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Contextual factors associated with eating in the absence of hunger among adults with obesity

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Abstract

Eating in the absence of hunger (EAH) is under-explored in adults with obesity. In this study, 50 adults with obesity recorded eating episodes and theoretically-relevant environmental, perceptual, and emotional correlates in the natural environment for 2 weeks via ecological momentary assessment (EMA). Generalized linear models and mixed models were used to characterize correlates and consequences of EAH vs. non-EAH episodes/tendencies (within-subjects and between-subjects effects, respectively), time of day, and time of day × EAH interactions. Approximately 21% of EMA-recorded eating episodes involved EAH, and 70% of participants reported at least 1 EAH episode. At the within-person level, participants' EAH episodes were associated with greater self-labeled overeating than their non-EAH episodes. At the between-person level, participants who tended to engage in more EAH reported less self-labeled overeating than those who engaged in less EAH. Across EAH and non-EAH episodes, eating in the evening was associated with overeating, expecting eating to be more rewarding, greater alcoholic beverage consumption, eating alone, eating because others are eating, and eating while watching television. Significant EAH × time of day interactions were also observed but the pattern of findings was not consistent. Findings suggest that EAH may be a relevant target for reducing food intake in

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individuals with obesity given its high prevalence and association with perceptions of overeating, although results should be extended using objective measures of food intake. Associations between evening eating episodes and perceptual and environmental factors should be further explored.

Keywords

Eating in the absence of hunger; disinhibited eating; overeating; obesity; overweight; ecological momentary assessment

1. Introduction

Obesity is associated with significant morbidity and mortality.[1] While multiple genetic and environmental factors contribute to obesity,[2] modifiable lifestyle factors such as eating behaviors have been subject to considerable research given their relevance to prevention and treatment.[3] Disinhibited eating, characterized by a lack of healthy restraint over eating including eating in the absence of hunger (EAH),[4] may promote excess energy intake,[5] unhealthy weight gain,[6–8] and obesity.[9–11] Contrary to pediatric samples,[12] EAH in adults is underexplored,[5, 13–17] particularly in the natural environment.[18]

Historically, obesity has been alternately attributed to an inability to discriminate between physiological hunger and emotional states,[19] and to hyper-reactivity to external food-related cues (e.g., taste of food) accompanied by hypo-reactivity to internal cues related to eating (e.g., hunger, satiety).[20] Evolving hypotheses of obesity now generally recognize that obesity is a highly complex, multi-factorial condition which originates from a dynamic interplay of environmental and individual factors.[21] Increasing rates of obesity have been largely attributed to the “toxic” food environment, in which highly palatable, energy dense food is omnipresent and easily accessible.[22, 23] Mere exposure to food cues triggers a series of physiological processes in preparation for digestion (e.g., salivation),[24] even when sated,[25] and these responses may be enhanced among individuals who are overweight.[26] The presence of palatable foods has been linked to overeating in both experimental[27] and naturalistic studies.[28] Simply expecting that food will be pleasurable or rewarding has been related to overeating in several studies,[29, 30] and these effects may be pronounced in individuals with obesity, who tend to experience greater reward while anticipating and consuming palatable foods.[31] Distractions that impair one’s focus on eating and ability to self-monitor intake (e.g., television viewing, conversing with dining companions) can also lead to increased palatable food consumption,[32, 33] perhaps via inhibiting taste perceptions.[34] Indeed, social facilitation effects on energy intake (i.e., eating more in the presence of others) are well-documented in the literature[35] and appear to be independent of pre-prandial hunger.[36] Finally, alcohol consumption may elicit disinhibited eating, perhaps via reducing self-regulation or enhancing the reward salience of food cues.[37]

Stress[5, 14, 38] and negative affect[39] also have been linked to disinhibited eating. It has been suggested that the naturally rewarding effects of food alleviate low mood via opioidergic, dopaminergic, and serotonergic mechanisms,[40] although some data suggest that acute stress mitigates the brain’s reward response to food cues.[13] While acute stress tends to

down-regulate appetite,[41] overweight individuals show increased EAH following a stress induction,[14] which may partially explain the relationship between stress and weight gain among those with higher initial body mass indices.[42] Similarly, negative mood may be associated with increased energy intake in individuals with obesity,[43, 44] but the role of hunger in this relationship is unclear.

Most studies of disinhibited eating have been conducted using retrospective self-report or laboratory-based methodologies.[45] Thus, there is a need to better understand proximal correlates and consequences of these behaviors using more ecologically valid approaches. Ecological momentary assessment (EMA) has been utilized extensively in studies of binge eating,[46] but less so in research on other problematic eating patterns that may contribute to excess weight.[28] EMA is ideal for exploring EAH in the natural environment, as it can be used to assess intrapersonal and environmental factors that precede and follow these episodes in real time.

The purpose of the current study was to utilize EMA to examine contextual correlates and consequences associated with EAH among adults with obesity. We hypothesized that, relative to non-EAH episodes, EAH episodes would be associated with increases in negative affect, stress, eating-related expectancies, and disinhibiting environmental cues, and would result in perceptions of having eaten excessively. This exploratory study was designed to contribute to the small body of literature on EAH in adults by assessing momentary factors associated with such eating episodes, which could inform the development and refinement of behavioral weight control interventions.

2. Material and methods

2.1 Participants

Participants were 50 adults, aged 18–65, with a body mass index (BMI; kg/m^2)>30, who were recruited from the community. Five participants (10%) met criteria for binge eating disorder (BED). Because individuals with BED comprise a significant subset of individuals with obesity,[47] these individuals were included in all analyses to enhance the representativeness of the sample and generalizability of the findings. Moreover, previous research suggests that individuals with obesity who deny binge eating during an initial interview commonly report binge episodes during EMA protocols,[48] and there appear to be many shared momentary binge antecedents across BED and non-BED samples with obesity.[49] Therefore, we did not expect the inclusion of individuals with BED to bias the findings. Exclusion criteria included previous gastrointestinal surgery; being currently pregnant or breastfeeding; participating in concurrent treatment for obesity; inability to read/understand English; and current or past diagnosis of anorexia nervosa or bulimia nervosa. The presence of other psychiatric disorders was not an exclusion criterion.

2.2 Procedures

This study was approved by the University of Minnesota Institutional Review Board. Although we have previously published several studies from this dataset on contextual factors associated with eating behavior in individuals with obesity,[50–53] the current study

was the first to specifically report on factors associated with EAH. A phone screen was conducted to assess initial eligibility criteria. Participants then attended a baseline assessment at the research facility during which they provided written informed consent, completed in-person assessments to confirm eligibility, and were trained to use the handheld computer for the EMA protocol.

EMA data were collected using Handspring Visors and Satellite Forms software (Alberta, Canada). Participants completed a 2-day trial period to ensure compliance with EMA procedures; all 50 participants completed the trial period, although trial data were not included in the analyses. After training, participants completed a 2-week EMA protocol during which they were instructed to complete recordings before and after eating; before bedtime; and after 6 semi-random prompts, which occurred every 2–3 hours between 8:00am and 10:00pm. Semi-random prompts were utilized to capture variables of interest to the study that were non-discrete and likely to vary continuously over time (e.g., mood).[54] Participants attended 2 in-person visits over the 2 weeks, during which data from the handheld computer were uploaded and monitored for compliance, and research coordinators provided feedback to participants about the quality of the data. Participants received $150 for completing the 2-week protocol and an additional $50 for completing at least 90% of signaled assessments within 45 minutes of semi-random prompts.

2.3 Measures

2.3.1 Psychosocial measures—The eating disorders module of the well-validated Structured Clinical Interview for DSM-IV Axis I Disorders/Patient Edition (SCID-I/P)[55–57] was administered by a trained master's- or doctoral-level researcher to assess current binge eating patterns and current or lifetime eating disorders. Participants also completed the Eating Disorders Questionnaire (EDQ),[58] a self-report measure assessing current and past dieting attempts ("Do you try to avoid certain foods in order to influence your shape or weight?"; "Over the last year, how often have you begun a diet that lasted for more than 3 days?") and psychiatric medication usage.[59]

2.3.2 Momentary measures—Participants were asked to rate their current hunger levels ("Please rate the extent to which you agree with the following statement: I am hungry") via a 1- to 5-point Likert scale (1="disagree strongly;" 5="agree strongly") at pre- and post-eating episode recordings. EAH episodes were defined as those preceded by low to neutral hunger levels (score of 1–3 on the Likert scale), while non-EAH episodes were defined as those preceded by moderate to high hunger levels (score of 4 or 5 on the Likert scale).

Participants reported on the extent to which their eating was influenced by others ("Please rate the extent to which you agree with the following statement: I am eating because others are eating") via the same 1- to 5-point Likert scale (1="disagree strongly;" 5="agree strongly") at pre-episode recordings. The location of the episode (home, car, work, school, cafeteria, restaurant, outside, or other), presence of dining companions ("Did you eat alone/with other people?"), watching television (yes/no), and alcohol consumption ("How much alcohol did you drink prior to and/or during the time you ate?"; range=0 to 5 or more drinks) were assessed at post-episode recordings.

Food hedonics (“I will enjoy the taste of this food”), affective expectancies (“If I eat this, I will feel better”), and restraint over eating (“I will eat less food to lose weight or to avoid gaining weight,”) all rated on the same 1- to 5-point Likert scale (1=“disagree strongly;” 5=“agree strongly”), as well as taste expectancies [“On a scale of 1 (terrible) to 10 (the best thing you have ever tasted), how good do you think this food will taste?”] all were assessed at pre-episode recordings. Post-episode recordings included the extent to which the episode was characterized by overeating (“To what extent do you feel that you overate?”) and/or loss of control (“While you were eating, to what extent did you feel…a sense of loss of control?”; “…that you could not stop eating once you started?”; “…that you could not resist eating?”; “…driven or compelled to eat?”), both of which were rated on a 1- to 5-point Likert scale (1=“not at all;” 5=“extremely”). Because of evidence that eating episodes involving loss of control differ from those that do not,[50] and that these episodes are distinct from EAH,[17] we excluded from the analyses any eating episodes characterized by a score of 4 or 5 on any of these four loss of control items (n=590).

Stress (“Please rate your current level of stress,” rated on a 1- to 5-point Likert-type scale where 1=“not at all” and 5=“extremely”) was assessed at pre-episode recordings. Negative affect was assessed via an abbreviated version of the Positive and Negative Affect Schedule (PANAS)[60] at pre- and post-episode recordings, and pre- to post-episode change in negative affect was calculated. The PANAS Negative Affect scale represents the sum of 11 items (e.g., afraid, upset), each rated on a 5-point scale, with a score of “1” indicating “not at all” and a score of “5” indicating “extremely.”

2.4 Statistical Analysis

Analyses were conducted in SPSS 22.0. Generalized linear models compared EAH and non-EAH episodes on their relation with *categorical* (location, influenced by others, alcohol consumption) and *dichotomous* (watching television, presence of dining companions) EMA-reported cues, while mixed model analyses were conducted to compare these episodes on their relation with *continuous* cues (overeating, food hedonics, affective expectancies, taste expectancies, change in negative affect, stress level). EAH was centered into between- (the person-specific *proportion* of all eating episodes involving EAH; hunger<4) and within-subjects (*momentary* indicator of presence/absence of EAH) components. EAH was included as a predictor, rather than an outcome variable, to avoid backwards temporal prediction, since approximately half of the contextual variables were assessed at post-episode recordings (whereas the operationalization of EAH was based on pre-episode hunger ratings). All models included effects for within- (momentary EAH ratings centered around each participant’s mean) and between-subjects (grand mean centered person-averaged) EAH, time of day (given evidence that disinhibited eating may vary by time of day),[61] and interactions between time of day and within- and between-subjects EAH effects as defined above. Time of day was categorized into morning (6:00am–11:00am), afternoon (11:00am–4:00pm), and evening (4:00pm–11:00pm). Significant interactions were probed using simple slopes tests in which time of day was converted to a continuous variable.[62] Analyses adjusted for body mass index and current/lifetime full- or sub-threshold BED.

For clarity, we report in text the *F* or Wald chi-square values corresponding to the overall tests of model effects, as well as the estimates of fixed effects or *B*s for specific contrasts, and their corresponding *S.E.* and *p*-values. False discovery rate (FDR) corrections were applied to all *p*-values for main and interaction effects yielded by the overall tests of model effects using the Benjamini-Hochberg procedure.[63, 64] This procedure involves ranking raw *p*-values from smallest to largest, and calculating the proportion of effects, according to rank and number of overall tests, that fall within a pre-selected allowable false discovery rate (i.e., the proportion that are likely to be false rejections of the null hypothesis). All *p*-values for main and interaction effects were entered simultaneously. Because analyses were exploratory, corrections were set to allow a 10% false discovery rate. Only effects that withstood FDR corrections are reported as significant in text. Power analyses were conducted during the design phase of the study. Given a two-tailed alpha of .05, and a conservative estimated subject standardized effect size difference of .5 (a moderate effect size),[65] power was .93 with a sample size of 50.

Results

3.1 Descriptive Characteristics

Table 1 describes the demographic characteristics of the sample. Participants completed an average of 13.9 (*SD*=2.5) days of EMA recordings, including 68.5 (*SD*=26.0) pre- and post-episode recordings. There was 82.2% compliance to responding to semi-random signals within 45 minutes and 78.9% compliance to completing end-of-day recordings. Although 8% of participants terminated early, their data were included in the analyses.

After excluding 590 loss of control eating episodes, 646 eating episodes were analyzed, including 135 (20.9%) EAH episodes and 511 (79.1%) non-EAH episodes; 32 (70%) participants reported at least one EAH episode (range=0 to 32). EAH and non-EAH episodes did not differ with respect to time of day, $F(1,473)=0.77$, $p=.380$. Most participants reported current food avoidance (66.0%; $n=33$) and/or recent dieting attempts (60.8%; $n=28$) on the EDQ, and 24.8% ($n=160$) of eating episodes were characterized by moderate to strong agreement with the statement, “I will eat less to lose weight or to avoid gaining weight.” A minority of participants reported currently taking psychiatric medications (40%; $n=20$), or having done so in the past (32%; $n=16$).

3.2 Main Effects

3.2.1 EAH—There were few main effects for within- or between-subjects EAH versus non-EAH (see Table 2). One exception was that EAH was associated with perceiving oneself as having overeaten at the within-subjects, $F(1,42)=9.00$, estimate of fixed effect=1.14, *S.E.*=0.40, $p=.005$, and between-subjects levels, $F(1,36)=9.21$, estimate of fixed effect= −1.01; *S.E.*=0.38; $p=.011$. Participants’ EAH episodes were significantly more likely to be associated with self-labeled overeating than their non-EAH episodes (within-subjects effect). Conversely, participants who reported *more* EAH during the protocol reported significantly *less* self-labeled overeating than those who reported *fewer* EAH episodes (between-subjects effect).

3.2.2. Time of day—Eating in the evening was more likely than eating in the morning to be associated with eating alone, Wald chi-square=15.59, *B*=−1.85, *S.E.*=0.52, $p<.001$; influenced by others, $F(2,585)=9.42$, estimate of fixed effect=−0.30, *S.E.*=0.10, $p=.002$; alcohol consumption, Wald chi-square=9.41, *B*=−0.21, *S.E.*=0.05, $p=.018$; food hedonics, $F(1,594)=9.12$, estimate of fixed effect=−0.28, *S.E.*=0.07, $p<.001$; taste expectancies, $F(1,588)=4.79$, estimate of fixed effect=−0.34, *S.E.*=0.12, $p=.005$; and overeating, $F(2,601)=17.47$, estimate of fixed effect=−0.42, *S.E.*=0.07, $p<.001$. Eating in the evening, Wald chi-square=99.61, was also more likely to occur while watching television than eating in the morning, *B*=−1.53, *S.E.*=0.33, $p<.001$, or afternoon, *B*=−2.09, *S.E.*=0.21, $p<.001$.

3.3 Interaction Effects

There was a significant interaction between EAH and time of day in terms of eating while watching television at the within-subjects, Wald chi-square=13.38, *B*=4.25, *S.E.*=1.23, $p=.001$, and between-subjects levels, Wald chi-square=12.95, *B*=1.95, *S.E.*=1.01, $p=.002$. At the within-subjects level, the probability of watching television was significantly *lower* for EAH relative to non-EAH episodes in the morning and afternoon hours, ps<.01, and significantly *higher* for EAH relative to non-EAH episodes in the evening hours, $p=.026$. At the between-subjects level, the probability of watching television was significantly *higher* for people who engaged in more EAH as compared to those who engaged in less EAH in the morning hours, $p<.01$, but significantly *lower* for people who engaged in more EAH as compared to those who engaged in less EAH in the evening hours, $p<.01$. The probability of watching television did not differ between participants engaging in relatively more or less EAH in the afternoon hours at the between-subjects level, $p=.640$.

3. Discussion

This study investigated contextual cues associated with naturalistic EAH among adults with obesity. At the momentary level, participants were more likely to report overeating after EAH compared to non-EAH episodes. Time of day was associated with multiple perceptual and environmental factors, regardless of EAH, which may be reflective of the typical structure of the day in the American culture. Overall, there were few contextual variables with which EAH was systematically associated. Therefore, mechanisms driving EAH require further study, especially given associations between EAH and excess weight status.[12] Indeed, time of day may be a more salient factor in the context of eating episodes than EAH in individuals with obesity, suggesting that weight control interventions may benefit from addressing time of day effects on eating behavior (e.g., encouraging mindful eating in the evening, when distractions may be more common).

Our finding that EAH was associated with perceptions of having overeaten at the within-subjects level is consistent with findings that overeating and EAH are distinct but overlapping constructs,[45] and that EAH may lead to excess energy intake.[12] The link between EAH and excessive energy intake may have served a functional purpose in times when food was not readily available,[66] as excess energy could be stored for use during periods of famine,[67] thus promoting survival. However, in today's obesogenic environment, such a link may be associated with adverse health outcomes. It is important to note,

however, that perceptions of overeating do not necessarily reflect excess energy ingestion; therefore, results should be replicated using more objective methodologies. Moreover, while between-subjects findings that tendencies to engage in more EAH across participants was inversely associated with overeating may seem contrary to within-subjects effects, the former may suggest that for some individuals, EAH reflects continuous eating behavior or "grazing," rather than discrete eating episodes. Although "grazing" behaviors were not assessed in the current study, future replication studies should include measures of typical eating patterns to address this possibility.

Contrary to expectations, EAH was not related to affective cues, which are well-established antecedents to binge eating episodes in BED and related disorders.[68, 69] BED status was also unrelated to these cues as depicted in Table 2, although eating episodes involving loss of control were not analyzed, which may have influenced the findings. Mood-related factors may be more relevant to the momentary occurrence of *pathological* eating behaviors as compared to more normative types of eating behavior such as EAH. Indeed, previous work from our group using the same dataset suggested that episodes involving both loss of control and overeating were associated with higher levels of negative affect than overeating without loss of control.[50] However, further research directly comparing binge eating to EAH and other types of potentially problematic eating episodes is needed.

Tests of interaction effects revealed complicated relationships between EAH and time of day. For television-watching, at the within-subjects level, individuals' experience of EAH was associated with a lower likelihood of eating while watching television during the morning and afternoon hours, as compared to their non-EAH episodes, perhaps suggesting that watching television in the morning is simply a marker of any eating behavior, rather than EAH specifically. However, at the between-subjects level, participants who generally engaged in more EAH during the EMA protocol were more likely to eat while watching television in the morning and less likely to eat while watching television in the evening, as compared to participants who generally engaged in *less* EAH. The reverse pattern was found for participants who engaged in less EAH. Taken together, EAH does not consistently track with either of these variables. Indeed, the inconsistent pattern of results may reflect that findings are spurious effects related to multiple testing.

We found a number of unanticipated but interesting results regarding time of day effects on the context of eating episodes. Eating in the evening, regardless of EAH, was associated with greater expectations about hedonic aspects of eating, greater alcohol consumption, and a higher likelihood of overeating, eating alone, with the television on, and because others were eating, relative to eating in the morning and/or afternoon. These findings suggest that adults with obesity may view eating as a way to unwind from the day's activities in the evening by pairing eating with other pleasurable activities (although in the absence of a control group of normal-weight status, it cannot be assumed that this tendency is specific to adults with obesity). This hypothesis is consistent with previous evidence that such factors may promote mindless or excessive eating.[28, 33, 35] However, it is also possible that opportunities to combine eating with other activities are more prevalent in the evening, which tends to be less structured than the daytime. Given that evening eating episodes were associated with perceived overeating in the current study, and with overall daily energy

intake in previous studies,[62, 70] future research should further explore energy consumption patterns associated with evening eating episodes, independent of hunger.

This study had several strengths, including the use of EMA to characterize eating behavior, and the heterogeneous community-based sample of adults with obesity, which enhances generalizability. However, several limitations may have contributed to the limited significant effects for EAH. First, the study involved secondary analysis of data and was designed to generally understand factors related to eating behavior in individuals with obesity, rather than specifically to assess EAH. Indeed, due to constraints of the methodology, which involved participants completing hunger ratings *before* and *after* but not *during* eating episodes (to avoid reactivity), it was not possible to generate an EAH construct that approximated the operationalization used in the previous literature (i.e., quantitative assessment of continued eating behavior after having already eaten to satiety in a laboratory setting).[12] Second, the sample was relatively small, and predominantly Caucasian and female, despite obesity's overrepresentation among non-Hispanic black and Hispanic adults, and equivalent gender distribution in the population.[71] Moreover, the sample included individuals who were attempting to control their weight or restrict their eating during some or all of the EMA protocol, as well as those who were taking psychiatric medications that could potentially impact eating behavior; however, these could also be perceived as study strengths in terms of enhancing the heterogeneity of the sample and generalizability of the findings. Third, there was no normal-weight control group which would have provided a meaningful comparison against which to evaluate the eating behavior of individuals with obesity. Fourth, many of our momentary measures, including hunger ratings, were based on self-report and were inherently subjective. Biases introduced by these measurement issues may offer alternative explanations for some of the findings (e.g., individuals who tend to engage in EAH more frequently in daily life may have rated themselves as *less* likely to overeat during momentary ratings because their threshold for overeating is naturally higher). Without objective measures of energy intake, it cannot be ascertained that perceptions of eating behavior during the EMA protocol are representative of all instances of EAH. Fifth, because most contextual variables were assessed concurrently with their associated eating episodes, temporal relationships among the constructs could not be inferred. Lastly, although EMA studies show limited reactivity effects,[72] the EMA protocol could have decreased EAH episode frequency due to the effects of self-monitoring on attendance to internal hunger and satiety cues. Alternatively, participants may have recorded EAH episodes less frequently due to decreased awareness during these eating episodes.

In summary, EAH is an obesity-related phenotype that has been well-studied in children, but is poorly understood in adult populations. Our data suggest that EAH may be associated with self-labeled overeating in the natural environment, but was minimally or inconsistently associated with emotional or environmental factors. We found evidence that eating in the evenings was associated with greater eating-related expectancies and several environmental factors that have been shown in previous research to promote disinhibited eating. This was one of the first studies, to our knowledge, to investigate EAH in the natural environment among adults with obesity, and although specific contextual variables related to EAH were limited, our findings suggest that EAH may be an important target of weight control interventions for adults given its association with perceptions of overeating (although results

should be substantiated using more objective assessments of energy intake). Furthermore, findings regarding eating in the evening should be used to guide future research and clinical work, in particular, in helping to devise stimulus control interventions to minimize the impact of environmental and perceptual factors on risk for excess energy intake.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Abbreviations

EAH	eating in the absence of hunger
EMA	ecological momentary assessment
SCID-I/P	Structured Clinical Interview for DSM-IV Axis I Disorders/Patient Edition
PANAS	Positive and Negative Affect Schedule

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Table 1

Sample characteristics

Variable	Full Sample (*N*=50)
Age, y	*M*=43.0; *SD*=11.9
Body mass index, kg/m^2	*M*=40.32; *SD*=8.51
Sex, % female (*n*)	84.0 (42)
Race, % (*n*)	
White	76.0 (38)
African-American	14.0 (7)
Asian	6.0 (3)
Other	4.0 (2)
Attended or completed college, % (*n*)	76.0 (38)
EMA eating in the absence of hunger frequency	*M*=2.7; *SD*=4.6
EDQ current food avoidance, % (*n*) endorsing	66.0 (33)
EDQ dieting in the past year, % (*n*) endorsing *	60.8 (28)
EDQ psychiatric medication usage, % (*n*) endorsing	
Current	40 (20)
Past	32 (16)

Note: EMA=ecological momentary assessment; EDQ=Eating Disorders Questionnaire.

* Percentage does not reflect a denominator of *N*=50 due to missing data.

Table 2

Parameter estimates for contextual variables associated with within- and between-subjects main eating in the absence of hunger and time of day

Contextual variable	BMI	Binge eating status	Within-subjects main effect	Between-subjects main effect	Main effect for time of day (with evening as the reference category)	
					Morning	**Afternoon**
ENVIRONMENTAL CUES						
Location of episode	*B*=−0.04; *S.E.*=0.05; *p*=.375	*B*=−0.78; *S.E.*=0.90; *p*=.385	*B*=5.39; *S.E.*=2.38; *p*=.024	*B*=0.19; *S.E.*=3.57; *p*=.958	*B*=2.90; *p*<.001	*B*=0.21; *p*<.001
Eating while alone	*B*=−0.00; *S.E.*=0.03; *p*=.970	*B*=−0.32; *S.E.*=0.80; *p*=.687	*B*=0.82; *S.E.*=1.27; *p*=.519	*B*=−1.25; *S.E.*=1.27; *p*=.325	***B*=−1.85; *S.E.*=0.52; *p*<.001**	*B*=−0.14; *S.E.*=0.24; *p*=.551
Eating while watching television	*B*=0.09; *S.E.*=0.04; *p*=.029	*B*=2.09; *S.E.*=0.84; *p*=.013	*B*=−0.76; *S.E.*=1.24; *p*=.543	*B*=−0.55; *S.E.*=1.24; *p*=.655	***B*=−1.53; *S.E.*=0.33; *p*<.001**	***B*=−2.09; *S.E.*=0.21; *p*<.001**
Eating because others are eating	Estimate=0.05; *S.E.*=0.02; *p*=.054	Estimate=0.24; *S.E.*=0.49; *p*=.627	Estimate=−0.56; *S.E.*=0.79; *p*=.476	Estimate=0.57; *S.E.*=0.77; *p*=.467	**Estimate=−0.30; *S.E.*=0.10; *p*=.002**	Estimate=0.11; *S.E.*=0.10; *p*=.239
Alcohol consumption before and during eating episode	*B*=−0.01; *S.E.*=0.00; *p*=.136	*B*=−0.03; *S.E.*=0.05; *p*=.558	*B*=−0.17; *S.E.*=0.21; *p*=.413	*B*=0.09; *S.E.*=0.22; *p*=.684	***B*=−0.12; *S.E.*=0.05; *p*=.018**	*B*=−0.11; *S.E.*=0.05; *p*=.048
PERCEPTUAL CUES						
Food hedonics (I will enjoy the taste of this food)	Estimate=0.03; *S.E.*=0.01; *p*=.024	Estimate=0.68; *S.E.*=0.24; *p*=.006	Estimate=−0.08; *S.E.*=0.40; *p*=.833	Estimate=0.27; *S.E.*=0.39; *p*=.487	**Estimate=−0.28; *S.E.*=0.07; *p*<.001**	Estimate=−0.05; *S.E.*=0.07; *p*=.459
Taste expectancies (On a scale of 1 to 10, how good do you think this food will taste?)	Estimate=0.03; *S.E.*=0.02; *p*=.172	Estimate=0.99; *S.E.*=0.53; *p*=.067	Estimate=−0.74; *S.E.*=0.86; *p*=.394	Estimate=0.84; *S.E.*=0.85; *p*=.323	**Estimate=−0.34; *S.E.*=0.12; *p*=.005**	Estimate=−0.02; *S.E.*=0.12; *p*=.852
Affective expectancies (If I eat this, I will feel better)	Estimate=0.01; *S.E.*=0.02; *p*=.504	Estimate=−0.08; *S.E.*=0.40; *p*=.846	Estimate=−0.48; *S.E.*=0.65; *p*=.461	Estimate=0.77; *S.E.*=0.64; *p*=.238	Estimate=0.07; *S.E.*=0.06; *p*=.244	Estimate=0.05; *S.E.*=0.06; *p*=.360
Overeating	Estimate=0.03; *S.E.*=0.01; *p*=.007	Estimate=0.26; *S.E.*=0.24; *p*=.293	**Estimate=1.14; *S.E.*=0.40; *p*=.005**	**Estimate=−1.01; *S.E.*=0.38; *p*=.011**	**Estimate=−0.42; *S.E.*=0.07; *p*<.001**	Estimate=−0.13; *S.E.*=0.07; *p*=.061
EMOTIONAL CUES						

Contextual variable	BMI	Binge eating status	Within-subjects main effect	Between-subjects main effect	Main effect for time of day (with evening as the reference category)	
					Morning	Afternoon
Change in negative affect	*B*=0.02; *S.E.*=0.02; *p*=.280	*B*=0.22; *S.E.*=0.54; *p*=.686	*B*=0.91; *S.E.*=0.50; *p*=.066	*B*=−0.75; *S.E.*=0.58; *p*=.197	*B*=−0.01; *S.E.*=0.24; *p*=.962	*B*=0.14; *S.E.*=0.17; *p*=.417
Pre-episode stress level	Estimate=0.01; *S.E.*=0.02; *p*=.550	Estimate=−0.40; *S.E.*=0.42; *p*=.347	Estimate=0.88; *S.E.*=0.68; *p*=.201	Estimate=−0.93; *S.E.*=0.67; *p*=.177	Estimate=−0.08; *S.E.*=0.06; *p*=.190	Estimate=0.02; *S.E.*=0.06; *p*=.770

Note: BMI=body mass index (m/kg^2). Morning=6:00am–11:00am; afternoon=11:00am–4:00pm; evening=4:00pm–11:00pm. Bold font indicates effects that remained significant after 10% false discovery rate corrections were applied to main effects for within-subjects eating in the absence of hunger, between-subjects eating in the absence of hunger, and time of day using the Benjamini-Hochberg procedure.