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Ecological momentary assessment of eating episodes in obese adults

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Abstract

Objective—The context of eating episodes in obesity is poorly understood. This study examined emotional, physiological, and environmental correlates of pathological and non-pathological eating episodes in a heterogeneous sample of obese adults.

Methods—Community-based participants [*n*=50; 84% female (*n*=42); *M* body mass index=40.3±8.5; *M* age=43.0±11.9] with (*n*=5; 10%) and without binge eating disorder (BED; *n*=45; 90%) recorded all eating episodes and their associated emotional, physiological, and environmental factors via ecological momentary assessment for two weeks. Generalized estimating equations examined relations between these variables and eating episodes characterized by both self-identified loss of control while eating and overeating (binge eating; BE), loss of control only (LOC), overeating only (OE), and neither loss of control nor overeating (non-pathological eating; NE).

Results—Episodes involving loss of control (BE and LOC) were associated with the highest levels of pre- and post-episode negative affect (Wald chi-square range=15.67–24.39; *p*s≤.001), while those involving overeating (BE and OE) were associated with the lowest levels of pre- and post-episode hunger (Wald chi-square range=18.14–39.75; *p*s<.001). LOC episodes were followed

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by the highest level of post-episode cravings (Wald chi-square=25.87; $p<.001$) and were most likely to occur when participants were alone (Wald chi-square=13.20; $p=.004$).

Conclusion—Binge and loss of control eating were more consistently associated with emotional and physiological cues than overeating and non-pathological eating, while most environmental variables did not differ among eating episode types. Results support distinctions among the different objective and subjective constructs characterizing aberrant eating, and should be used to inform interventions for obesity and related eating pathology.

Keywords

Obesity; binge eating; loss of control; overeating; ecological momentary assessment

Obesity affects approximately 35% of adults in the United States (1) and is associated with adverse physical and psychosocial health consequences (2). At its most basic, obesity results from an excess of energy intake relative to energy expenditure (3); however, multiple environmental and personal factors can contribute to excess energy intake. Behavioral treatments for obesity have limited long-term efficacy (4), perhaps due in part to an insufficient understanding of correlates of eating behaviors contributing to excess energy intake. Thus, a better understanding of the context in which excessive eating episodes occur can ultimately help contribute to the development of more effective interventions.

Binge eating, a form of problematic eating that is prevalent among obese individuals (5), is characterized by overeating (i.e., consuming an objectively large amount of food) while experiencing a sense of loss of control (i.e., a feeling that one cannot control what or how much one is eating) (6). While approximately 2–3% of community-based individuals meet formal criteria for DSM-IV binge eating disorder (BED; 7), subthreshold binge eating behaviors are frequently reported by obese individuals who deny binge eating on interview (8, 9). Thus, there is a need to better characterize binge eating behaviors in heterogeneous samples of obese individuals in order to maximize the applicability of weight control interventions across subsets of the obese population.

An ongoing controversy in the literature concerns the validity of the distinct components of a binge eating episode (10). As noted above, the current definition of binge eating refers to the presence of both overeating and loss of control (6). However, while loss of control may be more relevant to the experience of distress (11, 12), binge size appears to be positively associated with obesity severity (13). Because overeating and loss of control can occur independently of one another and are each related to different clinical indicators (14), it is important to identify whether distinct contextual variables contribute to the occurrence of each separately as well as to their co-occurrence.

Ecological momentary assessment (EMA; 15) is a behavioral sampling technique in which emotions, behaviors, and cognitions are assessed in “real time” in the natural environment using a handheld computer device. EMA has several advantages over typical self-report methods, including enhanced ecological validity and reduced retrospective recall bias (16). EMA is thus well-suited for the study of eating episodes and their correlates in obese samples. Common precipitants to binge eating episodes in obese individuals include

negative mood (12, 17, 18), stress (19), and hunger (20), and these episodes are more likely to occur during the evening hours, when individuals are alone, and in the home (18). Loss of control appears to be more strongly related to pre- and post-meal negative affect than the amount of food consumed (12), and the presence of palatable foods has been shown to predict overeating (21), suggesting that there may be factors that are independently related to different aspects of binge eating.

There is an incomplete understanding of contextual factors associated with eating episodes that do *not* involve loss of control or overeating in heterogeneous obese samples, which could inform the development and tailoring of weight control interventions for these individuals. For example, energy intake tends to be influenced by factors such as location (i.e., eating at versus away from home; 22), presence of distracting stimuli (e.g., television; 23), hunger (24), and stress (25) to a greater extent among overweight than normal-weight individuals, indicating that these cues need to be taken into consideration during weight control treatment. However, to date, such relationships have not been sufficiently studied using momentary, ecologically-valid methods of data collection.

The primary aim of the current study was to examine emotional, physiological, and environmental correlates of different types of eating episodes in a sample of obese adults. We specifically sought to compare eating episodes characterized by both loss of control and overeating (i.e., binge eating); loss of control only; overeating only; and neither loss of control nor overeating. We hypothesized that binge eating would be characterized by greater negative mood, stress, and hunger than non-pathological eating episodes, and would be more likely to occur under potentially disinhibiting circumstances such as while distracted (e.g., watching television, driving a car), after consuming alcohol, when experiencing a craving, and while in the presence of others who are eating. We further expected that episodes characterized solely by loss of control would be more strongly characterized by emotional factors, while those characterized solely by overeating would be more strongly characterized by environmental correlates.

Method

Participants

Participants were 50 obese adults (BMI>30; *M*=40.3; *SD*=8.5), aged 18–65 (*M*=43.0; *SD*=11.9), with (*n*=5; 10%) and without BED (*n*=45; 90%), who were recruited through community advertisements and flyers. Participants were primarily female (*n*=42; 84%) and Caucasian (*n*=38; 76%), followed by African-American (*n*=7; 14%), Asian (6%, *n*=3), or other (*n*=2; 4%). Most were well-educated, with 76% (*n*=38) having at least attended or completed college. Exclusion criteria included previous gastrointestinal surgery; being pregnant or breastfeeding; concurrent treatment for obesity; inability to read and understand English; and current or past diagnosis of anorexia nervosa or bulimia nervosa. The presence of other psychiatric disorders was not an exclusion criterion.

Procedures

This study was approved by the University of Minnesota Institutional Review Board. Data collection occurred from February, 2006 to March, 2007. A phone screen was conducted to assess initial eligibility criteria. Participants then attended an informational session at the research facility during which they provided written informed consent, completed in-person assessments to ensure study eligibility, and were trained in how to use the handheld computer for the EMA protocol.

EMA data were collected using Handspring Visors and Satellite Forms software, a commercial application. Participants were instructed to complete EMA recordings before and after any type of eating behavior; before bedtime; and after 6 semi-random prompts by investigators, which occurred every 2–3 hours between 8:00am and 10:00pm. Each participant completed a two-day trial period to ensure that they understood the EMA procedures; all 50 participants completed the trial period, although trial data were not included in the analyses. After training, participants were instructed to complete EMA recordings for the next two weeks. During this assessment period, participants attended two in-person visits 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 two-week assessment period and an additional $50 for completing at least 90% of assessments within 45 minutes of semi-random prompts.

Measures

The eating disorders module of the Structured Clinical Interview for DSM-IV Axis I Disorders/Patient Edition (SCID-I/P; 26) was administered by a trained master's- or doctoral-level researcher to assess current binge eating patterns and diagnose current or lifetime eating disorders, including BED. The SCID-I/P has good psychometric properties (27, 28).

At pre-episode and post-episode recordings, participants were asked about current cravings ("Please rate the extent to which you agree with the following statement: I am craving food"), hunger levels ("Please rate the extent to which you agree with the following statement: I am hungry"), and 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"), all of which were rated on a 1- to 5-point Likert-type scale (1="disagree strongly," and 5="agree strongly"). Post-episode recordings included the extent to which the episode was characterized by overeating and/or loss of control. Ratings for overeating ("To what extent do you feel that you overate?") and loss of control ("While you were eating, to what extent did you feel a sense of loss of control?") were made on a 1- to 5-point Likert-type scale (1="not at all," and 5="extremely"). Episodes in which either overeating or loss of control were rated as at least a "4" (corresponding to "moderately to extremely") were characterized as self-labeled overeating or loss of control episodes, respectively, to ensure that these constructs were unambiguously present; those in which both overeating and loss of control were present (i.e., a rating of at least 4 on both constructs) were classified as self-labeled binge eating to correspond with DSM criteria.

During post-eating episode recordings, participants were additionally asked about the location of the eating episode (i.e., home, car, work, school, cafeteria, restaurant, outside, or other), presence of dining companions ("Did you eat alone/with other people?"), eating while watching television (yes/no), and alcohol consumption during the episode ("How much alcohol did you drink prior to and/or during the time you ate?"; range=0 to 5 or more drinks).

Stressful event reports ["Since your last rating, please indicate which of the following has been stressful for you (choose all that apply): family concerns; personal relationships; financial problems; work-related problems; school-related problems; other; I have not experienced any stressful events"], based on Smyth et al. (29), and the Positive and Negative Affect Schedule (PANAS; 30) were completed at all EMA recordings (i.e., before and after eating, in response to semi-random prompts, and at bedtime). The PANAS Negative Affect scale represents the sum of 11 items (e.g., afraid, upset) rated on a 5-point scale, with a score of "1" indicating "Not at all" and a score of "5" indicating "Extremely" for each affective state (α=.91). For the purpose of this study, ratings of stressful events at *post*-eating episode recordings were used to coincide with the reporting of overeating and loss of control, and because stressful events were unlikely to occur between pre- and post-episode recordings; both pre- and post-episode PANAS ratings were utilized since these were theoretically more likely to differ at pre- and post-episode recordings.

Statistical Analysis

Generalized estimating equations were conducted in SPSS 18.0 to compare self-labeled binge eating (BE), loss of control eating (LOC), overeating (OE), and non-pathological eating (NE) episodes on their relation with EMA-reported emotional (i.e., negative affect), physiological (i.e., hunger, cravings), and environmental cues (i.e., presence of others, eating while watching television, eating because others were eating, location of the episode, alcohol consumption, stressful events). Linear regression was used for the following normally distributed variables: negative affect, hunger, cravings, and stressful events. Logistic regression was conducted for the following binary variables: presence of others, eating while watching television, eating because others were eating, and alcohol consumption. Finally, multi-nomial regression was used for the nominal variable of eating episode location. Age, gender, BMI, and level of education were included as covariates in all analyses. Given the large number of analyses, alpha was set at .01 to reduce the risk of Type I error.

Results

Descriptive Characteristics

Participants completed, on average, 13.9 (*SD*=2.5) days of EMA recordings, including 68.5 (*SD*=26.0) recordings prior to or subsequent to eating, over the two-week study period. A total of 1,704 eating episodes were analyzed, including 395 self-labeled BE episodes (23.2%), 431 self-labeled LOC episodes (25.3%), 110 self-labeled OE episodes (6.5%), and 768 NE episodes (45.1%); 40 (80%) participants reported at least one BE episode (range=0 to 32), 45 (90%) reported at least one LOC episode, (range=0 to 56), 30 (60%) reported at

least one OE episode (range=0 to 24), and 46 (92%) reported at least one NE episode (range=0 to 48). Participants with and without BED did not significantly differ in the mean number of self-reported BE episodes [$t(48)=1.75$; $p=.086$].

Participants reported a total of 4,150 stressful events, including 1,038 work-related problems (25.0%), 899 family concerns (21.7%), 798 financial problems (19.2%), 777 "other" problems (18.7%), 580 personal relationship problems (14.0%), and 58 school-related problems (1.4%). There was 82.2% compliance to responding to semi-random signals within 45 minutes and 78.9% compliance to completing end-of-day recordings. A total of 92% of participants completed the two-week protocol, with the remaining 8% terminating early due to personal circumstances or perceived burden of completing EMA recordings. These participants were included in all study analyses.

Emotional Context

Self-labeled BE was associated with significantly higher levels of both pre-episode (Wald chi-square=15.67; $p=.001$) and post-episode negative affect than LOC, OE, or NE (Wald chi-square=24.39; $p<.001$; see Table 1). Self-labeled LOC was associated with higher levels of both pre- and post-episode negative affect than NE, but not OE; OE and NE did not differ from one another in terms of pre- and post-episode negative affect.

Physiological Context

Self-labeled BE was associated with *lower* levels of *pre*-episode hunger than LOC and NE, but not OE; LOC, OE, and NE did not significantly differ from one another (Wald chi-square=18.14; $p<.001$). Self-identified LOC and NE were associated with *higher* levels of *post*-episode hunger than BE and OE, which did not significantly differ from one another (Wald chi-square=39.75; $p<.001$).

There were no significant differences among the eating episodes in terms of pre-episode cravings across participants ($p=.043$). However, self-labeled LOC episodes were associated with significantly higher post-episode cravings than BE and OE, but not NE episodes; self-labeled OE episodes were associated with significantly lower post-episode cravings than BE and NE (Wald chi-square=25.87; $p<.001$).

Environmental Context

Self-labeled LOC episodes were more likely than BE and OE, but not NE episodes, to occur when the participant was alone (Wald chi-square=13.20; $p=.004$); BE, OE and NE did not differ from one another on this variable. There were no significant differences among the eating episodes in terms of likelihood of eating while watching television ($p=.82$) or because others were eating ($p=.56$ for pre-episode ratings, and $p=.15$ for post-episode ratings); the location of the eating episode ($p=.75$); number of alcoholic beverages consumed prior to eating ($p=.014$); or number of stressful events ($p=.42$).

Discussion

The current study was designed to inform our understanding of the context in which different types eating episodes occur in obese adults. We found that the emotional, physiological, and environmental context of eating episodes differed among episodes characterized, to varying degrees, by self-reported overeating and loss of control while eating. In general, self-identified binge eating and loss of control eating episodes were more consistently characterized by emotional (i.e., negative affect) and physiological cues (e.g., hunger) across participants, while most environmental variables (e.g., location) did not differ among the eating episode types. Consistent with previous studies (8, 9), binge eating was reported during the EMA protocol by a significant subset of participants who did not meet baseline criteria for BED based on a well-validated diagnostic interview, suggesting that the two methods of data collection may be capturing different information (e.g., over-reporting on EMA or under-reporting on interview). Overall, results could inform the development or refinement of interventions for obesity.

Consistent with our hypotheses and with the previous literature (31), we found that negative affect was associated with episodes in which participants experienced loss of control while eating. While theoretical models and empirical studies have consistently suggested a relation between negative affect and loss of control eating among individuals with eating disorders (31, 32), our results extend these findings to a heterogeneous obese sample. Although our sample consisted of those with and without BED, these findings suggest that interventions targeting obesity (as opposed to those specifically targeting BED) could benefit from addressing loss of control eating and its affective context. Indeed, several recently-developed interventions for binge eating include modules addressing relevant emotional factors and healthy coping (33, 34) which could be easily incorporated into existing weight control interventions.

A related finding was that, contrary to expectation and to the previous literature (20), hunger levels were *lower* prior to self-labeled BE episodes relative to most other types of eating episodes (with the exception of OE episodes), again suggesting that these types of eating episodes are driven by factors other than physiological need for food (e.g., negative mood). Interestingly, hunger levels prior to self-defined LOC episodes were commensurate with those prior to OE and NE episodes; it is possible that LOC episodes are initiated for physiological reasons, with the experience of loss of control only developing later in the course of these episodes (e.g., after breaking a dietary rule), although this should be further explored. Relatedly, post-episode hunger levels and post-episode cravings were highest after self-labeled LOC episodes, although pre-episode cravings did not differ among the eating episode types. It is possible that LOC episodes reflect “interrupted” or prematurely terminated eating episodes that fail to evolve into objectively large binges. Further research is needed to explore this and other hypotheses.

In contrast to our expectation that potentially disinhibiting environmental cues would be related to overeating episodes, few environmental cues distinguished the different types of eating episodes, although we examined a variety of contextual variables (e.g., presence of dining companions). The one exception was that self-defined LOC episodes were more

likely to occur when the participant was alone, perhaps reflecting a sense of shame or embarrassment (35), or alternatively, a sense of opportunity. It is intriguing that this finding did not apply to self-labeled BE episodes as well, which one might posit would be characterized by similar feelings of shame or opportunism; this may be due to differences in the degree of loss of control characterizing these different types of eating episodes (i.e., if one feels intensely out of control it would be more difficult to delay eating until one is alone). Generally, our limited findings regarding environmental cues may indicate that these are less potent triggers of aberrant eating than internal cues. Alternatively, it is possible that disinhibiting environmental cues trigger eating episodes of *any* kind, rather than just those characterized by loss of control or overeating, or that certain traits that were not captured in our analyses (e.g., difficulties with impulse control) are associated with susceptibility to environmental cues to eat. Because our EMA data did not include objective assessment of dietary intake, it is unclear if environmental cues were associated with excess energy intake, thereby contributing to one's obese status. To address this possibility, future studies should include measures of dietary intake, and should also compare overweight and normal-weight samples in terms of environmental factors that could potentially maintain or exacerbate obesity.

Our study was characterized by several strengths, including the use of EMA to characterize eating episodes as they occur in the natural environment, and the diagnostically heterogeneous community-based sample, which enhances generalizability and allowed us to examine the context of eating episodes across the spectrum of obese individuals and eating episode types. However, several limitations should be noted. The sample size was relatively small, and was comprised of primarily female and Caucasian participants. Moreover, there was no normal-weight control group, which makes it difficult to determine if the observed associations are unique to eating episodes in obesity. The presence of non-eating psychiatric disorders was not assessed, and therefore the impact of psychiatric comorbidities on the current findings could not be evaluated. Furthermore, in order to maximize the number of eating episodes included in the analyses, we examined contextual variables that were reported at the same assessment point as their associated eating episodes, hence limiting our ability to infer temporal relationships among the constructs from the present findings (although our examination of several pre- and post-eating episode contextual variables somewhat addresses temporal order). Future studies might consider extending the duration of the EMA protocol in order to capture more eating episodes, which would facilitate examination of temporal sequencing. Finally, all behavioral, emotional, physiological, and environmental factors were based on subjective self-report. This includes ratings of loss of control and overeating, which precludes generalization to investigator-defined DSM loss of control and/or overeating episodes. Relatedly, our measure of stress was quite broad and might not have been sensitive enough to capture the types of stressors (or reactions to such stressors) that are most strongly related to eating behaviors. Future studies should replicate and extend our findings to address these limitations.

In summary, the current data inform our understanding of the context in which eating episodes occur among obese adults with and without pathological eating behaviors, in particular suggesting that aberrant eating episodes such as binge and loss of control eating

are associated with distinct emotional and physiological variables. Overall, results support the clinical significance of different components of binge eating episodes as described in DSM-5 (6) and indicate that internal factors such as negative mood and hunger may better distinguish different types of eating episodes in obesity (particularly those involving loss of control and/or overeating) than external factors such as one's physical environment. Outcomes for weight control interventions may be improved by addressing these factors.

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Acronyms

BED	binge eating disorder
EMA	ecological momentary assessment
BMI	body mass index
SCID-I/P	Structured Clinical Interview for DSM-IV Axis I Disorders/Patient Edition
PANAS	Positive and Negative Affect Schedule
BE	binge eating
LOC	loss of control
OE	overeating
NE	non-pathological eating

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Table 1

Contextual variables associated with different types of eating episodes, estimated marginal mean (*SE*) except where otherwise indicated

CONTEXTUAL VARIABLE		BINGE EATING (*N*=395)	LOSS OF CONTROL EATING (*N*=431)	OVEREATING (*N*=110)	NON-PATHOLOGICAL EATING (*N*=768)	TEST RESULT
EMOTIONAL CUES						
Negative affect	Pre-episode	18.39 (1.38)[a]	15.20 (0.94)[b]	13.66 (1.01)[bc]	13.30 (0.69)[c]	Wald chi-square=15.67; *p*=.001
	Post-episode	18.70 (1.24)[a]	15.32 (0.96)[b]	13.58 (0.92)[bc]	13.08 (0.61)[c]	Wald chi-square=24.39; *p*<.001
PHYSIOLOGICAL CUES						
Hunger	Pre-episode	3.76 (0.15)[a]	4.28 (0.15)[b]	4.05 (0.19)[ab]	4.09 (0.15)[b]	Wald chi-square=18.14; *p*<.001
	Post-episode	1.52 (0.18)[a]	2.05 (0.21)[b]	1.36 (0.17)[a]	1.85 (0.21)[b]	Wald chi-square=39.75; *p*<.001
Cravings	Pre-episode	3.64 (0.22)	3.96 (0.21)	3.56 (0.32)	3.59 (0.24)	Wald chi-square=8.14; *p*=.043
	Post-episode	1.88 (0.19)[a]	2.22 (0.20)[b]	1.49 (0.18)[c]	1.97 (0.23)[ab]	Wald chi-square=25.87; *p*<.001
ENVIRONMENTAL CUES						
Location of episode, % (*n*)						
Home		58.7 (232)	55.7 (240)	61.8 (68)	54.2 (416)	
Car		5.3 (21)	6.7 (29)	1.8 (2)	3.3 (25)	
Work		15.2 (60)	21.6 (93)	11.8 (13)	22.4 (172)	
School		0.0 (0)	0.0 (0)	0.0 (0)	0.3 (2)	Wald chi-square=1.22; *p*=.75
Cafeteria		3.0 (12)	3.7 (16)	5.5 (6)	4.6 (35)	
Restaurant		9.9 (39)	7.0 (30)	13.6 (15)	9.5 (73)	
Outside		0.5 (2)	2.1 (9)	1.8 (2)	2.0 (15)	
Other		7.3 (29)	3.2 (14)	5.0 (4)	3.9 (30)	
Eating while alone, % (*n*)[†]		48.6 (192)[a]	61.7 (266)[b]	46.4 (51)[a]	56.6 (435)[ab]	Wald chi-square=13.20; *p*=.004
Eating while watching television, %(*n*)[†]		39.0 (154)	32.0 (138)	35.5 (39)	29.4 (226)	Wald chi-square=0.92; *p*=.82

CONTEXTUAL VARIABLE		BINGE EATING (*N*=395)	LOSS OF CONTROL EATING (*N*=431)	OVEREATING (*N*=110)	NON-PATHOLOGICAL EATING (*N*=768)	TEST RESULT
Eating because	Pre-episode	1.86 (0.19)	1.64 (0.15)	1.85 (0.41)	1.68 (0.21)	Wald chi-square=2.07; *p*=.56
others are eating	Post-episode	1.80 (0.14)	1.50 (0.11)	1.78 (0.31)	1.59 (0.15)	Wald chi-square=5.37; *p*=.15
Pre-episode alcohol consumption±		0.08 (0.04)	0.04 (0.02)	0.11 (0.07)	0.05 (0.02)	Wald chi-square=10.55; *p*=.014
Post-episode stressful events±		0.39 (0.08)	0.32 (0.07)	0.33 (0.09)	0.28 (0.07)	Wald chi-square=2.81; *p*=.42

Note: *N*s refer to the number of eating episode types. Differing superscript letters indicate significant differences.

†Although analyses utilized estimated marginal means, proportions of eating episodes corresponding to categorical contextual variables are presented for ease of interpretation

±Means reflect the number of alcoholic beverages or stressful events, respectively