we also aimed to assess whether there were differences in between-person and within-person effects. We hypothesized that, similar to Egbert et al. (2020), there would be no main effect of either between- or within-person PA instability on LOC. However, given the changes that occur in affective instability during adolescence, we hypothesized that age would moderate the between-person association between daily PA instability and LOC. More specifically, we expected that there would be no association between PA instability and LOC for younger children and there would be a positive association for older children. Given that no studies to date have examined NA instability in either adults with binge eating or youth with

LOC, our examination of NA instability in this sample was more exploratory in nature; therefore, we chose to examine the association between NA instability and LOC similar to PA instability by examining the possible impact of age as a moderator to capture developmental differences in the link between NA and LOC that may emerge between ages eight to 13 years.

Method

Participants

German youth ages eight to 13 were recruited through schools and communities. See Table 1 for demographic characteristics. Youth were included in the original study (n = 118) if they experienced either one LOC episode in the last three months or they did not experience LOC but could be matched on age, sex, BMI percentile, education, and mother's education with a child who did experience LOC. For the purposes of the present study, only youth who met criteria for overweight/obesity (n=71) and endorsed LOC were included, bringing the total to 36. Exclusion criteria included compensatory behaviors (e.g., purging), serious mental illness in either the child or parent, medications that might impact eating or body weight, weight loss treatment, or living more than 30 minutes from the laboratory.

Table 1. Demographic Characteristics of Youth in Study 1 (Germany) (n = 36)

Age	10.61±1.46
Sex	
Male	16 (36%)
Female	23 (64%)
BMI z-score*	2.06±.51

*Based on Centers for Disease Control guidelines of BMI adjusted for age and sex

Procedure

Ethical review was obtained through the German Psychological Society Ethics Committee. Eligible participants were invited to attend an in-person interview in the lab, during which they completed a diagnostic interview, self-report questionnaires, and measurement of height and weight. Written parental consent and child assent were obtained prior to beginning the initial in-person interview. Prior to beginning the EMA assessment, participants received training on EMA procedures and were provided with a mobile phone with which they could call the research team. EMA measurements were taken through telephone interviews using child-specific mobile phones to increase compliance and decrease reliance on parents. EMA data collection occurred on four consecutive days, including two weekdays and two weekend days. Assessments were conducted from 2pm to 8pm on weekdays to avoid interference with school, and from 9am to 8pm on weekends, totaling 34 hours of assessment time across four days. Random sampling occurred by research assistants calling each child 12 times during the 34 hours. These assessments were generated randomly in blocks of 170 minutes each. Event-contingent sampling occurred by children calling the research assistants immediately after each eating episode and at the end of the assessment day.

Baseline Measures

Height and weight were measured using a stadiometer (to the nearest cm) and a balance scale (to the nearest 0.1 kg). The Eating Disorder Examination (EDE), adapted for children was administered by trained research staff to measure LOC, compensatory behaviors, and ascertain any eating disorder diagnosis (Bryant-Waugh et al., 1996). For the purposes of the current study, the German version of the EDE adapted for children, which has good reliability and validity (Hilbert, Buerger, et al., 2013), was used.

EMA Measures

LOC episodes were assessed on a binary scale (yes/no) using questions from the Child EDE. The Positive and Negative Affect Scale for Children (PANAS-C) was used to assess emotion (Laurent et al., 1999). The PANAS-C includes 20 items that ask about mood and are rated on a scale from 1 (very slightly or not at all) to 5 (extremely). The internal consistency of the PANAS is acceptable (Laurent et al., 1999). To minimize burden, the three highest loading items from the PANAS-C were chosen to measure NA (sad, afraid, upset) and the highest loading item was chosen to measure PA (happy).

Statistical Analysis

Generalized estimating equations (GEEs) were used to examine the independent and interactive effects of affective instability and age on LOC episodes among the 36 participants with LOC eating, adjusting for gender, age, and z-BMI. Affective instability was assessed by the mean squared successive difference (MSSD), which has previously been utilized as a metric of affect instability in other psychiatric conditions (e.g., (Berner et al., 2017; Snir et al., 2017). MSSD measures the squared successive differences in affect (NA or PA) between consecutive EMA ratings and thus provides an average measure of variance in NA and PA. The NA and PA MSSD indices were calculated within each day for each person (i.e., not lagging ratings between days).

Separate GEE models were conducted for daily NA and PA. The dependent variable in each model was the number of LOC episodes reported on a given day (based on ratings that occurred immediately after each meal). GEE models included within- and between-person effects of continuous independent variables (i.e., NA/PA MSSD), as well as the interactions of MSSD with age (grand-mean centered). That is, within-person effects (person-mean centered) reflect the degree to which daily NA/PA values differed from an individual's average level,

whereas between-person effects (grand-mean centered) reflect the degree to which an individual's average level of NA/PA across the EMA protocol deviated from the total sample means of these indices. Models included between- and within-person levels of affect intensity (i.e., mean NA or PA) in order to employ a more effective examination of the association between affective instability and LOC above and beyond the variability that could be attributed to mean affect scores (Ebner-Priemer et al., 2009). In addition, age, z-BMI (grand-mean centered) and sex (reference category: girls) were added as covariates. Each GEE employed an AR1 serial autocorrelation given the dependence within the nested data, and a negative binomial function to account for skewed distribution of the dependent count variable. Bonferroni post-hoc corrections were used for multiple comparisons at the $p < .05$ level with an alpha of .006. Analyses were conducted using available data without imputation in IBM SPSS Statistics version 25 (IBM Corp, Armonk, N.Y., USA).

Results

Overall, youth completed approximately 8.89±2.57 signal-contingent recordings and 7.20±2.58 event-contingent recordings for an average compliance rate of 74%. Results of GEE models are shown in Table 2. Neither PA nor NA were significant predictors of LOC episodes during the EMA period. Specifically, there were no significant main effects of NA or PA MSSD on LOC episodes, nor was there moderation by age.

Discussion

Study 1 sought to examine the association between affective instability and LOC in a German sample of youth in middle childhood and early adolescence. Results of Study 1 indicated no association between NA or PA intensity or instability and LOC, regardless of age. These findings are consistent with previous literature demonstrating no significant association

between momentary NA and LOC in middle childhood (Goldschmidt et al., 2018; Hilbert et al., 2009), and they add to the literature by suggesting that even momentary fluctuations in NA may not be pertinent to LOC episodes in these youth. Although some previous research has found that youth with LOC both retrospectively report more NA before and after eating (e.g., Tanofsky-Kraff et al., 2007), there is little evidence that this occurs in the natural environment, standing in contrast to the adult literature (Haedt-Matt & Keel, 2011). One hypothesis to explain this finding is that children have may more difficulty than adults identifying and describing NA in the moment (Nook et al., 2018). Additionally, momentary reporting of NA throughout the day may be particularly difficult for youth with eating pathology, who also report high levels of alexithymia, the inability to define or describe emotions (Shank et al., 2019).

Similar to Egbert et al., 2020, we also found no main effect of PA instability in Study 1. However, these null findings persisted even when examining age as a moderator. Although age may be considered a proxy for pubertal status, the two represent different constructs. It is possible that the experience of puberty specifically, along with the emotional and hormonal changes that occur during this time, is a driving factor of the development of an association between PA instability and LOC. This may explain why Egbert et al., 2020 found a moderating effect of puberty while Study 1 did not find a moderating effect of age. Additionally, the sample in Egbert et al., 2020 was 75% Black and Hispanic, as opposed to a German European sample in Study 1, and it is possible that cultural differences in eating behaviors and beliefs about eating in these populations may also help to explain the distinct findings between the two studies.

Taken together, Study 1 emphasizes that disruptions in momentary PA and NA may not be a driving factor in the experience of LOC in youth under age 13. This study indicates the importance of examining contextual factors that may influence the development of LOC in

younger populations, and of including momentary assessment in the study of emotion instead of relying on self-report measures, which may overemphasize the importance of PA and NA.

Table 2. Generalized estimating equation results predicting loss of control eating

	Study 1 (*n*=36)						Study 2 (*n*=30)					
			95% CI		Wald				95% CI		Wald	
Negative affect	*B*	*SE*	Lower	Upper	χ^2	*p*	*B*	*SE*	Lower	Upper	χ^2	*p*
Intercept	-2.07	0.38	-2.80	-1.33	30.08	<0.001	0.79	0.04	0.72	0.86	470.79	<0.001
Gender	-0.75	0.73	-2.19	0.69	1.03	0.310	n/a	n/a	n/a	n/a	n/a	n/a
z-BMI	-0.10	0.55	-1.17	0.98	0.03	0.862	0.03	0.02	-0.02	0.08	1.32	0.251
Age	0.30	0.23	-0.15	0.76	1.71	0.191	-0.11	0.06	-0.23	0.02	2.95	0.086
NA intensity (between)	1.00	3.79	-6.42	8.43	0.07	0.791	0.17	0.07	0.03	0.31	5.94	0.015
NA intensity (within)	-2.03	1.64	-5.24	1.18	1.54	0.215	-0.01	0.02	-0.06	0.04	0.22	0.639
NA MSSD (between)	3.65	5.65	-7.43	14.73	0.42	0.519	-0.05	0.09	-0.22	0.12	0.31	0.577
NA MSSD (within)	4.27	3.45	-2.49	11.03	1.53	0.216	-0.04	0.02	-0.07	<-0.01	4.76	0.029
Age X NA MSSD (between)	-0.53	2.26	-4.96	3.89	0.06	0.814	-0.05	0.04	-0.12	0.02	1.74	0.188
Age X NA MSSD (within)	-1.66	1.27	-4.15	0.83	1.71	0.191	0.01	0.01	-0.02	0.04	0.77	0.379
Positive affect												
Intercept	-2.06	0.34	-2.73	-1.39	36.26	<0.001	0.81	0.04	0.74	0.89	457.34	<0.001
Gender	-0.84	0.76	-2.33	0.66	1.21	0.272	n/a	n/a	n/a	n/a	n/a	n/a
z-BMI	0.20	0.49	-0.76	1.16	0.17	0.678	0.02	0.03	-0.03	0.07	0.83	0.361
Age	0.33	0.21	-0.09	0.74	2.42	0.120	<0.01	0.09	-0.18	0.18	<0.01	0.996
PA intensity (between)	0.15	0.33	-0.50	0.80	0.19	0.659	0.05	0.05	-0.05	0.14	1.01	0.314
PA intensity (within)	-0.72	0.38	-1.46	0.02	3.64	0.056	0.01	0.02	-0.04	0.06	0.18	0.668
PA MSSD (between)	-0.27	0.41	-1.07	0.54	0.41	0.521	-0.02	0.04	-0.09	0.06	0.25	0.615

PA MSSD (within)	0.21	0.18	-0.15	0.57	1.28	0.258		0.00	0.01	-0.02	0.02	0.02	0.890
Age X PA MSSD (between)	0.30	0.19	-0.08	0.67	2.40	0.121		**0.08**	**0.03**	**0.02**	**0.14**	**7.79**	**0.005**
Age X PA MSSD (within)	-0.15	0.09	-0.33	0.02	2.96	0.086		0.01	0.01	0.00	0.02	1.62	0.202

Note. CI=confidence interval; BMI=body mass index; NA=negative affect; PA=positive affect; MSSD=mean squared successive difference; between=grand-mean centered variable; within=person-mean centered variable. Gender was coded such that girls were the reference category. All p-values meeting significance after Bonferroni correction are in bold.

Study 2

The aim of Ranzenhofer et al. (2014) was to test the interpersonal model of LOC (i.e., that interpersonal problems lead to negative affect which in turn leads to LOC; Tanofsky-Kraff et al., 2007) using EMA in a sample of adolescent girls with concurrent LOC and obesity. In Study 2, we utilized the full sample from Ranzenhofer et al. (2014), the only published sample to date to examine LOC using EMA in youth over the age of 14, to extend the findings of Study 1 by examining associations between affect and LOC in older youth. Given that the sample had some overlap in age with Study 1, such that the youngest participants in Study 2 were the same age as the oldest participants in Study 1, we again included age as a moderator in our analyses. We anticipated that for younger participants in Study 2, there would be no association between PA instability and LOC, similar to the findings of Study 1. In contrast, we hypothesized that older youth in the sample would demonstrate an association between PA instability and LOC, more similar to findings in adult samples (Berner et al., 2017) In addition to PA instability, we were also interested in assessing the role of NA instability in early-middle adolescence. Since we found no associations between NA instability and LOC in Study 1, we again hypothesized that these results would be replicated in younger participants (i.e., 1 SD below the mean age; 13.34 years) in Study 2, but that there would be a positive association between NA instability and LOC in the older participants (i.e., 1 SD above the mean age; 16.44 years), like that of adults. Finally, we accounted for PA and NA intensity in all of our models of affective instability.

Method

Participants

Thirty girls ages 12-17 were recruited from communities in the metropolitan area of the District of Columbia. Inclusion criteria included BMI above the 85th percentile, and the

endorsement of at least two LOC episodes in the prior month. Exclusion criteria included major medical illness (as reported by parents), major psychiatric disorder, or use of medication that impacted body weight or appetite. All participants from Ranzenhofer et al. (2014) were included in the present study. See Table 3 for demographic characteristics.

Table 3. Demographic Characteristics of Youth in Study 2 (U.S.) (*n* = 30)

Age	14.89±1.55
Ethnicity	
Hispanic	1 (3%)
Non-Hispanic	29 (97%)
Race	
White	9 (30%)
Black	18 (60%)
Mixed Race	3 (10%)
BMI z-score*	2.17±.43

*Based on Centers for Disease Control guidelines of BMI adjusted for age and sex

Procedure

Review board approval was obtained from the Uniformed Services University of the Health Sciences. Eligible participants were invited into the laboratory for a screening visit where they completed fasting assessments of height, weight, and body composition. Written parental consent and child assent were also obtained prior to beginning the initial screening visit. Participants were then given breakfast and completed assessments of eating pathology and psychological functioning by trained study staff. Participants who met all inclusion criteria were given a Palm Pilot PDA (Personal Digital Assistant) device and trained on how to use it. They then completed a one-day practice EMA period immediately following the screening visit.

Finally, during the data collection period, participants completed a two-week EMA assessment. At the end of the assessment, participants returned the EMA device and completed evaluation forms.

During the EMA protocol, consistent with Study 1, a mixture of signal-contingent and event-contingent recordings were collected to assess LOC and other variables of interest. For the purposes of the current study, only LOC and state affect were considered. During the two-week data collection period, on weekdays, participants received three signal-contingent recordings each day between 15:00 and 23:00 to avoid giving prompts during the school day, and on weekends, they received five signal-contingent prompts between 11:00 and 23:00. In addition to signal-contingent recordings, participants were told to complete event-contingent recordings whenever they ate a meal or a snack. Both LOC and state affect were assessed before and after each eating episode.

Baseline Measures

Height and weight were measured using an electronic stadiometer (to the nearest millimeter) and digital scale (to the nearest 0.1 kg). The Eating Disorder Examination (Version 12) was used to assess for baseline LOC episodes (Fairburn & Cooper, 1993). The EDE is a well-validated interview for the assessment and diagnosis of eating disorders and has demonstrated excellent reliability for identifying LOC in adolescent populations (Glasofer et al., 2007).

EMA Measures

LOC eating was assessed by adapting relevant items from the EDE that were answered on a 1-5 item Likert scale, ranging from “No, not at all” to “Yes, very much.” These questions included probes about the adolescent’s perceived “level of control” and “loss of control” over

eating, as well as their "ability to stop" eating and how much they sensed being "out of control" of their eating.

Affect. Like Study 1, the Positive and Negative Affect Scale for Children (PANAS-C) was used to assess for momentary affective states (Laurent et al., 1999). The six highest-loading items on NA and on PA were utilized (i.e., NA: upset, scared, miserable, lonely, blue, sad; PA: happy, cheerful, proud, joyful, delighted, lively).

Statistical Analysis

Daily NA and PA MSSD indices were calculated analogously to Study 1, albeit with different affect items. Like Study 1, separate GEEs examined the independent and interactive effects of daily NA/PA MSSD predicting LOC severity based on post-meal ratings, adjusting for z-BMI and separating between- and within-person effects of NA/PA MSSD. NA/PA intensity were also included in the models. Gamma link functions were used in GEEs to account for skewed distributions of dependent continuous variables and post-hoc Bonferroni adjustments were used to account for multiple comparisons.

Results

Participants completed approximately 12.79±2.30 days of recordings with an average compliance rate of 69% of random recordings. They completed an average of 1.27±0.69 event-contingent recordings before meals and 1.17±0.62 after meals per day.

Results of the GEE analyses are shown in Table 2. There was a significant main effect of within-person NA MSSD predicting LOC severity, such that days characterized by *lower* NA MSSD (relative to an individual's own average), were associated with greater LOC severity. However, this finding was no longer significant after a Bonferroni post-hoc adjustment was made. With regards to PA, there were significant interactions between age and between-person

PA MSSD predicting LOC severity. As shown in Figure 1, simple slopes demonstrate that among older participants, those with higher overall PA MSSD (relative to the sample mean) reported increased LOC severity (p = .057), yet among younger participants, those with higher overall PA MSSD reported decreased LOC severity (p = .040). In sum, older participants with greater PA instability reported non-significant increased LOC severity whereas younger participant with less PA instability reported significant increased LOC severity.

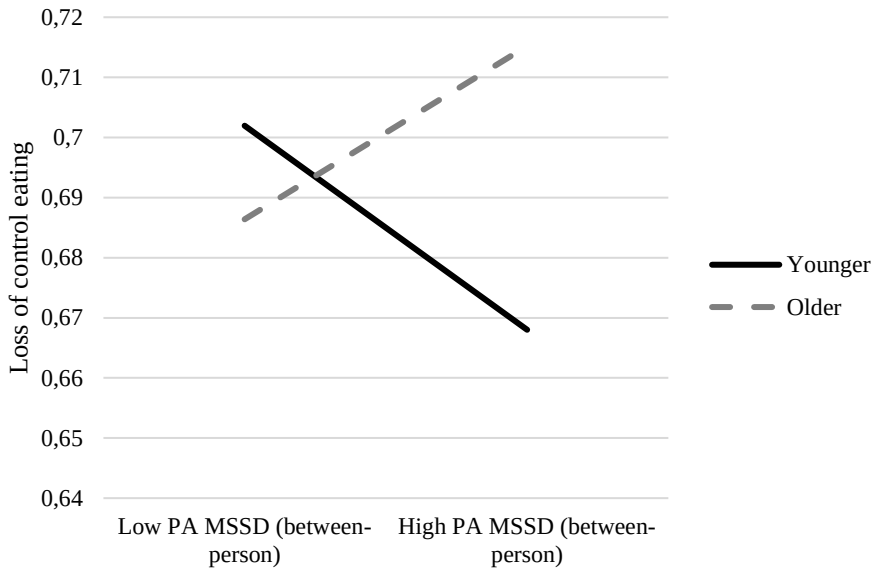

Figure 1. Study 2 interaction between age and between-person PA MSSD predicting loss of control eating severity. High and low values reflect 1 SD above and below sample means, respectively. MSSD = Mean squared successive difference; PA = positive affect

Discussion

The results of Study 2 again lend support to the hypothesis that the affective experience of LOC may be different for older adolescents than it is for youth in middle childhood. Consistent with our hypothesis, age emerged as a moderator of the association between PA instability and LOC. As expected, in older youth, there was a positive between-person association between PA instability and LOC. However, unexpectedly, the simple slope of this

association was not significant. Also contrary to our hypothesis, younger youth demonstrated a negative association between PA instability and LOC, instead of the null finding that we expected. With regards to NA, after adjusting for multiple comparisons, we found no association between NA instability and LOC. This was contrary to our hypothesis that NA instability would follow a similar pattern in the older youth in Study 2 as it does in adults.

Our unexpected findings for PA instability must be considered in light of the measures of development used (i.e., age) and the sample composition in Study 2. First, similar to Study 1, it is possible that our use of age instead of a more sensitive measure of development, like pubertal status, may have contributed to the null association between PA instability and LOC in older youth. It is also possible that we were underpowered to detect significant effects due to our small sample. Additionally, the negative association between PA instability and LOC in younger youth may be explained by higher levels of parental oversight of younger girls. Parents have more control over the food choices of early adolescents than they do late adolescents. They also may be more aware of their mood changes and take more steps to manage them than they do as their children age. Therefore, it is possible that parents of younger youth with high levels of PA instability do more to manage when and how much their children are eating because they are more hypervigilant about their behavior. As youth age, it may be less possible to exercise this type of control. Additionally, the sample in Study 2 was composed of almost 75% racial and ethnic minority youth. There is some evidence that Black youth in particular (who represent 60% of the sample) may have strong links between LOC and both NA and PA (Cassidy et al., 2013). Furthermore, in studies of Black women, research suggests that binge eating behaviors may be normative and linked to social gatherings (Scott et al., 2019). Therefore, it is possible that days where Black girls experience LOC may be characterized by high levels of PA that occur during

social gatherings, but these feelings may "crash" once the gathering is over, thus resulting in increased PA instability on those days.

Study 2 also found that, on days where youth had fewer fluctuations in NA relative to what they usually experienced, they also had greater reported LOC and that NA intensity was also higher on days where youth reported LOC. However, these findings were no longer significant when corrections for multiple comparisons were made. Nevertheless, due to the exploratory nature of the current study and the small sample size, future research should investigate links between NA instability and NA intensity and LOC in middle and late to assess whether these youth may be more likely to "get stuck" in NA intensive states throughout the day and engage in LOC in response to these states. If these associations do exist, future research should examine whether they may be due to higher levels of rumination and increasing NA throughout the day, which have been associated with increased levels of binge eating in adults with obesity and bulimia nervosa (Smyth et al., 2009; Wang et al., 2017).

Taken together, the findings from Study 2 indicate the importance of assessing both NA and PA instability in older youth who experience LOC and of considering how both development and cultural experience may play a role in how affective instability is associated with LOC in this population.

Overall Discussion

The current study provided an evaluation of affective instability and its relation to LOC in youth with overweight/obesity across different developmental stages. In a sample of middle childhood to early adolescent youth, we found no significant association between affective instability and LOC. However, consistent with a developmental framework of affective instability and psychopathology, we found that, in an older sample of youth (early to late

adolescent) age moderated the association between between-person PA instability and LOC. Our results suggest that the association between affective instability and LOC is more complex in younger children and may be opposite to that of older youth.

First, our findings demonstrate support for evaluating affective instability in LOC eating in adolescent youth. Although, in the past, affective instability has primarily been evaluated in the context of bulimia nervosa (Berner et al., 2017; Santangelo et al., 2014), the present studies indicate that it may also play a role in the experience of LOC in youth, outside of the context of purging behavior and regardless of the amount of food eaten. The developmental nature of our findings suggest that affective instability may become more important to LOC as youth age. Nevertheless, for pre- and early adolescent youth, the results of the present studies are also consistent with a growing literature suggesting that, despite similarities between binge eating in adults and LOC eating in youth, LOC in youth does not appear to be fully accounted for by the affect regulation model (e.g., Goldschmidt et al., 2018; Hilbert et al., 2009; Ranzenhofer et al., 2014). This does not mean that these youth do not experience and have difficulty regulating NA. However, it does indicate the possibility that NA may not be the only driving force behind LOC at the momentary level prior to adolescence, and thus interventions to help interrupt the cycle of LOC in children may benefit from also focusing on other factors, such as contextual factors like food availability, hunger, and craving. They also indicate the importance of future studies including samples of youth from middle childhood to middle-to-late adolescence given an identical protocol so that developmental factors relevant to LOC may be adequately studied.

Although there has been much more emphasis in the literature on understanding the experience of NA in youth with LOC, our research also indicates that it may be important to examine PA as a related but independent construct from NA. We found that the link between PA

and LOC may become more important to the experience of LOC later in development. In Study 2, older youth (i.e., 1 SD above the mean age) who exhibited more PA instability relative to their peers also experienced higher levels of LOC, but the simple slope of this association was not significant. In contrast the opposite was the case for younger youth (i.e., 1 SD below the mean age), where more PA instability was significantly associated with less LOC. This finding is consistent with research suggesting that in some cases, PA instability may be associated with positive mental health outcomes at least for youth in early adolescence (Spindler et al., 2016). Overall, our findings demonstrate that the association between PA instability and LOC is complex in early-to-middle adolescence. In addition to this, the results of the present study also indicate the importance of considering cultural factors, such as race and ethnicity, as our adolescent sample was composed largely of Black and mixed-race youth. It is possible that affective instability simply plays a larger role in the experience of LOC in racial and ethnic minority youth than it does in White or European samples, which may have contributed to the differences in findings between Study 1 and Study 2. It is possible that affective instability interacts with other minority stressors, such as discrimination and acculturation, that have been known to impact health behaviors including LOC (Kelly et al., 2020; Williams et al., 2019). This may inform tailored treatment interventions for youth from different cultural backgrounds.

With regards to overall emotional assessment in the context of LOC, there appears to be a consistent difference between the findings from retrospective assessment studies and the EMA methods used in the present studies, which can be conducted in near-real time. These differences are consistent with findings from other areas of psychopathology (Ebner-Priemer et al., 2006) and may be compounded for children, who may have more difficulty remembering events or articulating how they were feeling in the past. Given that many of our interventions have been

informed by retrospective findings, advancement in the field of treatment for LOC must consider differences between the emotion evoked by reflecting on a past LOC episode as compared with the actual emotional experience in the moment that the episode takes place. Although the present study did not directly compare associations between LOC and affect when measured in real time and retrospectively, future research would benefit from doing so to understand these differences better. Additionally, although initial research on interpersonal therapy and cognitive behavioral therapy demonstrate some efficacy in youth with LOC (Hilbert et al., 2020; Tanofsky-Kraff et al., 2007), there are currently no well-established treatments for LOC in youth. Therefore, future treatment development should focus on momentary correlates of LOC, including PA instability to facilitate skills that can be used in the moment to interrupt the cycle of LOC episodes.

It is important to note that the present studies should be understood within the context of overweight and obesity. Although LOC is more common in youth with obesity than those without, and most of the past research examining LOC in youth has oversampled for youth with obesity (e.g., Tanofsky-Kraff et al., 2007), it is possible that weight status may have played a confounding role in our results. Research suggests that youth with obesity may already display greater levels of emotional dysregulation compared with their non-overweight peers due to heightened levels of stress (Aparicio et al., 2016), therefore it is possible that some of our null findings with regard to affective instability and LOC may have been due to ceiling effects. However, given that youth with LOC in our sample showed differences in affective instability compared with their peers, who were of similar weight statuses, it is possible that the experience of LOC may be associated with affective instability above and beyond the impact of obesity. Therefore, future studies should examine whether youth who have both overweight/obesity and high levels of affective instability may be at higher risk for the development of LOC and

possibly full-threshold binge-eating disorder in the future. Finally, there is very little research about the normative emotional development of youth with obesity, and whether this may differ from non-overweight youth, therefore it is unclear whether our results generalize to youth from different weight statuses. As a result, future studies should examine whether these findings may replicate in youth across the weight spectrum.

Our findings must also be considered in light of the following limitations. It must be noted that although EMA captures significantly more information than traditional retrospective recall, it also has its own limitations, especially when used with youth. EMA compliance rates are at best modest in child and adolescent samples, particularly for event-contingent recordings (Wen et al., 2017). For example, in the current studies, youth consistently provided less than three event-contingent recordings (i.e., recordings of meals or snacks) per day. Although studies may attempt to account for this by collecting more signal-contingent prompts to increase compliance, as was done in both Study 1 and Study 2, important information may be lost between an eating episode and the next signaled prompt. Another limitation that is unique to youth is attending school, which makes it difficult to gather recordings for a large portion of the day Monday through Friday. Although research suggests that most LOC episodes occur in the afternoons and in evenings (Smyth et al., 2009), the time restrictions due to school make it impossible to obtain other information, such as about affect and events that during the school day. Because of this, it is difficult to collect a sufficient number of recordings to examine the temporal relation between these variables and LOC in youth. For example, Berner et al., 2017 gathered an average of 3.5±1.3 pre-meal and 4.3±1.9 post-meal recordings in their study of affective instability in adult women with bulimia nervosa, with recordings collected throughout the day on both weekdays and weekends. In contrast, in Study 2, we only had 1.27±0.69 before

meal recordings and 1.17±0.62 after meal recordings even with 68% signal-contingent response compliance during the weekdays. Although the day level analyses that we have presented provide value by allowing for the aggregation of multiple dynamic processes to view overall patterns of emotion, our smaller number of recordings precluded us from looking at temporal associations between affective instability and LOC in both Study 1 and Study 2.

Overall, EMA represents a unique and highly informative method of assessment. However, the limitations of EMA assessment make it imperative to develop more acceptable methods of assessment, especially for youth, such as passive sensing technology, that may be able to detect when a child is eating and may be able to measure heart rate, distance from peers, and other factors to gather information on affect. In addition to addressing issues related to compliance, this would also minimize the reliance on self-reported data, which was used to evaluate all variables of interest in both Study 1 and Study 2.

Other limitations include the small sample size in both studies, which influenced our power to detect significant effects, and likely contributed to the attenuated findings regarding NA instability and NA intensity in Study 2 after adjusting for multiple comparisons. Additionally, the present studies did not examine whether affect instability on one day might have influenced LOC the following day. As a result, the time lagged impact of affective instability on eating behaviors in this sample is unknown, representing a limitation of the current research, and an important direction for future study given its clinical implications. In addition to this, there were differences in methodology between Study 1 and Study 2. First, Study 1 and Study 2 had slightly different inclusion criteria for LOC, such that Study 1 required one episode of LOC in the preceding three months and Study 2 required two episodes of LOC in the preceding month. However, the inclusion criteria in Study 1 is consistent with recommendations for identifying

LOC in youth under the age of 12, who may have normatively lower levels of LOC than older youth (Tanofsky-Kraff et al., 2008).

In addition to differences in inclusion criteria, other methodological differences include assessment over the phone in Study 1 and via mobile application in Study 2. As such, in Study 1, assessors could query youth and ask follow-up questions if answers were unclear, whereas in Study 2, this was not possible. However, youth in Study 1 may have been subject to response bias since they reported directly to study assessors instead of doing so independently using mobile devices. Additionally, the EMA period in Study 2 (14 days) was longer than in Study 1 (4 days), resulting in a larger number of observations in Study 2. However, the large number of event-contingent calls in Study 1 and the high level of contact with study assessors for updates on compliance likely compensated in part for the shorter observation period. Other differences include the use of slightly different descriptors for NA and PA across studies. Specifically, only one descriptor (happy) for PA in Study 1 represents a limitation as this narrow definition may not be generalizable to other components of PA. However, both studies used items from the PANAS-C, a well-validated measure of affect, which likely made comparison more reliable. Findings from Study 1 were also partially consistent with Egbert et al., 2020, specifically with regards to null main effects, which lends further confidence to the results. Nevertheless, future studies should replicate the findings of Study 1 utilizing mobile EMA methods and a comprehensive list of PA descriptors. In addition to affect items, another difference between the two studies is that Study 2 assessed only adolescent girls, while Study 1 assessed both boys and girls. Although we accounted for sex in Study 1 analyses, this difference in gender between the two studies may have also impacted the findings, as affective instability in boys appears to be

more constant across adolescence than it does in girls (Bailen et al., 2019), and future studies should replicate the results of Study 2 using a larger sample.

In sum, the current study provides support for the role of affective instability in youth with both overweight/obesity and LOC eating and indicates that developmental status may also be an important consideration. Overall, we found that the association between affective instability and LOC may not emerge until later in adolescence. These results indicate that the experience of LOC in youth may be different than that of adults and emphasize the need to develop specific models of LOC that, although different from adult models, are appropriate for children and adolescents.

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