Appetite 52 (2009) 72–82

Contents lists available at ScienceDirect

Appetite

journal homepage: www.elsevier.com/locate/appet

Research report

Triggers of eating in everyday life

A. Janet Tomiyama *, Traci Mann, Lisa Comer

University of California, Los Angeles, University of Minnesota, University of Northern Colorado, United States

ARTICLE INFO

Article history:
Received 8 April 2008
Received in revised form 6 August 2008
Accepted 8 August 2008

Keywords:
Eating
Restraint
Daily diary

ABSTRACT

Understanding the triggers of eating in everyday life is crucial for the creation of interventions to promote healthy eating and to prevent overeating. Here, the proximal predictors of eating are explored in a natural setting. Research from laboratory settings suggests that restrained eaters overeat after experiencing anxiety, distraction, and the presence of positive or negative moods, but not hunger; whereas the only factor that triggers eating in unrestrained eaters is hunger. In this study, 137 female participants reported hourly for 2 days on these potential predictors and their eating using electronic diaries, allowing us to establish the relationships between these factors while participants went about their normal daily activities. The main outcome variables were the number of servings eaten and whether or not food was eaten. Contrary to findings from laboratory settings, in everyday life restrained eaters (1) did not overeat in response to anxiety; (2) ate less in the presence of positive or negative moods; and (3) ate more in response to hunger. The relationships between these factors and eating among unrestrained eaters were closer to those found in laboratory settings. In conclusion, predictors of eating must be studied in everyday life to develop successful interventions.

Introduction

What causes individuals to eat? Although physiological factors play an important role in human eating, the eating at any particular meal is influenced by a variety of psychological factors. These factors can lead dieters to experience lapses in self-control and subsequent weight fluctuation and can lead non-dieters to overeat and gain weight that is difficult to lose. Comprehensive understanding of the factors that trigger eating is of use to both dieters and non-dieters and may lead to the development of beneficial weight loss strategies.

Current knowledge of the proximal predictors of eating and overeating comes partly from laboratory studies that compare the eating of restrained eaters to that of individuals who are not restrained eaters. Restrained eaters are concerned about "keeping their weight down," (Herman & Polivy, 1975, p. 668) and can be thought of as chronic dieters. They impose cognitive controls on their eating and aim to ignore the physiological signal of hunger. Restrained eaters frequently fail at their attempts to restrict their eating in response to triggers that tend to have the opposite association – or no association – with the eating habits of non-restrained eaters.[1] As we review below, restrained eaters overeat in response to distraction and both positive and negative emotions. Their eating does not tend to show strong associations with hunger (for a summary, see Herman & Polivy, 1984). In contrast, non-restrained eaters tend to eat more when they are hungry, less when they are distracted, and their eating is not influenced by emotions.

The relationship between emotion and eating has been explored in laboratory studies as well. Several studies have examined the effects of anxiety[2] on eating among restrained and unrestrained eaters (see Greeno & Wing, 1994, for a summary). These studies have consistently shown that restrained eaters consume more when anxious than when not anxious, while unrestrained eaters either consume less when anxious than when not anxious, or are unaffected by anxiety. Studies using mood inductions have also found that food intake among restrained eaters increases with other negative moods, such as depression and anger (Cools, Schotte, & McNally, 1992; Frost, Goolkasian, Ely, & Blanchard, 1982; Schotte, Cools, & McNally, 1990; Ruderman,

* Corresponding author at: UCLA Department of Psychology, Box 951563, Los Angeles, CA 90095-1563, United States.
E-mail address: tomiyama@psych.ucla.edu (A.J. Tomiyama).

0195-6663/$ – see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.appet.2008.08.002

[1] There is disagreement over whether restrained eaters are *by definition* prone to disinhibited eating in certain situations, or whether there are sub-types of restrained eaters, only some of which are prone to disinhibited eating. This debate is beyond the scope of the current manuscript.

[2] Some of these studies refer to stress rather than anxiety, but regardless of the conceptualization or the label, stress or anxiety both lead to overeating among restrained eaters.

1985), and also with positive mood inductions, such as humor (Cools et al., 1992). Unrestrained eaters are generally unaffected by these mood inductions (Cools et al., 1992; Ruderman, 1985; Schotte et al., 1990).

In line with the viewpoint that people need to pay attention to themselves and their goals in order to control their behaviors, (Carver & Scheier, 1998), studies have shown that restrained eaters overeat while listening to the radio (Bellisle & Dalix, 2001) or engaging in a cognitively distracting task (Lattimore & Caswell, 2004;[3] Ward & Mann, 2000), whereas unrestrained eaters tend to eat less in such situations. Further supporting the notion that attention is necessary if one is to control one's eating, restrained eaters who had been given a preload did not overeat if they were forced to pay close attention to their behavior (Polivy, Herman, Hackett, & Kuleshnyk, 1986). More recent work, however, suggests that attention does not necessarily lead to overeating among restrained eaters, but rather interacts with situational cues to predict consumption (Mann & Ward, 2004). Restrained eaters who are distracted will only overeat if there are salient cues to eat present. If salient cues promote dieting, restrained eaters will consume less.

While these laboratory studies give us causal information about factors that influence eating when one is *required* to eat, it is not clear if these findings accurately explain real-life eating outside of the lab, nor do they inform the question of when individuals choose to eat. Studies of eating in more natural settings can begin to address such questions. These studies necessarily lack the tight controls of the laboratory environment and because participants must report on their own eating, it is not possible to keep them unaware that eating is a focus of the study. Despite these concerns, field studies of eating are an important and necessary complement to laboratory studies.

Many naturalistic eating studies require individuals to report on factors that influenced their eating months after the eating took place (e.g., Grilo, Shiffman, & Wing, 1989); or require them to report several weeks worth of eating at the end of that time frame (e.g., Baker, Little, & Brownell, 2003). The validity of these retrospective reports is questionable, as memory of food consumption may be biased by many factors, including self-presentational concerns, current mood, beliefs about factors that influence eating, and past behaviors (see Stone & Shiffman, 1994, for a discussion of these issues). Because individuals may not be able to accurately recall the time sequence of eating and the factors that are presumed to cause that eating, these studies cannot be used to establish proximal predictors of eating.

A newer methodology has been used to examine factors associated with diet relapse among obese individuals on formal diets (Carels, Douglass, Cacciapaglia, & O'Brien, 2004; Patel & Schlundt, 2001; Schlundt, Sbrocco, & Bell, 1989), as well as eating among large populations of individuals who are not necessarily dieting (see de Castro, 2000, for a review). This method requires individuals to use paper and pencil diaries to report every instance of eating when it happens. At that time, they are also expected to report various situational factors that may be linked to a dietary lapse. While more rigorous than the studies that require retrospective reporting, the methodology has two weaknesses. First, the incident that triggers participants to complete a food diary is the dietary lapse, so any factors reported at that same time may have been a result of the dietary lapse rather than a cause of it. Further, researchers do not conduct analyses exploring predictors at one time point and eating at later time points. Because diaries are only completed when eating occurs, no information is collected about the overall presence of various triggers, or about situations that enable individuals to refrain from eating (except in the work of de Castro, who also collected diary entries at random points throughout the day). Second, it is still possible with this methodology for participants to complete all the forms at the end of the day—or even at the end of the entire study. This problem poses a threat to the reliability of these findings, because if the potential trigger and the eating are both reported later in the day or week, it will be difficult for the participant to accurately assess which came first, or even if the trigger was present at all.

Despite these limitations, as well as the fact that participants in these studies monitor and record every item they eat, these studies provide information about eating in a natural environment and they have explored some of the same factors as the laboratory studies. All four of the studies of obese dieters replicated the laboratory finding (Cools et al., 1992; Frost et al., 1982; Ruderman, 1985, 1986; Schotte et al., 1990) that negative moods are associated with dietary lapses and three of them replicated the finding (Cools et al., 1992) that positive moods are associated with dietary lapses (all except Schlundt et al., 1989). Of the three studies that explored the role of hunger, two (Carels et al., 2004; Schlundt et al., 1989) replicated the laboratory findings (Herman & Polivy, 1975, 1984) that hunger was not associated with overeating among dieters, while one found that hunger was associated (Carels et al., 2001). An additional study of general population eaters found that hunger was associated with amount eaten, although the participants were not necessarily dieting (de Castro & Elmore, 1988).

The newest generation of research on eating has aimed to reduce the problems associated with laboratory contexts, as well as those associated with paper and pencil diary studies, by using an ambulatory electronic diary methodology that participants complete at certain times while going about their normal daily activities. Electronic diaries benefit from time-stamp and lock-out features that provide information about when the diary was actually completed and prevent retrospective responding. They also provide an added guarantee of confidentiality by having potentially sensitive information disappear immediately into computer memory, accessible only to research staff. Previous studies suggest that this methodology has not been found to significantly alter the participant's normal activities (e.g., Larson, 1989).

Studies using this methodology have examined the prevalence of eating disorder symptoms among individuals with eating disorders (Stein & Corte, 2003), as well as predictors of binge eating among individuals with binge eating disorder (Freeman & Gil, 2004; Greeno, Wing, & Shiffman, 2000; Wegner et al., 2002). Despite being ideally suited for the exploration of the proximal predictors of eating in everyday life, these methods have not yet been applied to such questions or used to examine these eating triggers in individuals without significant eating pathology (see Smyth et al., 2001, who recommend that eating research use this methodology).

The current manuscript reports the first study, to our knowledge, to comprehensively assess several proximal triggers of eating in everyday life using a methodology that prevents retrospective reporting. We use an ambulatory electronic daily diary methodology in which participants report on their eating and an array of potential eating triggers every hour over a 2-day period. By requiring participants to report on these triggers whether or not they ate, this methodology allows us to assess which triggers were present in the environment just prior to each instance of eating, as well as whether those triggers were present when participants did not eat. To minimize the salience of eating during the study, as well as the extent to which participants must self-monitor their eating, participants respond to only three questions about their eating, a question about whether they ate at all, a question about how many servings they ate, and a question about whether the food was high,

[3] The authors refer to the reaction time task as an active coping stress task.

medium, or low fat.[4] To the extent that self-monitoring eating influences eating, participants in the current study should be less influenced by this simple monitoring than the studies cited above in which participants completed detailed food diaries of each food they consumed over the course of the study. We test the predictions from prior research to see if eating in everyday life is associated with the same triggers as eating in the laboratory.

Methods

Participants

137 female students in an introductory psychology class signed up for the study on a web-based sign-up page that did not provide any information about the diary portion of the study. After the study had been fully described in the laboratory, six individuals refused to participate in the diary portion of the study. The remaining 131 participants gave informed consent and entered the study. Four of these participants were later dropped because their diary data were irreparably corrupted during the downloading process. On average, the response rate among the remaining 127 participants was high. A predetermined minimum of 20 complete diary entries over the two-day period was required for participants to be retained for analysis. 93% ($n = 118$) of the participants met this strict inclusion criterion. The 118 participants who met the inclusion criteria (86% of the total number of participants approached for the study) completed 2834 total diary observations, for an average of 24 hourly entries each.

Procedures

Prior to using the ambulatory daily diaries, participants completed a baseline questionnaire that included demographic questions about age, ethnic group, year in school, and country of origin. It also included the Dietary Restraint Scale (DRS; Herman & Polivy, 1980), which assesses attitudes toward eating, frequency of dieting, and weight fluctuations. The DRS has attained satisfactory levels of test-retest reliability, as well as construct and criterion validity, when used with nonobese participants (Ruderman, 1986). Cronbach's α for this measure in our sample was 0.85. The baseline questionnaire also included measures of anxiety, stress, depression, and self-esteem, which are not discussed further in this paper. Participants were then trained in the use of an ambulatory personal digital assistant (PDA) device that had been programmed with the study questions. They were also trained to estimate portion sizes of foods using commonly used written instructions for estimating serving sizes. Participants were paged through the device once each hour ($\pm$10 min) over the following two days (minus sleep times). Participants were instructed to engage in normal activities and complete the diaries each time they were paged, but to skip any entry signal that occurred during an incompatible event such as an exam or while driving.

When paged, participants answered the diary questions on the PDA. Diary questions referred to the time since participants were last paged and assessed whether participants had eaten a meal or snack, the number of servings consumed, and the fat content of the foods eaten. Questions also assessed the extent to which each of several psychological states were felt on 5-point Likert scales that ranged from not at all (1) to extremely (5).[5] The items "anxious," "nervous," "worried," and "stressed," were combined to form a measure of anxiety. The items "sad" and "down" were combined to form a measure of negative mood (distinct from anxiety). The items "energized or motivated" and "happy" were combined to form a measure of positive mood. The items "tired or sleepy' and "distracted or having difficulty paying attention' were combined to form a measure of distraction. Hunger was measured with the single word "hungry." When participants reported that they had eaten during the time interval, the questions about triggers specifically asked whether each of the above states was present *before* the eating took place.[6] The questions took approximately 90 s to answer.

Data analysis

Overview of multilevel modeling

In daily diary data, measurements are nested within individuals. As such, multilevel modeling (also called hierarchical linear modeling; Bryk, Raudenbush, & Congdon, 1996), which uses a random effects model to simultaneously estimate both within-subject (Level 1) and between-subject (Level 2) variance, was used to analyze the data. Using HLM 6.0 software (Scientific Software International), a series of equations were built. For example, to test the hypothesis that daily positive and negative affect would predict the number of servings eaten (a test at Level 1, or within-subjects), but that this relationship would be moderated by each individual's baseline dietary restraint score (a test at Level 2, or between-subjects), the following equation was estimated:

$$\text{Level 1 Servings}_{ij} = \beta_{0j} + \beta_{1j(\text{POSITIVE AFFECT})} + \beta_{2j(\text{NEGATIVE AFFECT})} + R_{ij}$$

$$\text{Level 2 } \beta_{0j} = \gamma_{00} + \gamma_{01(\text{RESTRAINT})} + U_{0j}$$

$$\beta_{1j} = \gamma_{10} + \gamma_{11(\text{RESTRAINT})} + U_{1j}$$

$$\beta_{2j} = \gamma_{20} + \gamma_{21(\text{RESTRAINT})} + U_{2j}$$

The β_0 in the Level 1 equation (the intercept) can be interpreted as each individual's mean number of servings eaten. The other β values in the Level 1 equation represent slopes and can be interpreted like b values in traditional regression models. Thus, the Level 1 equation can be summarized as follows: the number of servings a person eats can be represented as their overall mean number of servings plus the effect of positive and negative affect and random error.

Each β component in the Level 1 equation is in turn estimated by the Level 2 equations. The γ_{00} value in these equations refer to the grand mean, or the mean number of servings eaten for the *entire* sample over *all* observations. γ_{10} and γ_{20} in turn represent the average *within*-person slopes across the sample. The second set of γ_{01}, γ_{11}, and γ_{21} values are estimates taking into account the scores on the dietary restraint variable (in other words, the potential moderator). U_{0j}, U_{1j}, and U_{2j} values refer to random error at the between-subjects level. Thus, the Level 2 equations test whether between-subject variables (e.g., dietary restraint) moderate the relationships tested in the Level 1 equation. Additionally, we specified that all error terms (in the example above: R_{ij}, U_{0j}, U_{1j}, and U_{2j}) were assumed to be independently and normally distributed, with $\mu = 0$ and constant σ^2.

Data analytic plan

Two main outcome variables were addressed—the number of servings eaten (a continuous outcome measure) and whether the

[4] The outcome of high/medium/low fat was not analyzed and will not be discussed further.

[5] The intended question "Were you around a friend or family member who was eating?" was inadvertently skipped by the PDA device and was not asked of any participant.

[6] Inadvertently, the questions for the trigger variable of anxiety did not specify that the trigger was present before the eating took place. To be certain the sequence of events was such that the trigger preceded any eating, for this variable we emphasize the outcome of eating in the following hour in our analyses. It should be noted, however, that the results are identical when predicting current-hour eating and next-hour eating.

participant ate (a dichotomous outcome measure[7]). These outcome variables were predicted in the same hour the trigger was assessed and in the next hour. In Step 1 (Model 1 in Appendixes 1 and 2), each Level 1 eating-trigger predictor variable was entered separately in an equation predicting each of the two outcomes. The one exception to this was in the case of positive and negative mood, where both variables were simultaneously entered into one equation. Estimating the effects of these variables independent of one another is necessary given research indicating that positive and negative affect are independent constructs rather than two ends of one continuum (e.g., Gable, Reis, & Elliot, 2003). Dichotomous (yes/no) triggers were entered into the equation uncentered; continuous triggers were entered into the equation group-centered.

In the case of eating as an outcome variable, odds ratios (OR) are presented below with the 95% confidence interval in brackets.[8] In the case of number of servings eaten, unstandardized hierarchical linear modeling coefficients (similar to a b value in regression) are presented below with standard error values in brackets. All estimates are with robust standard errors.

In Step 2 (Model 2 in Appendixes 1 and 2), baseline levels of dietary restraint were included (grand-centered) in the equation to see whether dietary restraint moderated the relationship between each trigger variable and the outcome measures. Error at Level 2 was modeled initially. If the error terms were not significant at Level 2, these parameters were dropped in future models.

Finally, in Step 3 (Model 3 in Appendixes 1 and 2), all significant predictors emerging from Step 1 and Step 2 were included into a single equation to examine the independent contributions of each of the trigger variables to the outcome measures.

Results

Descriptive results

Participants ranged in age from 17 to 33 years old (M = 19.4, S.D. = 2.18). The ethnicities represented in the sample were Asian-American (41.4%), Euro-American (37.1%), Latina (15.8%), "other" (2.9%), African-American (1.4%), and American Indian (1.4%). Participants had an average body mass index of 22.31 (S.D. = 3.53, range from 16.83 to 38.46) and their scores on the restraint scale ranged from 0 to 29, with a mean of 12.75 (S.D. = 5.57).

Participants ate a meal or a snack in 34.7% of the 2834 assessed intervals and reported feeling hungry in 56.0% of them. Participants reported feeling distracted 71.2% of the time, feeling some anxiety 47.8% of the time, feeling some negative mood 54.2% of the time, and feeling some positive mood 79.0% of the time.

Multi-level modeling results

Overall, the results for the dichotomous eating outcome were nearly identical to the results for the number of servings eaten. In the interest of simplicity, we limit our discussion of results mainly to the dichotomous eating outcome, but all results are displayed in Appendixes 1 and 2.

Dietary restraint

To first see whether dietary restraint has any effect on eating without taking into account any trigger variables, an empty Level 1 equation (Model 0 in Appendixes 1 and 2) was built with restraint as a Level 2 moderator. Dietary restraint had no significant effect on whether or not participants ate (OR = 1.01 [1.00,1.02], ns) and similarly had no effect on the number of servings eaten ($b = -0.004$, S.E. = 0.005, ns).

Anxiety

Levels of anxiety (grand mean = 1.39, S.D. = 0.59) did not predict eating in the current hour (OR = 1.11 [0.98, 1.26], ns) or the following hour (OR = 0.99 [0.82, 1.20]; ns). This relationship was not moderated by restraint (current hour: slope = 0.01, S.E. = 0.01, ns; following hour: slope = −0.01, S.E. = 0.01, ns). This finding replicates laboratory work for unrestrained eaters but not for restrained eaters.

Hunger

Participants were almost three times more likely to eat in the current hour (OR = 2.81 [2.48, 3.18], $p < 0.001$) and slightly more likely to eat in the following hour: (OR = 1.16 [1.08, 1.25], $p < 0.001$) if they were hungry (grand mean = 1.98, S.D. = 1.11). Dietary restraint, however, did not emerge as a significant moderator of this relationship (current hour: slope = −0.01, S.E. = 0.01, ns; following hour: slope = −0.002, S.E. = 0.01, ns). The overall finding replicates laboratory work on unrestrained eaters and the existing field study on a general population sample, but the finding for restrained eaters goes against the laboratory work and the majority of field studies on hunger.

Distraction

For distraction (grand mean = 0.50, S.D. = 0.38), the findings diverge for the two time points (current hour versus following hour). Participants were less likely to eat in the same hour (OR = 0.70 [0.52, 0.96]; $p = 0.024$) if they were distracted. However, the relationship between distraction and eating is not significant when predicting eating in the following hour (OR = 0.88 [0.72, 1.08]; ns).

Restraint emerged as a significant moderator of this relationship in the current hour (slope = −0.05, S.E. = 0.03, $p = 0.041$) and marginally so in the following hour (slope = −0.03, S.E. = 0.01, $p = 0.058$). Moderation in multilevel modeling can be interpreted similarly to traditional regression. These findings can be interpreted as follows: participants who score one point higher than the average (of all participants) in restraint decrease their odds ratio of eating from 0.70 to 0.67 in the current hour.

The results of these distraction analyses suggest that as in laboratory studies, unrestrained eaters consumed less when distracted than when not distracted. Regarding restrained eaters, laboratory studies find that restrained eaters consume more if they are distracted. Here, we find the opposite: restrained eaters consume less when they are distracted. Because the size of this

[7] To estimate coefficients for the dichotomous outcome, a separate model was built in an analogous manner to the continuous outcome discussed above. We used the Bernoulli sampling model using the logit link, assuming that the probability of Y_{ij} (in this case, whether or not food was eaten) is 1 with probability φ_{ij}. Due to the dichotomous outcome, deviance statistics were not estimated. To illustrate, the following equations were estimated when examining the effect of distraction on whether participants ate:

$$\text{Level 1} \quad \text{Eat}_{ij} = \pi_{0j} + \sum_{p=1}^{P-1} \pi\, p j X\, p i j(\text{DISTRACTION})$$

$$\text{Level 2} \quad p_{0j} = \beta_{00}$$

$$\pi_{pj}(\text{DISTRACTION}) = \beta_{p0} \quad \text{for } p > 0$$

[8] HLM provides coefficients for dichotomous outcomes as log odds. As such, the coefficients were exponentiated to produce odds ratios.

effect is small, however, a more accurate conclusion may be that restraint, in a daily setting, has only a minimal effect on eating when participants are distracted.

Positive and negative mood

Both being in a positive mood (grand mean = 0.79, S.D. = 0.41) and being in a negative mood (grand mean = 0.54, S.D. = 0.50) led participants to be significantly *less* likely to eat in the current hour (positive mood: OR = 0.08 [0.06, 0.11]; $p < 0.001$; negative mood: OR = 0.05 [0.04, 0.07]; $p < 0.001$). Dietary restraint was a marginally significant moderator for negative mood (slope = 0.05, S.E. = 0.03, $p = 0.063$) but not positive mood (slope = 0.04, S.E. = 0.03, ns). In other words, the effect of negative mood on eating is slightly tempered for those higher in restraint. This moderation effect is quite small. A one-point increase in restraint score only increases the odds of eating by 0.05.

Interestingly, both positive mood (OR = 1.59 [1.25, 2.01]; $p < 0.001$) and negative mood (OR = 1.29 [1.07, 1.56]; $p = 0.008$) caused participants to be *more* likely to eat in the *following* hour. Here again, dietary restraint moderated this relationship for negative mood (slope = −0.03, S.E. = 0.02, $p = 0.05$) but not positive mood (slope = −0.01, S.E. = 0.02, ns), again so that those higher in restraint are slightly less likely to eat than those lower in restraint (for negative mood). However, each one point increase in mean restraint score only decreased the odds of eating by 0.02, so this again is a very small moderation effect.

Several points are noteworthy here. Laboratory and field studies show that restrained eaters consume *more* when in positive or negative moods, whereas we found that restrained eaters consumed less immediately when in positive or negative moods. In the following hour, however, restrained eaters did eat more if they were in positive or negative. Further, laboratory studies also found that unrestrained eaters are generally unaffected by mood, but here, unrestrained eaters consumed less in the current hour when in positive or negative moods and more in the following hour. Finally, positive mood and negative mood *independently* predicted eating, adding evidence to the argument that they are separate constructs.

Final equation

Each trigger variable held up in the final equation for the current hour, such that hunger (OR = 1.79 [1.66, 1.93], $p < 0.001$), distraction (OR = 0.55 [0.42, 0.73], $p < 0.001$), negative mood (OR = 0.08 [0.07, 0.22], $p < 0.001$) and positive mood (OR = 0.12 [0.10, 0.16], $p < 0.001$) all remained significant predictors of eating. However, restraint as a moderating variable was no longer significant for the two trigger variables (distraction: slope = −0.01, 0.01, S.E. = –0.03, ns; negative mood: slope = 0.01, S.E. = 0.02, ns) that it moderated in earlier analyses.

Findings for the following hour similarly mirrored the earlier models, where each trigger variable held up in the final equation. Hunger (OR = 1.28 [0.48, 0.58], $p < 0.001$), negative mood (OR = 1.38 [1.13, 1.70], $p < 0.01$), and positive mood (OR = 1.50 [1.14, 1.84], $p < 0.01$) were all predictors of eating. However, restraint again was no longer a significant moderator for negative mood (slope = −0.03, S.E. = 0.02, ns). The sum of the findings suggests that restraint may not be an important moderator of any of the relationships noted above.

Fig. 1 (eating as a dichotomous outcome) and 2 (number of servings eaten) depict graphically the contribution of each of the final trigger variables.

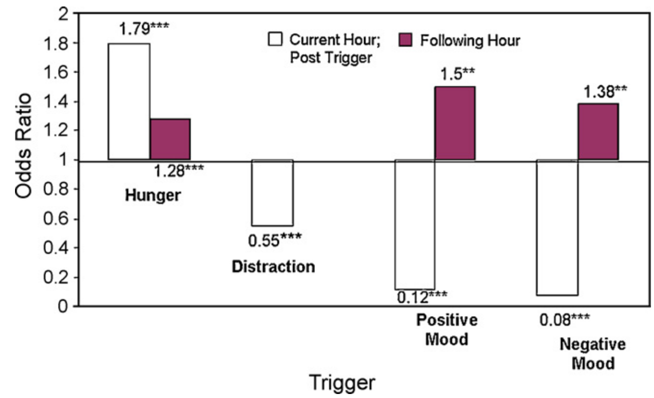

Fig. 1. Odds ratios for each of the final trigger variables predicting eating in the current hour (white bars) after exposure to each trigger and eating in the following hour (dark bars). Odds ratios less than 1.00 indicate that eating was *less* likely to occur. Odds ratios greater than 1.00 indicate that eating was *more* likely to occur. Distraction for the following hour was not significant in initial runs and was therefore not estimated. $^{**}p < 0.01$, $^{***}p < 0.001$.

Discussion

Differences from laboratory findings

This study underscores the important role of hunger in the eating of restrained individuals. Although restrained eaters may aim to eat according to cognitive controls rather than according to hunger, the restrained eaters in the current study did not achieve that goal. Their eating was strongly influenced by their self-reported hunger.

Our study differed from laboratory studies in the area of anxiety-related eating. Laboratory studies typically find that restrained eaters overeat in response to anxiety. In our everyday life setting, restrained eaters did not overeat following self-reported anxiety. Although it is possible that the anxiety our participants reported was not as strong as the manipulated anxiety in these laboratory studies (the grand mean was 1.39 out of 5), it is likely that real-life anxiety would be more meaningful to participants than anxiety associated with the laboratory tasks of working on an unsolvable puzzle, watching an unpleasant video, or preparing and delivering a speech. In addition, our participants did not overeat even at the highest levels of anxiety they reported.

In terms of eating in response to positive and negative moods, we found that restrained eaters consumed less food in response to both positive and negative moods immediately upon experiencing those moods and then ate more in the following time period, about an hour later. These findings are at odds with laboratory studies, which generally find that restrained eaters experiencing positive or negative moods consume more immediately after the mood induction. Our findings are also at odds with laboratory studies showing that unrestrained eaters are generally unaffected by mood induction. Our unrestrained eaters consumed less when experiencing either positive or negative moods and then more in the following time period.

Finally, in everyday life, restrained eaters did not overeat in response to distraction, as has been shown in several laboratory studies. Indeed, in our study, restrained eaters consumed less when distracted than not distracted. As in laboratory eating studies, the unrestrained eaters in our study also ate less when distracted than not distracted. As we defined restrained eaters in an identical manner to the lab studies (using a median split on the Restraint Scale—see Herman & Polivy, 1975, 1980), we are not inclined to believe these differences are due to different definitions or ranges of restrained eaters.

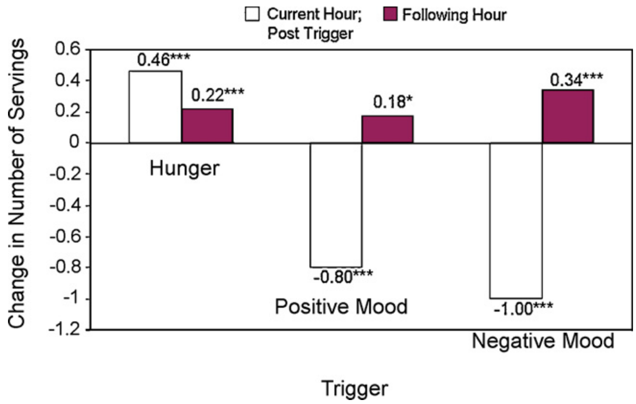

Fig. 2. Unstandardized hierarchical linear modeling coefficients for each of the final trigger variables predicting number of servings in the current hour (white bars) after exposure to each trigger and in the following hour (dark bars). Positive numbers indicate that when each trigger was present, the number of servings increased relative to each participant's own mean. Negative numbers indicate that when the trigger was present, the number of servings decreased relative to each participant's own mean. $^{**}p < 0.01$, $^{***}p < 0.001$.

There are several explanations for differences between laboratory eating and everyday eating. First, in laboratory studies, participants are typically required to eat and participants are often aware of this situation when they sign up for the study. Thus, these studies tend to minimize the number of participants who are unwilling to threaten their diets and maximize the number of participants who are looking for an excuse to violate their diets. This sampling issue might lead to results that cannot be generalized to all restrained eaters. Second, because participants are required to eat in laboratory studies, these studies can only address factors that cause individuals to continue eating once they start and cannot address factors that lead individuals to start eating in the first place. Third, constructs such as "distraction" can be well-operationalized in the laboratory through, for example, the use of memory tasks, but similar operationalizations are not possible in daily diary studies. It may have been the case that restrained participants reporting "distraction" may have been distracted by thoughts surrounding the diet itself, thus resulting in our finding that distraction does not affect eating.[9] Finally, in the laboratory, each potential trigger is manipulated independently, which prevents such studies from assessing what happens when a variety of triggers is present. Because in everyday life triggers are present in various combinations, these laboratory studies might not be typical examples of everyday situations.

Among unrestrained eaters in our study, eating was predicted primarily by hunger and not by the other predictors of eating. These findings did conform to those found in the laboratory studies, with the exception of negative and positive mood. In our study, we found that these moods tended to affect eating, whereas laboratory studies generally find no effect of moods on the eating of unrestrained individuals.

Estimating consumption

Because our findings on the eating of restrained eaters diverge from previous research, it is particularly important to address potential concerns about our methodology. One concern is that participants were biased in their self-report of how much they ate, and in particular, underestimated their consumption. This does not seem to be the case, as the results of our study were virtually identical regardless of whether the outcome variable was the number of servings participants ate or whether or not they ate at all. Because we believe that participants were able to accurately determine and report whether or not they had eaten, this bolsters our confidence in the validity of the reported number of servings eaten.

To provide further evidence that participants did not underestimate the number of servings they ate at each meal, we conducted a validation study ($N = 35$) of our serving size estimation training procedures. Participants were trained in an identical manner using exactly the same materials and were subsequently given a pop quiz to determine whether they underestimated the number of servings. The quiz items were the top 10 most frequently eaten foods reported in a previous food diary study conducted in our lab with a similar sample and participants were presented with actual pre-measured foods and were instructed to estimate how many servings of each food were shown. Results supported our hypothesis that the participants were not underestimating their serving sizes. In fact, if participants made an error on the quiz, they tended to *over*estimate the number of servings. Participants underestimated the serving size 8% of the time, were correct 73.43% of the time, and overestimated 18.57% of the time.

Self-monitoring, reactivity, and diary methods

A second concern about the methodology in this study involves the effects of monitoring one's consumption on that consumption. One might argue that self-monitoring can lead to at least temporary success in behavioral goals and that participants may have reacted to being monitored by altering their food intake. This point must be addressed, because even though the amount of food-monitoring our participants engaged in was significantly less than in other naturalistic eating studies, it was still more than in laboratory studies of eating. And because participants were asked about their eating every hour, we could not hide from them our interest in predictors of eating, an interest that is effectively hidden in laboratory studies. By measuring a large number of potential predictors at a time, however, it is likely that participants were unaware of which ones were hypothesized to correlate with eating (and in which direction). The one trigger that participants might likely assume to be related to eating – hunger – did correlate with eating in the current time period to a high degree, but was also a significant predictor of eating in the following time period, which participants would not be likely to assume.

Further, the reactivity of eating (and binge eating) to diary methods has been evaluated in a number of studies and in every case it has been shown that the diary methods have not led to reactivity, including in the one study that tried to use monitoring eating on an electronic diary as an intervention to reduce eating (le Grange, Gorin, Dymek, & Stone, 2002). It found no effects on eating compared to a control group that did not monitor eating. It has been suggested that reactivity might be more pronounced in the early days of a diary study, compared to the later days, by which point participants would have adapted to the methodology. However, two studies show that even in the early days of a study, participants show very little reactivity to the monitoring procedures (Stein & Corte, 2003), suggesting that a short-term diary study such as the current one can provide valid data.

Finally, electronic diaries have been validated in terms of reactivity for a host of other behaviors. For example, studies of pain reporting have assessed participants' reactivity based on the number of reports they were assigned to make per day and found no effects (Stone et al., 2003) and studies of alcohol use found no reactivity on diary reports compared to patients in the same program who did not report on their alcohol use (Litt, Cooney, & Morse, 1998).

[9] We thank anonymous Reviewer 2 for this and other helpful suggestions.

Direction of causality

A third concern surrounding daily diary methodology is the issue of causality. The “trigger” variables that we measured may have actually been caused by the eating, rather than the other way around as we have contended. We attempted to overcome this concern by explicitly asking whether each of the states was present *before* the eating took place. Further, we also conducted lag-hour analyses to ensure that the trigger preceded the eating in time. These two strategies, however, still leave open the possibility that, for example, *not* eating may have caused negative emotion. Assessing the impact of *not* eating on the trigger variables is extremely difficult. For example, a question would have to be phrased, “Before you didn’t eat, did you experience negative mood?” Such a question would make interpretation of any results difficult, as it would require inferring an event from a non-event.

Conclusions

The strengths of the current study include its use of electronic daily diaries, which prevented participants from retrospectively reporting on their eating. This is notable as even in our *own* studies where subjects were instructed to report their food intake immediately after each meal, 96.3% of participants did not report their breakfast by 11 am, 93.59% of participants did not report their lunch by 3 pm, 77.78% of participants did not report their dinner by 8 pm, and a full 48.45% waited until the *following day* to enter their food intake.

Another strength of this study is the simultaneous measurement of numerous hypothesized predictors of eating. In addition, this study is the first diary study of eating that uses hierarchical linear models for data analysis, taking under consideration the nested and non-independent nature of the data and allowing for predictions of eating at one time point from the predictors present at the previous time point.

Knowledge of the true predictors of eating in everyday life is crucial for the creation of interventions to promote healthy eating and to prevent overeating. The current results suggest that hunger was strongly related to the eating of dieters and that interventions might be more effective if they aim to reduce feelings of hunger. In addition, interventions might focus on having dieters distract themselves at times when they might be tempted to eat. These findings also suggest that dieters might benefit by being alerted to delayed effects of moods on their eating.

Laboratory research has led to useful hypotheses about the factors that predict eating, but naturalistic studies are also necessary if we are to understand and influence individuals’ eating in daily life. This study presents an important first step in understanding the many factors that trigger eating in everyday life. Future research on effective eating interventions must combine the strong internal validity of findings from experimental laboratory studies with the external validity of daily diary studies.

Acknowledgements

This research was supported by a National Science Foundation Graduate Fellowship and an NIMH Health Psychology Predoctoral Fellowship T32MH15750-29 (A.J.T); University of California Council on Research Grant (T.M.); grant MH63795 from the National Institutes of Mental Health (T.M), and a University of Northern Colorado Faculty Grant (L.C.). We acknowledge the efforts of our undergraduate research assistants, and the invaluable assistance of Rachel Shasha and Ashley Moskovich. We would also like to thank Shelly Gable and Richard Slatcher for statistical assistance and Steve Engel for his usual wisdom.

Appendix A. Multilevel modeling results with whether participants ate or not (dichotomous) as outcome

			Model 0 (current hour)			Model 0 (next hour)		
	Fixed effect		Estimate[7]	Odds ratio	C.I.	Estimate	Odds ratio	C.I.
	Intercept	γ_{00}	-0.625^{***}	0.535^{***}	0.490, 0.584	-0.658^{***}	0.518^{***}	0.473, 0.568
	Restraint	γ_{01}	0.011	1.011	0.998, 1.024	0.013	1.013	0.999, 1.027
	Random effect		Estimate	S.D.	Chi-square	Estimate	S.D.	Chi-square
	Level 2	U_{0j}	0.050^{*}	0.223	147.312	0.068^{**}	0.261	159.627
			Model 1 (current hour)			Model 1 (next hour)		
Anxiety[5]	*Fixed effect*		Estimate	Odds ratio	C.I.	Estimate	Odds ratio	C.I.
	Intercept	γ_{00}	-0.772^{***}	0.462^{***}	0.373, 0.571	-0.656^{***}	0.519^{***}	0.413, 0.653
	Anxiety							
	Intercept	γ_{10}	0.108	1.114	0.983, 1.261	0.003	1.003	0.871, 1.157
	Random effect		Estimate	S.D.	Chi-square	Estimate	S.D.	Chi-square
	Level 2							
	Intercept	U_{0j}	0.126	0.354	95.517	0.370	0.608	132.792
	Slope	U_{1j}	0.010	0.100	90.231	0.072	0.268	125.112
Hunger	*Fixed effect*		Estimate	Odds Ratio	C.I.	Estimate	Odds Ratio	C.I.
	Intercept	γ_{00}	-0.715^{***}	0.489^{***}	0.440, 0.544	-0.656^{***}	0.519^{***}	0.473, 0.569
	Hunger							
	Intercept	γ_{10}	1.032^{***}	2.808^{***}	2.480, 3.181	0.148^{***}	1.160^{***}	1.079, 1.246
	Random effect		Estimate	S.D.	Chi-square	Estimate	S.D.	Chi-square
	Level 2							
	Intercept	U_{0j}	0.159^{***}	0.399	194.137	0.080^{**}	0.281	167.151
	Slope	U_{1j}	0.300^{***}	0.548	250.590	0.012	0.111	103.362
			Model 1 (current hour)			Model 1 (next hour)		
Distraction	*Fixed effect*		Estimate	Odds ratio	C.I.	Estimate	Odds ratio	C.I.
	Intercept	γ_{00}	-0.429^{***}	0.651^{***}	0.553, 0.766	-0.591^{***}	0.554^{***}	0.481, 0.638
	Distraction							
	Intercept	γ_{10}	-0.350^{*}	0.705^{*}	0.520, 0.955	−0.128	0.880	0.716, 1.080

Appendix A. (*Continued*)

	Random effect		Estimate	S.D.	Chi-square	Estimate	S.D.	Chi-square
	Level 2							
	Intercept	U_{0j}	0.298***	0.546	228.835	0.071**	0.266	161.057
	Slope	U_{1j}	1.680***	1.296	280.157	0.045	0.212	109.790
Mood	*Fixed effect*		Estimate	Odds ratio	C.I.	Estimate	Odds ratio	C.I.
	Intercept	γ_{00}	−0.968***	0.380***	0.339, 0.426	−0.662***	0.516***	0.470, 0.565
	Positive mood							
	Intercept	γ_{10}	−2.442***	0.087***	0.059, 0.106	0.461***	1.586***	1.250, 2.012
	Negative mood							
	Intercept	γ_{20}	−2.978***	0.051***	0.039, 0.067	0.258**	1.294**	1.072, 1.561
	Random effect		Estimate	S.D.	Chi-square	Estimate	S.D.	Chi-square
	Level 2							
	Intercept	U_{0j}	0.283	0.532	101.317	0.078***	0.277	142.549
	Positive mood	U_{1j}	3.438***	1.854	162.390	0.238	0.489	114.295
	Negative mood	U_{2j}	2.760***	1.661	162.280	0.139	0.373	121.271
			Model 2 (current hour)			Model 2 (next hour)		
Anxiety[6]	*Fixed effect*		Estimate	Odds ratio	C.I./S.E.	Estimate	Odds ratio	C.I./S.E.
	Intercept	γ_{00}	−0.657***	0.518***	0.473, 0.568	−0.771***	0.462***	0.372, 0.575
	Restraint	γ_{01}	0.013		0.007	0.017		0.018
	Anxiety							
	Intercept	γ_{10}	−0.032	0.969	0.999, 1.027	0.106	1.112	0.966, 1.281
	Restraint	γ_{11}	0.011		0.013	−0.006		0.010
	Random effect		Estimate	S.D.	Chi-square	Estimate	S.D.	Chi-square
	Level 2							
	Intercept	U_{0j}	0.068**	0.261**	159.649	0.119	0.345	96.192
	Slope	U_{1j}	N.E.			N.E.		
Hunger	*Fixed effect*		Estimate	Odds ratio	C.I./S.E.	Estimate	Odds ratio	C.I./S.E.
	Intercept	γ_{00}	−0.719***	0.487***	0.438, 0.542	0.661***	0.517***	0.471, 0.566
	Restraint	γ_{01}	0.015		0.008	0.013		0.007
	Hunger							
	Intercept	γ_{10}	1.037***	2.821***	2.487, 3.198	0.151***	1.163***	1.081, 1.251
	Restraint	γ_{11}	−0.014		0.012	−0.002		0.006
	Random effect		Estimate	S.D.	Chi-square	Estimate	S.D.	Chi-square
	Level 2							
	Intercept	U_{0j}	0.158***	0.398	191.250	0.070**	0.264	160.375
	Slope	U_{1j}	0.301***	0.549	249.721	N.E.		
Distraction	*Fixed effect*		Estimate	Odds Ratio	C.I./S.E.	Estimate	Odds Ratio	C.I./S.E.
	Intercept	γ_{00}	−0.437***	0.646***	0.554, 0.753	−0.594***	0.522***	0.482, 0.632
	Restraint	γ_{01}	0.033*		0.014	0.027*		0.011
	Distraction							
	Intercept	γ_{10}	−0.344*	0.709*	0.528, 0.951	−0.128	0.880	0.720, 1.077
	Restraint	γ_{11}	−0.053*		0.026	−0.026		0.014
	Random effect		Estimate	S.D.	Chi-square	Estimate	S.D.	Chi-square
	Level 2							
	Intercept	U_{0j}	0.215***	0.464	217.404	0.063**	0.251	155.643
	Slope	U_{1j}	1.525***	1.235	274.625	N.E.		
Mood	*Fixed effect*		Estimate	Odds Ratio	C.I./S.E.	Estimate	Odds Ratio	C.I./S.E.
	Intercept	γ_{00}	−1.039***	0.354***	0.315, 0.398	−0.667***	0.513***	0.467, 0.564
	Restraint	γ_{01}	0.029**		0.009	0.014		0.007
	Positive mood							
	Intercept	γ_{10}	−2.619***	0.073***	0.054, 0.098	0.460**	1.584**	1.221, 2.055
	Restraint	γ_{11}	0.041		0.030	−0.009		0.022
	Negative mood							
	Intercept	γ_{20}	−3.140***	0.043***	0.033, 0.057	0.265**	1.304**	1.079, 1.575
	Restraint	γ_{21}	0.053		0.028	−0.031*		0.016
	Random effect		Estimate	S.D.	Chi-square	Estimate	S.D.	Chi-square
	Level 2							
	Intercept	U_{0j}	0.242	0.492	94.941	0.071***	0.267	160.881
	Positive mood	U_{1j}	3.472**	1.863	157.820	N.E.		
	Negative mood	U_{2j}	2.614**	1.617	151.920	N.E.		

		Model 3 (current hour)			Model 3 (next hour)		
Fixed effect		Estimate	Odds ratio	C.I./S.E.	Estimate	Odds ratio	C.I./S.E.
Intercept	γ_{00}	1.200***	3.321***	2.392, 4.610	−0.638***	0.528***	0.481, 0.581
Restraint	γ_{01}	0.012		0.024	0.006		0.008
Hunger							
Intercept	γ_{10}	0.581***	1.788***	1.660, 1.926	0.246***	1.279***	1.168, 1.399
Restraint	γ_{11}	N.E.			N.E.		
Distraction							
Intercept	γ_{20}	−0.594***	0.552***	0.418, 0.728	N.E.		
Restraint	γ_{21}	−0.011		0.030	N.E.		

Appendix A. (*Continued*)

Positive mood							
Intercept	γ_{30}	−2.093***	0.123***	0.097, 0.156	0.371**	1.449**	1.143, 1.836
Restraint	γ_{31}	N.E.					
Negative mood							
Intercept	γ_{40}	−2.483***	0.083***	0.066, 0.106	0.325**	1.384**	1.126, 1.702
Restraint	γ_{41}	0.007		0.022	−0.025		0.016
Random effect		Estimate	S.D.	Chi-square	Estimate	S.D.	Chi-square
Level 2							
Intercept	U_{0j}	0.082**	0.286	160.325	0.093**	0.304	140.077
Hunger	U_{1j}	N.E.			0.059*	0.242	126.837
Distraction	U_{2j}	N.E.			N.E.		
Positive mood	U_{3j}	N.E.			0.194*	0.441	124.126
Negative mood	U_{4j}	N.E.			0.314†	0.561	121.862

Notes: C.I. = confidence interval; S.E. = standard error. For the restraint moderation analyses at Level 2, we present S.E. rather than C.I.; N.E. = not estimated (components were not significant in initial runs of models) †$p = 0.051$ *$p < 0.05$ **$p < 0.01$ ***$p < 0.001$.

Appendix B. Multilevel modeling results with number of servings (continuous) as outcome

			Model 0 (current hour)			Model 0 (next hour)		
	Fixed effect		Estimate	S.E.		Estimate	S.E.	
	Intercept	γ_{00}	0.832	0.034		0.829	0.035	
	Restraint	γ_{01}	−0.004	0.005		0.006	0.006	
	Random effect		Estimate	S.D.	Chi-square	Estimate	S.D.	Chi-square
	Level 1	R_{ij}	1.944	1.394		1.956	1.398	
	Level 2	U_{0j}	0.051***	0.227	189.252	0.059***	0.243	189.818
	Deviance		9995.252			9333.722		
			Model 1 (current hour)			Model 1 (next hour)		
Anxiety[5]	*Fixed effect*		Estimate	S.E.		Estimate	S.E.	
	Fixed effect		Estimate	S.E.		Estimate	S.E.	
	Intercept	γ_{00}	0.822***	0.036		0.829***	0.035	
	Anxiety							
	Intercept	γ_{10}	0.034	0.060		0.029	0.065	
	Random effect		Estimate	S.D.	Chi-square	Estimate	S.D.	Chi-square
	Level 1	R_{ij}	1.910	1.382		1.945	1.394	
	Level 2							
	Intercept	U_{0j}	0.063***	0.252	186.938	0.059***	0.243	179.327
	Slope	U_{1j}	0.023	0.152	111.132	0.050*	0.223	138.273
	Deviance		9277.376			9328.352		
Hunger	*Fixed effect*		Estimate	S.E.		Estimate	S.E.	
	Intercept	γ_{00}	0.8222	0.036		0.829	0.036	
	Hunger							
	Intercept	γ_{10}	0.676	0.039		0.155***	0.028	
	Random effect		Estimate	S.D.	Chi-square	Estimate	S.D.	Chi-square
	Level 1	R_{ij}	1.362	1.167		1.920	1.384	
	Level 2							
	Intercept	U_{0j}	0.089***	0.298	280.086	0.060***	0.246	195.090
	Slope	U_{1j}	0.111***	0.333	317.056	0.009	0.097	121.376
	Deviance		8502.463			9295.845		
Distraction	*Fixed effect*		Estimate	S.E.		Estimate	S.E.	
	Intercept	γ_{00}	0.822***	0.036		0.829***	0.036	
	Distraction							
	Intercept	γ_{10}	0.217	0.139		0.112	0.116	
	Random Effect		Estimate	S.D.	Chi-square	Estimate	S.D.	Chi-square
	Level 1	R_{ij}	1.823	1.350		1.920	1.386	
	Level 2							
	Intercept	U_{0j}	0.067***	0.230	208.441	0.060***	0.246	195.026
	Slope	U_{1j}	1.102***	1.050	242.075	0.443**	0.666	162.303
	Deviance		9233.642			9320.342		
Mood	*Fixed effect*		Estimate	S.E.		Estimate	S.E.	
	Intercept	γ_{00}	0.822***	0.036		0.827***	0.035	
	Positive mood							
	Intercept	γ_{10}	−0.914***	0.106		0.112	0.075	
	Negative mood							
	Intercept	γ_{20}	−1.252***	0.091		0.224**	0.076	
	Random effect		Estimate	S.D.	Chi-square	Estimate	S.D.	Chi-square
	Level 1	R_{ij}	1.079	1.039		1.892	1.375	
	Level 2							
	Intercept	U_{0j}	0.101***	0.318	315.241	0.061***	0.248	175.308

Appendix B. (*Continued*)

	Positive mood	U_{1j}	0.802***	0.896	337.368	0.019	0.138	96.406
	Negative mood	U_{2j}	0.657***	0.810	366.078	0.228**	0.478	153.558
	Deviance		8035.738			9284.279		
			Model 2 (current hour)			Model 2 (next hour)		
Anxiety[6]	*Fixed effect*		Estimate	S.E.		Estimate	S.E.	
	Intercept	γ_{00}	0.823***	0.036		0.829***	0.035	
	Restraint	γ_{01}	−0.007	0.006		−0.006	0.006	
	Anxiety							
	Intercept	γ_{10}	0.051	0.061		0.052	0.068	
	Restraint	γ_{11}	−0.002	0.008		−0.013	0.010	
	Random effect		Estimate	S.D.	Chi-square	Estimate	S.D.	Chi-square
	Level 1	R_{ij}	1.916***	1.384		1.946	1.395	
	Level 2							
	Intercept	U_{0j}	0.063***	0.250	196.692	0.059***	.0243	
	Slope	U_{1j}	N.E.			0.042*	0.204	135.833
	Deviance		9292.588			9341.337		
Hunger	*Fixed effect*		Estimate	S.E.		Estimate	S.E.	
	Intercept	γ_{00}	0.822***	0.036		0.830***	0.035	
	Restraint	γ_{01}	−0.008	0.006		−0.006	0.006	
	Hunger							
	Intercept	γ_{10}	0.676***	0.039		0.157***	0.028	
	Restraint	γ_{11}	−0.006	0.007		−0.004	0.006	
	Random effect		Estimate	S.D.	Chi-square	Estimate	S.D.	Chi-square
	Level 1	R_{ij}	1.363	1.167		1.930	1.389	
	Level 2							
	Intercept	U_{0j}	0.089***	0.297	276.473	0.060***	0.245	192.346
	Slope	U_{1j}	0.111***	0.333	312.692	N.E.		
	Deviance		8517.516			9312.457		
Distraction	*Fixed effect*		Estimate	S.E.		Estimate	S.E.	
	Intercept	γ_{00}	0.823***	0.036		0.829***	0.035	
	Restraint	γ_{01}	−.007	0.006		−0.006	0.006	
	Distraction							
	Intercept	γ_{10}	−0.216	0.139		0.112	0.116	
	Restraint	γ_{11}	0.006	0.023		−0.014	0.017	
	Random effect		Estimate	S.D.	Chi-square	Estimate	S.D.	Chi-square
	Level 1	R_{ij}	1.822	1.340		1.919	1.385	
	Level 2							
	Intercept	U_{0j}	0.067***	0.259	205.669	0.061***	0.246	193.389
	Slope	U_{1j}	1.133***	1.064	242.922	0.459**	0.678	161.546
	Deviance		9246.070			9333.312		
Mood	*Fixed effect*		Estimate	S.E.		Estimate	S.E.	
	Intercept	γ_{00}	0.822***	0.036		0.827***	0.035	
	Restraint	γ_{01}	−.007	0.006		−0.006	0.006	
	Positive mood							
	Intercept	γ_{10}	−.925***	0.106		0.126	0.076	
	Restraint	γ_{11}	0.032	0.020		−0.007	0.013	
	Negative mood							
	Intercept	γ_{20}	−1.251***	0.091		0.221**	0.073	
	Restraint	γ_{21}	0.018	0.017		−0.031*	0.012	
	Random effect		Estimate	S.D.	Chi-square	Estimate	S.D.	Chi-square
	Level 1	R_{ij}	1.080	1.040		1.893	1.376	
	Level 2							
	Intercept	U_{0j}	0.101***	0.318	312.951	0.062***	0.250	196.058
	Positive mood	U_{1j}	0.791***	0.889	334.259	N.E.		
	Negative mood	U_{2j}	0.648***	0.805	364.636	0.194**	0.440	168.439
	Deviance		8051.463			9301.629		

		Model 3 (current hour)			Model 3 (next hour)		
Fixed effect		Estimate	S.E.		Estimate	S.E.	
Intercept	γ_{00}	0.822***	0.036		0.827***	0.035	
Restraint	γ_{01}	N.E.			−0.006	0.006	
Anxiety							
Intercept	γ_{10}	N.E.			N.E.		
Restraint	γ_{11}	N.E.			N.E.		
Hunger							
Intercept	γ_{20}	0.458***	0.030		0.217***	0.030	
Restraint	γ_{21}	N.E.			N.E.		
Distraction							
Intercept	γ_{30}	N.E.			N.E.		
Restraint	γ_{31}	N.E.			N.E.		
Positive mood							
Intercept	γ_{40}	−0.798***	0.097		0.180*	0.076	

Appendix B. (*Continued*)

Restraint	γ_{41}	N.E.			N.E.		
Negative mood							
Intercept	γ_{50}	-0.998^{***}	0.084		0.340^{***}	0.081	
Restraint	γ_{51}	N.E.			-0.032^{**}	0.011	
Random effect		Estimate	S.D.	Chi-square	Estimate	S.D.	Chi-square
Level 1	R_{ij}	0.849	0.921		1.844	1.358	
Level 2							
Intercept	U_{0j}	0.112^{***}	0.335	400.685	0.064^{***}	0.254	201.327
Anxiety	U_{1j}	N.E.			N.E.		
Hunger	U_{2j}	0.054^{***}	0.233	238.245	N.E.		
Distraction	U_{3j}	N.E.			N.E.		
Positive mood	U_{4j}	0.678^{***}	0.823	351.172	N.E.		
Negative mood	U_{5j}	0.557^{***}	0.746	361.800	0.220^{***}	0.469	117.332
Deviance		7523.843			9237.879		

Notes: S.E. = standard error (robust); S.D. = standard deviation. N.E. = not estimated (components were not significant in initial runs of models) $^{*}p < 0.05$ $^{**}p < 0.01$ $^{***}p < 0.001$.

References

Baker, C. W., Little, T. D., & Brownell, K. D. (2003). Predicting adolescent eating and activity behaviors: The role of social norms and personal agency. *Health Psychology, 22*, 189–198.

Bellisle, F., & Dalix, A. (2001). Cognitive restraint can be offset by distraction, leading to increased meal intake in women. *American Journal of Clinical Nutrition, 74*, 197–200.

Bryk, A. S., Raudenbush, S. W., & Congdon, R. T. (1996). *Hierarchical linear modeling with the HLM/2L and HLM/3L programs*. Chicago, IL: Scientific Software.

Carels, R. A., Douglass, O. M., Cacciapaglia, H. M., & O'Brien, W. H. (2004). An ecological momentary assessment of relapse crises in dieting. *Journal of Consulting and Clinical Psychology, 72*, 341–348.

Carels, R. A., Hoffman, J., Collins, A., Raber, A. C., Cacciapaglia, H., & O'Brien, W. H. (2001). Ecological momentary assessment of temptation and lapse in dieting. *Eating Behaviors, 2*(4), 307–321.

Carver, C., & Scheier, M. (1998). *On the self-regulation of behavior*. New York, NY: Cambridge University Press.

Cools, J., Schotte, D. E., & McNally, R. J. (1992). Emotional arousal and overeating in restrained eaters. *Journal of Abnormal Psychology, 101*, 348–351.

de Castro, J. M. (2000). Eating behavior: Lessons from the real world of humans. *Nutrition, 16*(10), 800–813.

de Castro, J. M., & Elmore, D. K. (1988). Subjective hunger relationships with meal patterns in the spontaneous feeding behavior of humans: Evidence for a causal connection. *Physiology and Behavior, 43*(2), 159–165.

Freeman, L. M. Y., & Gil, K. M. (2004). Daily stress, coping, and dietary restraint in binge eating. *International Journal of Eating Disorders, 36*, 204–212.

Frost, R. O., Goolkasian, G. A., Ely, R. J., & Blanchard, F. A. (1982). Depression, restraint and eating behavior. *Behavior Research and Therapy, 20*, 113–121.

Gable, S., Reis, H. T., & Elliot, A. J. (2003). Evidence for bivariate systems: An empirical test of appetition and aversion across domains. *Journal of Research in Personality, 37*(5), 349–372.

Greeno, C. G., & Wing, R. R. (1994). Stress-induced eating. *Psychological Bulletin, 115*(3), 444–464.

Greeno, C. G., Wing, R. R., & Shiffman, S. (2000). Binge antecedents in obese women with and without binge eating disorder. *Journal of Consulting and Clinical Psychology, 68*(1), 95–102.

Grilo, C. M., Shiffman, S., & Wing, R. R. (1989). Relapse crises and coping among dieters. *Journal of Consulting and Clinical Psychology, 57*(4), 488–495.

Herman, C. P., & Polivy, J. (1975). Anxiety, restraint, and eating behavior. *Journal of Abnormal Psychology, 84*(6), 66–72.

Herman, C. P., & Polivy, J. (1980). Restrained eating.. In A. J. Stunkard (Ed.), *Obesity* (pp. 208–225). Philadelphia, PA: W. B. Saunders.

Herman, C. P., & Polivy, J. (1984). A boundary model for the regulation of eating. In A. J. Stunkard & E. Stellar (Eds.), *Eating and its disorders* (pp. 141–156). New York, NY: Raven Press.

Larson, R. F. (1989). Beeping children and adolescents: A method for studying time use and daily experience. *Journal of Youth and Adolescence, 18*(6), 511–530.

Lattimore, P., & Caswell, N. (2004). Differential effects of active and passive stress on food intake in restrained and unrestrained eaters. *Appetite, 42*(2), 167–173.

le Grange, D., Gorin, A., Dymek, M., & Stone, A. (2002). Does ecological momentary assessment improve cognitive behavioural therapy for binge eating disorder? A pilot study. *European Eating Disorders Review, 10*, 316–328.

Litt, M. D., Cooney, N. L., & Morse, P. (1998). Ecological momentary assessment (EMA) with treated alchoholics: Methodological problems and potential solutions. *Health Psychology, 17*, 48–52.

Mann, T., & Ward, A. (2004). To eat or not to eat: Implications of the attentional myopia model for restrained eaters. *Journal of Abnormal Psychology, 113*, 90–98.

Patel, K. A., & Schlundt, D. G. (2001). Impact of moods and social context on eating behavior. *Appetite, 36*(2), 111–118.

Polivy, J., Herman, C. P., Hackett, R., & Kuleshnyk, I. (1986). The effects of self-attention and public attention on eating in restrained and unrestrained subjects. *Journal of Personality and Social Psychology, 50*(6), 1253–1260.

Ruderman, A. J. (1985). Dysphoric mood and overeating: a test of restraint theory's disinhibition hypothesis. *Journal of Abnormal Psychology, 94*, 78–85.

Ruderman, A. J. (1986). Dietary restraint: A theoretical and empirical review. *Psychological Bulletin, 99*, 247–262.

Schlundt, D. G., Sbrocco, T., & Bell, C. (1989). Identification of high-risk situations in a behavioral weight loss program: Application of the relapse prevention model. *International Journal of Obesity, 13*, 223–234.

Schotte, D. E., Cools, J., & McNally, R. J. (1990). Film-induced negative affect triggers overeating in restrained eaters. *Journal of Abnormal Psychology, 99*, 317–320.

Smyth, J., Wonderlich, S., Crosby, R., Miltenberger, R., Mitchell, J., & Rorty, M. (2001). The use of ecological momentary assessment approaches in eating disorder research. *International Journal of Eating Disorders, 30*(1), 83–95.

Steiger, H., Gauvin, L., Engelberg, M. J., Kin, N. M. K. N. Y. , Israel, M., Wonderlich, S. A., et al. (2005). Mood- and restraint-based antecedents to binge episodes in bulimia nervosa: Possible influences of the serotonin system. *Psychological medicine, 35*, 1553–1562.

Stein, K. F., & Corte, C. M. (2003). Ecologic momentary assessment of eating-disordered behaviors. *International Journal of Eating Disorders, 34*, 349–360.

Stone, A. A., Broderick, J. E., Schwartz, J. E., Shiffman, S., Litcher-Kelly, L., & Calvanese, P. (2003). Intensive momentary reporting of pain with an electronic diary: Reactivity, compliance, and patient satisfaction. *Pain, 104*, 343–351.

Stone, A. A., & Shiffman, S. (1994). Ecological momentary assessment (EMA) in behavioral medicine. *Annals of Behavioral Medicine, 16*(3), 199–202.

Ward, A., & Mann, T. (2000). Don't mind if I do: Disinhibited eating under cognitive load. *Journal of Personality and Social Psychology, 78*, 753–763.

Wegner, K. E., Smyth, J. M., Crosby, R. D., Wittrock, D., Wonderlich, S. A., & Mitchell, J. E. (2002). An evaluation of the relationship between mood and binge eating in the natural environment using ecological momentary assessment. *International Journal of Eating Disorders, 32*(3), 352–361.