


Negative emodiversity is associated with emotional eating in adolescents: An examination of emotion dynamics in daily life

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Abstract

Introduction: Emotional eating is a mental health concern, common in adolescents, that develops as a result of their tendency to use high-energy food to regulate their fluctuating emotions. Due to their highly fluctuating emotional life, adolescents tend to have unique within-person profiles of emotional experiences that change across moments and days, often lost in global assessments of emotions. Hence, it is imperative to examine individual differences in dynamics of emotions, as experienced in daily life, in relation to emotional eating in adolescents.

Methods: In an Ecological Momentary Assessment study, we examined individual differences in three within-person dynamic characteristics (baseline levels, intraindividual variability, and emodiversity) of emotions in 158 dominantly Hispanic adolescents in the United States, aged 14–17 years old, predicting trait-level emotional eating.

Results: Results indicated that higher negative emodiversity, baselines, and variability in stress were predictive of emotional eating in adolescents. When all considered together, negative emodiversity (i.e., variety of the types of negative emotions experienced in one's daily life) remained the only significant predictor of emotional eating.

Conclusions: This study affirms the importance of diversity in emotional experiences in relation to emotional eating, particularly in daily contexts of adolescents' lives. Additionally, the study emphasizes the importance of distinguishing between diversity (i.e., variety in types) in positive versus negative emotional experiences with regard to emotional eating. By taking into account the ecological validity of adolescents' daily lives and individual differences in dynamical changes in emotions, we are taking a step forward by shedding light on how the dynamics of negative emotions—in terms of within-person baselines, variability, and diversity—might be related to general levels of emotional eating in adolescents.

KEYWORDS

adolescence, ecological momentary assessment, emodiversity, emotion, emotional eating, intraindividual variability

1 | INTRODUCTION

Adolescence is a developmental period marked with high levels of stress, depression, anxiety, and negative emotionality (Willemssen et al., 2011). Perceived stress, mood, anxiety (Nguyen-Rodriguez et al., 2008, 2009), and depression (Van Strien, Snoek, et al., 2010) are linked to emotional eating which in turn is associated with overweight/obesity (Braet et al., 2008; Gouveia et al., 2019). Ethnically minoritized youth (e.g., Latinos/as), are at risk for using food, especially high-energy dense food, to regulate their mood (i.e., engage in emotional eating; Nguyen-Michel et al., 2007). Within the past decade,

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researchers have found links between negative affect, stress, boredom, and binge eating, as well as technology use and cravings for sweet and salty snacks and sweetened drinks among urban adolescents from lower income Hispanic families (Borgogna et al., 2015; Grenard et al., 2013; Lee et al., 2019). Recent data suggest that 18.5% of adolescents in the United States are obese, with higher rates among ethnic minority youth (e.g., Hispanics and non-Hispanic Blacks; Hales et al., 2017).

One major predictor of the tendency to use food to regulate mood is the emotional experiences that occur in daily life (Van Strien, 2018). Previous studies examining stable and global assessments of emotions as predictors of emotional eating, found that mostly negative emotions such as depression, anxiety, and perceived stress are triggers of overeating among individuals with eating disorders (Pinaquy et al., 2003). More frequently in recent years, researchers have begun to explore the role of momentary experiences of emotional states in daily life using experience sampling methods (Macht et al., 2004; Smith et al., 2020). To date, however, individual differences in the within-person dynamics of people's emotional experiences (e.g., emotional diversity, intraindividual variability [IIV], emotional baseline) in day-to-day life is yet to be examined in relation to their general levels of emotional eating. This is especially important in adolescents because of the high variability of their emotional states (Larson et al., 2002).

Experience sampling or Ecological Momentary Assessment (EMA; Larson & Csikszentmihalyi, 2014; Stone & Shiffman, 1994) designs allow researchers to examine the *dynamics* of people's moment-to-moment experiences as they unfold over time. With such designs, we can examine how individuals differ from others, but also how individuals change compared to themselves over time. For this purpose, we can use intensive momentary data collected through EMA, to identify within-person characteristics of change in emotions and compare them to interindividual differences. For instance, we can derive how much a person's moment-to-moment experiences of emotion fluctuate in daily life and use this index of IIV (Ram & Gerstorf, 2009) to investigate interindividual differences in trait-level emotional eating (see, e.g., Heshmati et al., 2021). In the current study, we aim to derive three such within-person characteristics of emotions in adolescents' daily lives: (1) baseline levels: a person's average level of emotional experiences; (2) IIV: level of fluctuation in emotional experiences around the baseline; (3) emodiversity: variety in types of emotion experiences within each individual across days. Subsequently, we will investigate whether these three within-person dynamics of change in emotions predict trait-level emotional eating in adolescents. With this approach, we aim to shed light on the dynamic processes of emotional experiences in relation to general levels of emotional eating.

2 | EMOTION DYNAMICS IN ADOLESCENTS

The dynamical nature and variability in emotion levels can be examined in both long-term (e.g., months, years, life stages) and short-term time scales (e.g., moments, hours, days). While there has been extensive research on dynamical changes in emotional experiences across the adolescence years (Larsen et al., 2002; Maciejewski et al., 2017), daily life studies have also demonstrated dynamical changes in emotions across shorter time spans of adolescents' daily lives. One of the first studies conducted using experience sampling methods on adolescents (Larson et al., 1980), examined mood variability as a characteristic of adolescents' experience in daily life. The study confirmed that mood swings are wider and quicker in adolescents compared to adults and appear to be a natural state of this developmental stage (Larson et al., 1980). These short-term changes have displayed different patterns across specific emotions (Heshmati et al., 2017) while also varying across individuals (Heshmati et al., 2020).

Although some of these dynamical changes might be typical to adolescents' lives, specific patterns of dynamical changes across various emotions may prove to become problematic for this age group and be predictive of certain psychopathology. For example, one study demonstrated that variability of emotions assessed across days in adolescents from age 13 to 14 years, demonstrated that fluctuations in four emotions (happiness, anxiety, anger, and sadness) were differentially related to various psychopathology onset (Neumann et al., 2011). Another study showed that inertia in emotional experiences (regulation of emotions across time) was a predictor of depressive symptoms (Kuppens et al., 2012). Thus, due to the fluctuation in adolescents' daily moods and emotions, as well as individual differences in these fluctuations, it is important to look more closely at the dynamics of emotional states and how they are related to mental health outcomes such as emotional eating.

3 | EMOTIONS AND EMOTIONAL EATING

Eating and finding comfort in food are universal experiences. Indeed, emotions not only underlie behaviors, but can also drive them (e.g., eating). Numerous studies have examined the role of emotional experiences in emotional eating. For decades, we have known that emotional arousal precedes emotional eating (Arnou et al., 1995; Greeno & Wing, 1994). According to psychosomatic theory (Bruch, 1964), emotional eating has been conceptualized as an inability to distinguish the physiological state of hunger while experiencing negative emotions. As a result, eating behavior is altered to reduce negative moods such as depression, boredom, anger, and loneliness (Ganley, 1989). As posited by restraint theory (Herman & Polivy, 1980),

altered eating behavior (e.g., restrained or overeating) is triggered by negative affect. In essence, emotional eating can also be conceptualized through emotion regulation theories. Emotion regulation has been conceptualized as a multicomponential process that unfolds over time (Gross, 1998). Individuals influence how they experience and express their emotions—a process that is automatic or controlled, conscious or unconscious (Gross, 1998). Since emotions unfold over time, emotion regulatory processes include changes in emotion dynamics (i.e., latency, rise time, magnitude, duration, and offset; Gross, 1998; Thompson, 1990). Regulating emotions, rather than the emotion itself, is an important consideration when observing or understanding the role of emotions and eating in daily life. Along these lines, food intake is a form of emotion-regulation as comfort food can decrease the effect of stress and improve mood through the increase of dopamine transmission (Kaplan & Kaplan, 1957). Moreover, stress as a specific form of negative emotion may be particularly influential, given that it is an aversive state that disrupts self-control processes (Duckworth et al., 2013; Oaten & Cheng, 2005) and increase the salience of rewarding taste attributes on choice (Maier et al., 2015). Thus, from an emotion regulation perspective dietary related behavior should only follow the experience of negative not positive emotions, and stress may be particularly influential as compared to other emotional states (e.g., sadness).

Previous studies have demonstrated mixed results as it relates to emotions and emotional eating. For example, the past couple decades have contributed to our understanding of negative emotional experiences increasing risk of emotional eating (e.g., perceived stress, depression, alexithymia, and poor emotion regulation skills) as well as the negative health outcomes as a result of emotional eating (e.g., binge eating disorder, overeating, obesity, chronic dieting, and eating disorder psychopathology; Lindeman & Stark, 2001; Pinaquy et al., 2003; Van Strien, 2018). Although limited in its lack of ecological validity, a recent meta-analysis of 56 experimental studies found that positive emotions led to increased eating both in healthy individuals and those with eating disorders, and those with restrained eating patterns experienced increased eating in response to negative emotions (Evers et al., 2018). While important, these findings should be considered in light of the constraints of global assessments of emotions, as these studies did not assess emotional experiences in an ecological valid manner (as demonstrated in Evers et al., 2018). Global assessments of emotions have their own limitations, leading to recall bias, lacking ecological validity, and missing the dynamics of emotions as life is lived (Heshmati et al., 2021; Shiffman et al., 2008).

4 | DAILY EXPERIENCES OF EMOTIONS AND EMOTIONAL EATING

Studies that focus on understanding emotional states in moment-by-moment daily contexts in people's daily lives allow for the measurement of momentary fluctuations and changes in emotion dynamics over time—a process that needs to be understood for investigations into the complex relationship between emotions and emotional eating. Increasing evidence suggests that using experience sampling methods (Csikszentmihalyi & Larson, 1987; Schwartz & Stone, 1998) is a relevant method for understanding emotional eating. Using this methodology, researchers began exploring the daily emotional context in which emotional eating occurs in nonclinical individuals (e.g., nondisordered eating and normal weight; Macht et al., 2004; Macht & Simons, 2000). Exploring periods of emotional eating in people's natural daily environments, Macht et al. (2004) found that emotional eating and emotional states co-occur more often than not, even in nonclinical populations.

Before this study, Macht and Simons (2000) found that subjective motivation to eat in everyday life was associated with emotional states and emotional eating. For example, compared to positive (e.g., relaxation or joy) or unemotional states (i.e., neutral), negative emotional states (e.g., anger, tension, fear) were more strongly associated with a higher motivation to eat and irregular eating patterns (Macht & Simons, 2000). The researchers concluded that emotionally instrumental eating (i.e., to regulate or control emotions; Booth, 1994) may also play a role in normal eating in everyday life.

Other researchers have examined daily emotional experiences and emotional eating in children and adolescents. A recent systematic review demonstrated mixed findings regarding associations between affect (negative and positive) and stress in relation to eating in children and adolescents (Mason et al., 2020). Mason et al. (2020) found that some studies reported associations between negative affect (e.g., boredom, loneliness, worry, aversive tension) and eating (e.g., increased sweets consumption, unhealthy dietary intake, thoughts of binge eating, loss of control eating, Grenard et al., 2013; Kolar et al., 2016; O'Reilly et al., 2015; Ranzenhofer et al., 2016), whereas others found that momentary negative affect did not precede loss of control eating (Goldschmidt et al., 2018; Hilbert et al., 2009; Ranzenhofer et al., 2014). Additionally, some researchers found higher energy levels positively related to sweet beverage consumption (Grenard et al., 2013), but others did not find a relationship between positive affect (momentary and variability) and eating and dietary intake (Grenard et al., 2013; Mason et al., 2019; O'Reilly et al., 2015). Whereas the reduced momentary ability to cope with stress has predicted greater intake of sugary foods (Mason et al., 2019), some researchers have found no associations between momentary stress and eating (i.e., loss of control eating or food and drink intake; Dunton et al., 2017; Goldschmidt et al., 2018; Grenard et al., 2013).

Other researchers have found associations in daily emotion dynamics and eating among adult populations, albeit mixed. Bongers and Jansen's (2017) study provided the first experimental evidence for the idea that negative emotions can produce a Pavlovian response (i.e., negative mood-induced eating increased an inclination for sweet food). Altheimer et al. (2021)

found that individuals who self-identify as sad or anxious eaters did not eat more when induced to experience these emotions in the lab or in daily life, but due to methodological limitations (e.g., self-reported, retrospective measure of emotional eating), the researchers cautioned the readers from drawing firm conclusions from their findings. Other researchers found that an increase in day-to-day fluctuations and greater average positive emotions (e.g., enthusiasm, excitement, desire) increased daily physical activity levels among adolescents and their caregivers, while greater average positive emotions were associated with caregiver overeating (Cummings & Lansing, 2022). Boh et al.'s (2016) EMA study demonstrated that neutral and positive emotions (i.e., calm/relaxed, cheerful/happy) preceded eating events and shed light on the role of weight status and negative emotions. For instance, compared to individuals within a healthy weight range, those who were overweight scored higher on negative emotions during both eating and noneating moments. The findings from Boh et al.'s study led the researchers to conclude that negative emotions were not specific triggers for food consumption. Although positive emotions are more consistently linked to eating behaviors in studies focused on daily emotional experiences, there is more to be discovered as it relates to daily negative emotional experiences and eating.

Finally, it is important to consider that gender differences also exist in emotional dynamics in daily life and in relation to emotional eating. Previous researchers have discovered different dietary choices associated with emotional eating, particularly among Latino/a youth (Nguyen-Michel et al., 2007). In their cross-sectional study, Nguyen-Michel et al. (2007) found that emotional eating was positively associated with a higher intake of fruits and vegetables for Latino adolescent boys only, and salty high energy-dense food intake was positively associated with emotional eating for both Latino/a adolescent boys and girls. Another study found that alexithymia (i.e., difficulty in identifying or describing feelings) was more strongly associated with emotional eating in men with obesity than in women (Larsen et al., 2006).

The findings above demonstrate mixed findings with regard to emotional states in relation to emotional eating and substantiate the evidence that observed differences exist in levels of emotional states and emotional eating when examined in daily life contexts. Also indicated in these studies is the limited evidence on the dynamics of emotional states as examined through a momentary assessment and how they relate to eating.

5 | THE CURRENT STUDY

The importance of examining the within-person dynamic characteristics of people's daily experiences have been highlighted in the past literature (e.g., Fiske & Rice, 1955; Nesselrode, 2001; Ram & Gerstorf, 2009). However, to our knowledge, the understanding of the correlates of emotional eating with regard to the dynamics of daily emotional experiences in adolescents have yet to be explored. In the current study, we aim to explore individual differences in person-specific characteristics of emotional experiences—in particular negative emotionality—as they unfold in everyday life contexts and how they relate to trait-level emotional eating in adolescents. Specifically, we will derive three intraindividual characteristics of daily emotions through (1) within-person emotional baseline levels (i.e., a person's average level of emotional experiences), (2) IIV in emotions (i.e., degree of fluctuation in emotional experience around the baseline), and (3) within-person emodiversity (i.e., the variety of different types of emotions experienced at the level of the individual).

Using these three intraindividual characteristics of daily emotional experiences (further elaborated in Section 6), we will investigate the association between the intraindividual dynamics of emotions in daily life and interindividual differences in adolescents' emotional eating. Examining the unfolding of emotions in real-time and natural environment is particularly relevant to adolescents, as they are in a developmental stage with many emotional ebbs and flows and variability in emotions (Larson et al., 2002), which may lead to tendencies toward emotional eating.

The enumerated studies highlight the evidence that emotional experiences in daily life are related to emotional eating. Since other researchers have shown evidence linking negative emotional states to increases in emotional eating (Grenard et al., 2013; Kolar et al., 2016; O'Reilly et al., 2015; Ranzenhofer et al., 2016) and health risks and poor health outcomes have been associated with negative emotional experiences and emotional eating (Lindeman & Stark, 2001; Mason et al., 2020; Pinaquy et al., 2003; Van Strien, 2018), we focused our examination of within-person dynamics of emotions on reports of negative emotional states. Since no previous studies have examined the three dynamic characteristics enumerated above in relation to emotional eating, we base our hypotheses on previous studies focused on other mental health correlates of intraindividual dynamics of emotions. Previous studies have demonstrated that lower baselines and lower IIVs in negative emotions are associated with better mental health outcomes (Hardy & Segerstrom, 2017; Oravec et al., 2020). However, the research on emodiversity has been mixed. Whereas two studies by Quidbach et al. (2014) demonstrated that emodiversity is beneficial for mental health outcomes regardless of the valence of the emotions, more recent research has shown that emodiversity in negative emotions is in fact associated with greater symptoms of mental health problems such as depression and anxiety as well as physical health symptoms (Urban-Wojcik et al., 2022; Werner-Seidler et al., 2020). Hence, we hypothesized that lower baselines and IIVs in

negative emotions, as well as lower negative emotion diversity in emotions experienced in daily life will be predictive of lower levels of emotional eating in adolescents.

We also chose to include body mass index (BMI), gender, age, and ethnicity as covariates in our models. Since emotional eating has long been shown to be correlated with weight status and BMI (Boh et al., 2016; Nguyen-Rodriguez et al., 2008), we chose to control for the effect of BMI on emotional eating in our examination. Additionally, as previously described, research has demonstrated that gender differences exist in emotional eating and emotion dynamics (Larsen et al., 2006; Nguyen-Michel et al., 2007) and we, therefore, decided to control for the effect of gender differences in our model. Although our sample was majority Hispanic/Latinx, we, however, had a small percentage of people from other races and ethnicities in our sample. Therefore, we included race/ethnicity as a covariate as well. Age was also included as a covariate to account for potential effect due to age, although the age range of our sample was pretty small.

6 | METHODS

The data in this study was taken from a primary study that examined the associations between students' momentary "cues" (e.g., where students were, who they were with, self-reported emotions, etc.) and their dietary habits. A detailed description of the procedures and measures used in the primary study can be found in Grenard et al.'s (2013) paper.

6.1 | Participants

Students were recruited from schools located within 30 miles of an assessment site in Southern California. In addition, the inclusion criteria for these schools were as follows: a minimum of 100 students, at least 25% of students were eligible for free or reduced-cost lunches, at least 25% were Hispanic, and at most 25% of students were Asian. After the distribution of 3000 flyers, 1423 students expressed interest in participating. The students were screened for age (14–17 years old), proficiency in English (both written and spoken), health status (i.e., free of major illness), treatment for obesity (i.e., no treatment for obesity), and ability to provide transportation to the study site. After screening, 158 students consented to participate. 56.96% identified themselves as female while 43.04% were identified as male. 67.72% were Hispanic, 15.8% were mixed, 5.1% were White, 4.4% were African American, 2.5% were Asian, 2.5% were Native American, and 1.1% were other or missing. The average age of students was 15 ($M = 15.98$, $SD = 1.03$). About half of the participants had parents who had not finished high school. 57% of students were within normal BMI (5th–85th percentile), 18% of students were overweight (85th–95th percentile), and 25% of students were obese (>95th percentile).

6.2 | Procedures

At the beginning of the study, participants read and signed assent forms while parents read and signed consent forms, which were available in both English and Spanish. Participants completed self-report measures on laptop computers to establish baseline assessments of demographics, selected behaviors, and psychosocial variables; the Dutch Eating Behavior Questionnaire (DEBQ)—which was used to measure emotional eating—was also included in this battery of questionnaires, measured one time before the EMA. Personal digital assistants (PDAs) were given to the participants along with instructions and training on how to use them for EMA data collection. Data were collected over a period of 7 days whereby participants would complete three types of reports: Eating Reports, Random Reports, and Evening Reports. For the purpose of the current study, we only used the EMA data from the random reports section of the larger study. EMA prompts would be given twice on school days (once per 3-h interval between 3:00 and 9:00 p.m.) and four times on nonschool days (once per 3-h interval between 9:00 and 9:00 p.m.). Students were instructed to avoid EMA device usage during school hours (8:00 a.m. to 3:00 p.m.) based on school guidelines. Participants reported a variety of information on the Random Reports: food(s)/drink (s) consumed, location of consumption, and factors that surrounded their consumption (moods, activities, exercise levels, stress levels, appetites/cravings, and food availability). For this study, only reports on mood were used from the EMA Random Reports which led to a maximum of 18 possible data points per person (2 per 5 school days + 4 per 2 nonschool days). The completion rate of the respondents was 70.84% with a mean of 1.69 random prompts per day. Participants were compensated for the total time required to attend the training session and complete the EMA protocol upon completion of the study and return of the PDA. Participant compensations were not proportionate to the number of EMA reports completed.

6.3 | Measures

6.3.1 | Emotional states

Thirteen items adapted from the Daily Affect Scale used in other EMA data collections of adolescents measured different emotional states (Weinstein & Mermelstein, 2007; Weinstein et al., 2007). The scale contained four positive emotions (relaxed, happy, energetic, and cheerful) and nine negative emotions (tired, stressed, sad, lonely, left-out, frustrated, embarrassed, bored, and angry) on a sliding scale from 0 (“not at all”) to 100 (“very much”). Using these measures, we created a mean positive emotion score and a mean negative emotion score by aggregating the four positive emotions and the nine negative emotions, respectively. We also used the momentary assessments of these scales to calculate the three person-specific characteristics of negative emotions, described in Section 6.4.

6.3.2 | Emotional eating

Emotional eating was measured using the 13-item subscale of the DEBQ (Van Strien et al., 1986; $\alpha = .93$). In previous research, the DEBQ has demonstrated strong internal consistency, factorial validity, and categorical stability (Van Strien et al., 1986; Wardle, 1987). Participants answered the questions on a five-point scale (“never” to “very often”). Higher scores indicated greater emotional eating. A sample item includes “Do you have a desire to eat when you are emotionally upset?”

6.3.3 | Demographics

Demographic information included ethnicity, age, and gender. Data were coded as binary for both gender (either “male” or “female”) and ethnicity (either “Hispanic or Latino” or “not Hispanic or Latino”). Age varied on a range from 14 to 18, which was rounded down in ages-in-years that participants reported.

6.4 | Data analysis

6.4.1 | Analysis of person-specific characteristics of emotional states

To capture individual differences in self-reports of adolescents' experienced emotions in daily life, we examined three different within-person characteristics of emotional experiences: baseline levels, IIV, and emotional diversity (emodiversity). All missing data were treated as completely at random (MCAR) and were handled using a listwise deletion method.

Baseline

The first intraindividual characteristic calculated was baseline levels of emotional states. Baseline levels in the current study refer to the average level of each discrete emotion that an individual reported experiencing over the 7-day period of EMA measurement. We calculated the baseline levels of each of the 13 discrete emotions measured in the current study by taking the person-specific mean (iMean) of each emotion reported over 7 days by each individual. Figure 1 demonstrates two examples individuals' scores on boredom over the 7-day period. Baseline levels are illustrated via the black horizontal line. The plot on the left in Figure 1 shows an individual with a higher boredom baseline score and the plot on the right shows an individual with a lower baseline score.

IIV

The second intraindividual characteristic calculated in this study was IIV. IIV for emotional states describes the degree in the fluctuation of self-reported levels of emotions around the person's baseline levels. This characteristic is quantified as a within-person variance or standard deviation parameter. We calculated IIVs for each person by taking the person-specific standard deviation (iSD) of each emotional state reported across the 7 days. Figure 2 shows two individuals' sadness scores over time and their fluctuations around the baseline. The left plot in Figure 2 illustrates an individual with lower fluctuations in reported sadness and the plot on the right shows an individual with higher levels of IIV in sadness.

Emodiversity

The third intraindividual characteristic calculated was emotional diversity or “emodiversity.” Emodiversity describes the variety in types of emotions and the level of abundance in emotional experiences one reports in daily life. Figure 3 includes two radar plots illustrating the degree of diversity in two example individuals' reports of 13 emotions—four positive and nine

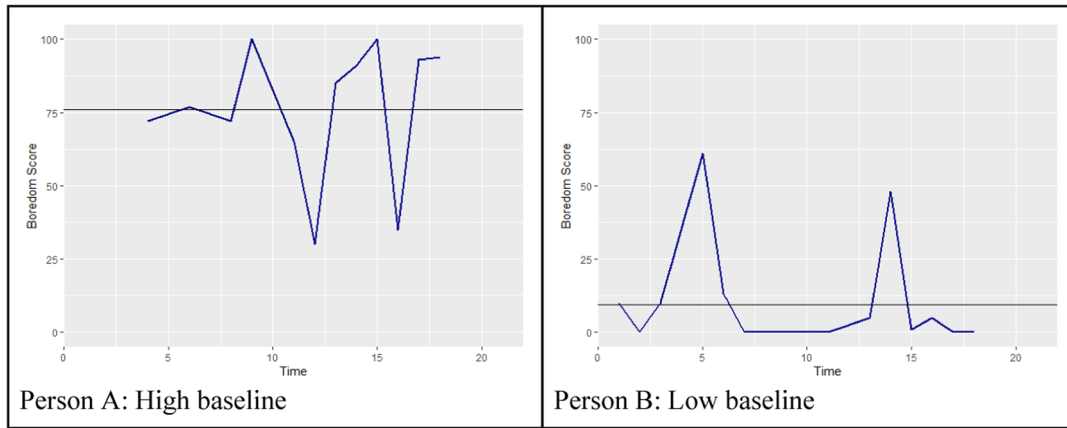


FIGURE 1 Illustration of baseline levels of boredom for two example individuals. Each plot demonstrates one person's self-reported momentary boredom levels across 7 days of the study. The plot on the left illustrates a person with higher baseline levels compared to the person demonstrated on the right-hand side who shows a lower baseline level, despite their observed higher variability of boredom around their baseline.

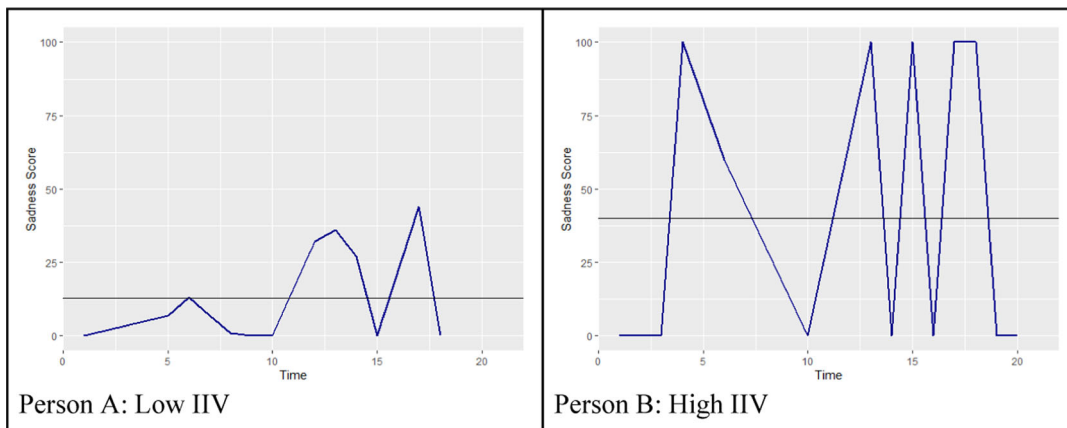


FIGURE 2 Illustration of intraindividual variability of boredom for two example individuals. Each plot demonstrates one person's self-reported momentary sadness levels across the 7 days of the study. Even though the baseline levels (black horizontal line) for the two individuals are close to each other, fluctuation levels for person A is lower than person B.

negative emotions—as experienced across the 7 days of the study. Each radar plot has an angular bar that demonstrates the number of instances each discrete emotion was reported as low (pink) to high (purple) by person A (left radar plot) and person B (right radar plot). Person A demonstrates low negative emodiversity indicated by the sparsity of radar bars for negative emotions but high positive emodiversity indicated by the four radar bars representing all the positive emotions available to report; the global emodiversity for person A was also low. Person B, however, demonstrates high emodiversity in both negative and positive emotions hence displaying high global emodiversity—all 13 discrete emotions were reported to be experienced by person B with high intensity. This is while both persons have to some extent similar mean levels of positive and negative emotions, indicating that measures of emodiversity provide information about people's emotional experiences beyond aggregates of their emotional states.

We calculated two emodiversity indexes—one for negative emotions, and a global one with all 13 emotions. First, responses on the continuous scales of each discrete emotion were recoded into a binary scale such that ratings of “0” were treated as “0” (i.e., no emotion experienced) and nonzero ratings were recoded as “1” (i.e., emotion experienced). The binary scale for each emotion was then used in the following Gini coefficient:

$$GiniDiversity_i = G_i = 1 - \left(\left(\frac{2\sum_{j=1}^m j c_{ij}}{m\sum_{j=1}^m c_{ij}} \right) - \frac{m + 1}{m} \right), \tag{1}$$

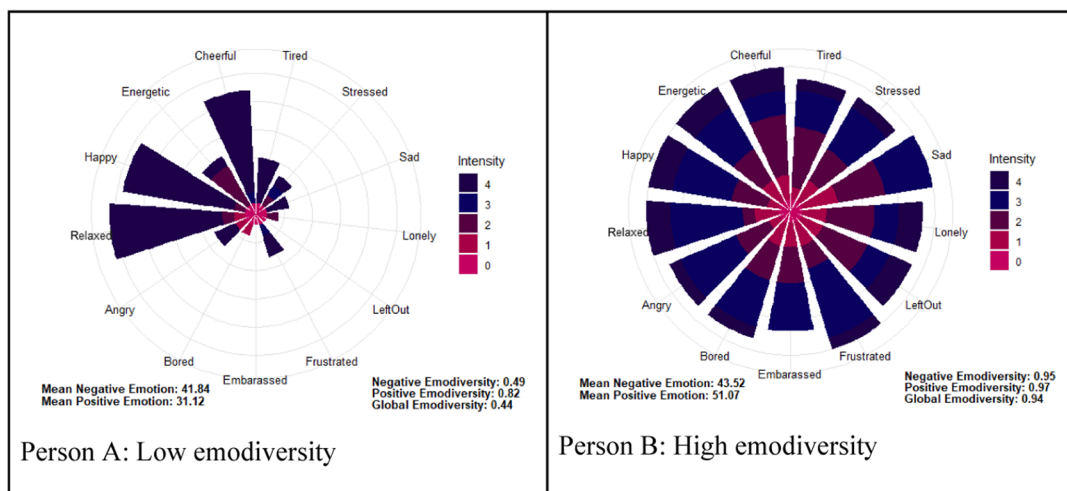


FIGURE 3 Illustration of emodiversity for two example individuals. Two radar plots illustrating two examples persons' emodiversity across the 13 discrete emotions measured in the current study. Each angular bar in the plots indicates the number of instances each emotion was reported and the intensity of those reports as low (pink) to high (purple). Person A (left plot) shows lower emodiversity compared to Person B (right plot) who shows higher diversity across all 13 discrete positive and negative emotions.

where c_{ij} is the count of individual i 's experiences within $j = 1$ to m categories (e.g., emotion types) indexed in nondecreasing order ($c_{ij} < c_{ij+1}$).

High values suggest a more diverse experience of emotions. For example, an individual with an emodiversity of 0 would experience a single emotion while an individual with an emodiversity of 1 would experience all possible emotions.

6.4.2 | Multiple regression analysis

Multiple regression analyses were conducted to evaluate the associations between person-specific characteristics of negative emotionality and emotional eating. We conducted separate regression analyses to test whether (a) emotional baselines, (b) IIV in emotions, and (c) emodiversity are predictive of emotional eating in adolescents. Emodiversity was divided into two categories: global emodiversity and negative emodiversity. The association between each emodiversity measure and emotional eating were evaluated while controlling for grand mean of positive and negative emotions, age, gender, ethnicity, and BMI.

7 | RESULTS

7.1 | Descriptive statistics

Descriptive statistics for all positive and negative emotions, types of emodiversity, and baselines and IIVs can be found in Table 1. Bivariate correlations can be found in the supplemental material. Accordingly, we checked for multicollinearity recommendation for variance inflation factor cutoffs (<5) and found no issues with multicollinearity.

7.2 | Emotional eating and person-specific characteristics of emotional states

7.2.1 | Baselines of negative emotional states and emotional eating

To test whether person-specific baselines of each of the nine negative emotions would predict emotional eating while controlling for age, gender, BMI, and ethnicity, we entered the baseline of all negative emotions into one multivariate regression model predicting emotional eating. Baseline levels in stress ($\beta = .22, p = .039$) and gender ($\beta = .20, p = .019$) were the two significant predictor of emotional eating. The results suggest that higher baselines in daily stress are associated with higher emotional eating above and beyond baselines in other negative emotions while females also showing a higher emotional eating tendency than males.

TABLE 1 Descriptive statistics of person-specific emotion characteristics and emotional eating

	N	Mean	SD		N	Mean	SD
Emotional eating	158	1.94	0.75	iMeanBored	158	32.37	23.47
Positive emotions	158	47.45	17.47	iMeanAngry	158	15.13	14.12
Negative emotions	158	19.81	12.79	iSDTired	157	31.20	11.19
BMI	158	24.99	5.50	iSD Stressed	157	21.88	12.53
Global emodiversity	158	0.55	0.16	iSD Sad	157	17.94	13.17
Negative emodiversity	158	0.54	0.20	iSD Lonely	157	13.27	13.11
iMeanTired	158	43.53	21.20	iSDLeftOut	157	9.24	11.44
iMeanStressed	158	21.85	18.59	iSD Frustrated	157	22.07	12.49
iMeanSad	158	15.76	16.88	iSDEmbarrassed	157	8.28	10.19
iMeanLonely	158	12.25	16.67	iSD Cheerful	157	23.23	11.09
iMeanLeftOut	158	8.18	12.60	iSD Bored	157	24.31	11.57
iMeanFrustrated	158	22.14	19.09	iSD Angry	157	19.24	13.02
iMeanEmbarassed	158	7.12	10.36				

Abbreviations: EmoDiversity, emotional diversity; iMean, within-person mean; iSD, within-person standard deviation; NegEmoDiversity, negative emotional diversity.

7.2.2 | Negative emotional variability and emotional eating

To test whether variability in daily experiences of negative emotions predict emotional eating while controlling for variability in other negative emotions, age, gender, and ethnicity, we entered the IIV's of all negative emotions into one multivariate regression model predicting emotional eating. Once again, out of the nine negative emotions, variability in stress ($\beta = .28$, $p = .037$) was the only negative emotionality predicting emotional eating, with higher variability in daily stress being associated with higher emotional eating. In addition, gender remained a significant predictor of emotional eating ($\beta = .18$, $p = .023$).

7.2.3 | Emodiversity and emotional eating

For each person, two emodiversity values were calculated using the Gini coefficient explained in the data analysis section: (1) global emodiversity including all 13 positive and negative emotions, and (2) negative emodiversity including only the nine negative emotions. We then entered these variables in multiple regression models predicting emotional eating, as explained in the following sections.

Global emodiversity

Multiple regression models were used to determine whether global emodiversity was related to emotional eating independent of mean levels of both positive and negative emotions. Emodiversity was calculated using all 13 emotions and then used in a regression predicting emotional eating. We found that global emodiversity was significantly related to emotional eating ($\beta = .28$, $p = .022$) above and beyond the effect of mean positive emotion ($\beta = -.08$, $p = .341$), mean negative emotion ($\beta = -.08$, $p = .514$) and controlling for age ($\beta = .003$, $p = .971$), gender ($\beta = .17$, $p = .037$), BMI ($\beta = .12$, $p = .118$), and ethnicity ($\beta = -.014$, $p = .073$).

Negative emodiversity

Finally, another regression model was created to examine the relationship between negative emodiversity and emotional eating while controlling for mean levels of positive and negative emotions. Negative emodiversity was calculated using nine negative emotions (tired, stressed, sad, lonely, left-out, frustrated, embarrassed, bored, and angry). Results revealed that negative emodiversity was positively related to emotional eating, ($\beta = .24$, $p = .016$), even when controlling for mean positive emotion ($\beta = -.10$, $p = .207$), mean negative emotion ($\beta = .016$, $p = .875$), age ($\beta = -.004$, $p = .957$), gender ($\beta = .15$, $p = .060$), BMI ($\beta = .13$, $p = .109$), and ethnicity ($\beta = -.012$, $p = .11$).

TABLE 2 Final model with significant predictors of emotional eating

	<i>b</i>	SE	β
<i>Control variables</i>			
Age	-0.002	0.03	-.005
Gender	0.23	0.12	.15
Hispanic	-0.24	0.15	-.12
BMI	0.02	0.01	.11
Positive emotion	-0.0001	0.0002	-.05
Negative emotion	-0.0006	0.0006	-.12
<i>Predictor variables</i>			
Intercept	1.23*	0.60	
Negative emodiversity	0.88*	0.39	.23
iSD stressed	0.001	0.006	.02
iMean stressed	0.006	0.006	.15
R^2	0.14		
<i>F</i>	2.72**		

Abbreviations: BMI, body mass index; iMean, within-person mean; iSD, within-person standard deviation.

* $p < .05$; ** $p < .01$; *** $p < .001$.

7.3 | Final regression model

A final regression model was created to examine all previously identified significant predictors (i.e., stress baseline, stress variability, and negative emodiversity) of emotional eating in one model, predicting emotional eating while all other relationships were accounted for. Negative emodiversity was the only significant predictor of emotional eating ($\beta = .23$, $p = .024$) above and beyond the effect of stress baseline and IIV. The final model along with the relevant statistics can be found in Table 2. From these results, we can conclude that from the possible person-specific dynamics of emotions that we examined, negative emodiversity is the best predictor of emotional eating in adolescents.

8 | DISCUSSION

This study addressed a gap in the literature by applying EMA methods to explore individual differences in person-specific characteristics of emotional experiences as they unfold in everyday life contexts and how they relate to general levels of emotional eating in adolescents. By examining intraindividual characteristics of momentary experiences of emotions—in particular negative emotions—as characterized by baseline levels, IIV, and diversity of emotions, we have gained a better understanding of the *dynamics* of daily emotional states in relation to emotional eating in adolescents.

First, we examined within-person baseline levels (i.e., a person's average level) of negative emotions over moments in adolescents' daily lives. We discovered that across the nine discrete negative emotions, baseline levels of stress were the only significant predictor of emotional eating, above and beyond baseline levels of all other negative emotions while controlling for gender and ethnicity; higher baseline levels in stress predicted higher emotional eating. Stress has been identified previously as a prominent precursor to emotional eating in adolescents (Nguyen-Rodriguez et al., 2008, 2009) and plays a central role in the development, maintenance, and exacerbation of various mental and physical health illnesses (e.g., asthma, rheumatoid arthritis, anxiety disorders, depression; Slavich, 2016). Stress has been linked to unhealthy coping responses in adolescents (e.g., overeating or disordered eating; Cartwright et al., 2003; Pinaquy et al., 2003) and newer evidence suggests that higher levels of stress are associated with fewer healthy behaviors in adolescence (Milas et al., 2019).

Next, we examined emotional variability around the baseline (IIV) across all nine negative emotions in adolescents' daily lives in relation to emotional eating. Through this intraindividual characteristic, we were able to draw distinctions among participants whose average levels of negative emotions might be similar while they might display varied fluctuations in their negative emotionality around the baseline. Once again, across all nine negative discrete emotions, we found that variability in stress was the only significant predictor of emotional eating over and above variability in all other negative emotions while

controlling for gender and ethnicity; as expected, higher fluctuations in experiences of stress predicted higher levels of emotional eating. Despite the scarcity in research looking at IIV in emotions in relation to emotional eating, we find our results being consistent with previous research examining variability in daily life stress with regard to other mental and physical health outcomes. For instance, higher within-person fluctuations of stress have been found to be associated with lower levels of emotion differentiation (Erbas et al., 2018), a phenomenon negatively associated with psychological well-being (Kashdan et al., 2015). Hence, this lowered ability in emotion differentiation as a result of higher variability in stress, may have resulted in the nonsignificant associations between variability in other negative emotions and emotional eating. Other studies have demonstrated that daily stress and stress variability have been negatively associated with self-control (Nielsen et al., 2020), positively associated with depression and self-esteem instability (Franck & De Raedt, 2007), and future poor metabolic control among individuals with Type 1 diabetes (Aikens et al., 1992). These data together suggest that stress may disrupt self-control abilities which, in turn, leads to higher levels of emotional eating. Conclusively, previous research on stress variability's association with mental and physical health supports our finding regarding stress variability's positive association with emotional eating, above and beyond variability in other negative emotions.

Furthermore, we examined the diversity in types of discrete emotions adolescents experienced (i.e., emodiversity) across all negative emotions (negative emodiversity), and all positive and negative emotions together (global emodiversity) in daily life. In accordance with our hypotheses, we found that only negative emodiversity (i.e., diversity in negative emotions) predicted emotional eating. The direction of this association was positive, indicating that the more diversely negative emotions are experienced by adolescents, the more likely it is that they experience emotional eating in their daily lives. This relationship was present even after controlling for individuals' average levels of positive and negative emotions. Drawing on findings from previous research examining mental and physical health correlates of diversity in emotional experiences, our findings on emodiversity in relation to emotional eating were to some extent in line with previous research. Previous research has demonstrated that having high emotional granularity—the capability to differentiate and experience emotions in a more complex and rich way—has been linked to positive mental health and emotion regulation skills (Helson & Wink, 1987; Labouvie-Vief & Medler, 2002; Lindquist & Barrett, 2008). On the other hand, recent research distinguishing between diversity in negative and positive emotional experiences in the context of mental and physical health outcomes have shown different directions (Rivera et al., 2020; Werner-Seidler et al., 2020). For example, one recent study found that enhanced negative emodiversity and reduced positive emodiversity were both correlated with depression (Werner-Seidler et al., 2020). Continuously experiencing negative emodiversity has not only been correlated with mental health conditions (i.e., depression and anxiety) but also physical health conditions (e.g., Type 2 Diabetes, insulin resistance, rheumatoid disease, oxidative stress; Rivera et al., 2020). Thus, while the ability to experience emotions in a complex and diverse way might be important (Lindquist & Barrett, 2008), our finding highlights the necessity to draw distinctions between diversity in positive versus negative emotional experiences, specifically in relation to health problems such as emotional eating in adolescents.

Finally, we examined each of the significant intraindividual characteristics of emotions as predictors of emotional eating found in previous models all together in a final model. With this approach, we were able to investigate whether the effects of each intraindividual characteristic of emotions on emotional eating hold while controlling for others. We found that only negative emodiversity was significantly predictive of emotional eating, above and beyond stress baseline, and stress variability while controlling for mean levels of positive and negative emotions as well as demographics. This finding implies that even though stress is an important factor as it relates to emotional eating, negative emodiversity was the strongest predictor of emotional eating in adolescence.

Adolescence is a vulnerable developmental period marked with variable stress levels and range of emotions. The high levels of stress and emotion variability across adolescence (Maciejewski et al., 2017; Willemsen et al., 2011) are evidence of the well-known “storm and stress” adage of adolescence. Not only are adolescents experiencing declining affect and fluctuating self-worth (Moneta et al., 2001), the interplay of various cognitive, behavioral, emotional, and physiological factors influence their ability to cope with stressors (Connor-Smith et al., 2000) and a range of diverse emotions. Unhealthy coping (e.g., emotional eating) has been associated with negative emotionality (Van Strien, van der Zwaluw, et al., 2010), a common experience during adolescence (Willemsen et al., 2011). Not only did our findings support previous research demonstrating the association between stress, negative emotionality, and emotional eating (Nguyen-Rodriguez et al., 2008, 2009; Van Strien, Snoek, et al., 2010), they further demonstrated that the diversity of experiencing negative emotions predicted emotional eating in adolescents. Food is a source of comfort for adolescents that is used for regulating the effect of stress and improving mood with the increase of dopamine transmission (Kaplan & Kaplan, 1957). Hence, based on emotion regulation theory, eating behavior is more likely to be altered following negative emotionality as opposed to positive emotional experiences and especially when facing stress; stress disrupts self-control (Duckworth et al., 2013; Oaten & Cheng, 2005) and increases the salience of rewarding taste attributes (Hamilton et al., 2014; Maier et al., 2015).

Previous literature around the notion of diversity in emotional experiences highlights the significance of a diverse, rich, and complex emotional life for beneficial psychological outcomes (Barrett, 2009, 2013; Barrett & Bliss-Moreau, 2009). Our results around the importance of emodiversity in emotional eating extend previous literature on emotional complexity and measures of granularity by (a) affirming the significant role of complexity and diversity in emotional experiences in mental

health, specifically for adolescents, and (b) emphasizing the importance of distinguishing between diversity in positive emotions versus diversity in negative emotions vis-a-vis physical and mental health issues such as emotional eating, where diversity in negative emotions might actually be detrimental with regard to adolescents' mental health such as emotional eating.

Our findings not only corroborate previous EMA research but also advance our understanding of the underlying mechanisms of emotional eating. Previously, Smyth et al. (2001) argued for a more naturalistic approach to examining emotional eating and its proximal antecedents such as affective states which change quite rapidly in short time scales. Through EMA research, Smyth and colleagues demonstrated that higher levels of daily perceived stress and increased negative affect contribute to disordered eating behaviors (i.e., bingeing or purging; Deaver et al., 2003; Smyth et al., 2009; Wegner et al., 2002), emphasizing the day-to-day experiences of negative emotionality in eating behavior. Emotion regulation theory also posits that emotion regulation is not a static phenomenon; rather it is conceptualized as a dynamic process that unfolds over time (Gross, 1998). With the change of emotions over time and on a momentary basis, emotion regulatory behavior comprises the dynamic changes in emotional experiences (e.g., variability, inertia, magnitude, etc.; Gross, 1998; Thompson, 1990). This further underscores the importance of examining emotional experiences through their dynamic characteristics in daily life with regard to eating behavior as a potential emotion regulatory system. The approach we adopted in our study confirmed the importance of examining emotions in short time scales in daily life in relation to emotional eating while also shedding light on the importance of dynamic characteristics of change in emotional experiences for adolescents with regard to emotional eating tendencies.

Our major finding about the diversity of negative emotional experiences predicting emotional eating expands upon previous EMA research and aligns with the notion that it is not just negative emotionality in general that leads to eating, rather it is the diversity of negative emotions that are experienced in daily life and the possible challenges of coping with them (e.g., suppress, control) that may help us better understand emotional eating (Evers et al., 2010; Taut et al., 2012; Vandewalle et al., 2014). This finding is supported by Gross's (1998) emotion regulation hypothesis, underscoring the challenge of regulating diverse emotion dynamics in daily life and its effect on eating. Further, based on psychosomatic theory (Bruch, 1964) emotional eating is characterized as the inability of distinguishing between hunger as a physiological state and the experience of high arousing negative emotions, leading to changes in eating behavior as a regulatory system. Our findings, on the other hand, suggest that the diversity of the negative emotions experienced is related to emotional eating in adolescents above and beyond specific types of negative emotionality or their degree of arousal. Hence, when more diverse negative emotions are experienced, tendency toward emotional eating as a means of coping might increase due to further difficulty in distinguishing among diverse emotions and their regulation.

Our findings have important clinical implications for clinicians working with adolescent patients. Clinicians can use this information as a preventive tool or to supplement their interventions with patients who struggle with disordered or emotional eating. Clinicians are recommended to help their patients gain self-awareness around how they cope with emotions and the diversity of their own negative emotional experiences by keeping a daily journal to track antecedent events leading up to eating experiences. Clinicians are also recommended to educate adolescent patients on healthful self-regulation strategies (e.g., diaphragmatic breathing, progressive muscle relaxation) to manage momentary distressing negative emotions. Although not an exhaustive list, these are practical ways to improve emotion regulation strategies whereby interrupting the pattern of emotional eating which can lead to poor health outcomes.

9 | LIMITATIONS AND FUTURE DIRECTIONS

To our knowledge, this is the first study to examine intraindividual characteristics of discrete emotional experiences (i.e., baseline, IIV, emodiversity) in relation to emotional eating in adolescence. Despite decades of research demonstrating the role of emotional experiences in emotional eating, we know substantially less about the relationship between person-specific dynamics of emotional experiences and emotional eating. This alone warrants the need for future studies to further examine the relationship between these dynamical variables in relation to emotional eating in different contexts and across various vulnerable populations. One limitation of our study was that emotional eating was assessed as a one-time assessment and, therefore, may be limited in terms of recall bias. Additionally, the nature of this one-time measure prevented us from assessing the dynamics of emotional eating as related to changes in emotional experiences on a moment-to-moment basis. Future studies are needed to explore the momentary nature of emotional eating in relation to the dynamics of emotional experiences introduced in this study.

A distinctive aspect of our study was the demographics of our participant pool. Over 60% of our sample in the current study were Hispanic which makes our study more inclusive in relation to minority populations. However, we acknowledge that our findings might only be generalizable to the Hispanic adolescent population and we caution our readers from drawing implications to other race/ethnic groups.

Not only should future studies explore dynamical experiences of emotional states and emotional eating among a more racially diverse sample of American youth, but also consider the health disparity as it relates to emotional eating among American minority youth. For instance, prior research has found that not only do Hispanic female adolescents report higher rates of weight-based teasing compared to their White and African American counterparts (Van den Berg et al., 2008), peer and parental weight-based teasing is directly linked to emotional eating among minority girls (Hispanic and African American; Olvera et al., 2013).

10 | CONCLUSION

Adolescents, especially minority youth, are a vulnerable population with fluctuating levels of stress and negative emotionality and thus are more prone to engage in unhealthy behaviors such as emotional eating. Previous research on emotional eating has highlighted the importance of negative emotions in relation to emotional eating. Our study is the first to look at the dynamics of within-person characteristics of negative emotionality in relation to emotional eating in adolescents. By considering the ecological validity of adolescents' daily lives and the moment-to-moment changes in emotions, we are taking a step forward by shedding light on how the nuances of negative emotions might be related to emotional eating in adolescents. By exploring the dynamics of within-person emotional experiences, we were able to illuminate that diversity in negative emotional experiences are meaningfully related to emotional eating.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

This research was approved by the Claremont Graduate University Institutional Review Board (IRB#1292).

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