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No haste, more taste: An EMA study of the effects of stress, negative and positive emotions on eating behavior

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A R T I C L E I N F O

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A B S T R A C T

Objectives: Stress and emotions alter eating behavior in several ways: While experiencing negative or positive emotions typically leads to increased food intake, stress may result in either over- or undereating. Several participant characteristics, like gender, BMI and restrained, emotional, or external eating styles seem to influence these relationships. Thus far, most research relied on experimental laboratory studies, thereby reducing the complexity of real-life eating episodes. The aim of the present study was to delineate the effects of stress, negative and positive emotions on two key facets of eating behavior, namely taste- and hunger-based eating, in daily life using ecological momentary assessment (EMA). Furthermore, the already mentioned individual differences as well as time pressure during eating, an important but unstudied construct in EMA studies, were examined.
Methods: Fifty-nine participants completed 10 days of signal-contingent sampling and data were analyzed using multilevel modeling.
Results: Results revealed that higher stress led to decreased taste-eating which is in line with physiological stress-models. Time pressure during eating resulted in less taste- and more hunger-eating. In line with previous research, stronger positive emotions went along with increased taste-eating. Emotional eating style moderated the relationship between negative emotions and taste-eating as well as hunger-eating. BMI moderated the relationship between negative as well as positive emotions and hunger-eating.
Conclusions: These findings emphasize the importance of individual differences for understanding eating behavior in daily life. Experienced time pressure may be an important aspect for future EMA eating studies.

1. Introduction

In prosperous societies, characterized by high availability and public visibility of palatable and energy-rich foods, eating behavior is driven not only by physiological or homeostatic processes like hunger and satiety but also by food hedonics (Berthoud, 2006; Lowe & Butryn, 2007), e.g., to high palatability and cue elicited craving. Especially when it comes to in-between meal snacking or unhealthy eating, hunger does not represent the only and most important reason for consummation (Cleobury & Tapper, 2014). As snacking often involves high fat and sugar products (Cleobury & Tapper, 2014; Ovaskainen et al., 2005), identifying possible aspects promoting this eating behavior seems necessary to optimally tackle the rising prevalence of overweight and obesity (Ng et al., 2014).

Previous literature has emphasized stress and emotions as prominent factors influencing eating behavior. Stress can be defined as a state in which environmental demands exceed an individual's resources (incl. coping skills), with reactions on cognitive-emotional (i.e., experiencing negative emotions), behavioral, or physiological levels (Dickerson & Kemeny, 2004). Several physiological and psychological accounts have been proposed to explain stress/emotion eating relationships. Regarding *physiological* accounts, during acute stress, activation of the sympathetic nervous system (SNS, supporting fight-or-flight responses) and the associated noradrenaline release redirect blood-flow away from

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the digestive system (Torres & Nowson, 2007). Thus, a defensive stress response could be expected to decrease food intake. Effects of hypothalamic-pituitary-adrenal (HPA) activity, however, are more complex since its constituents (corticotropin-releasing hormone, CRH, adrenocorticotropin, ACTH, and cortisol) have combined but also independent effects on food intake and influence a range of other metabolic regulators such as insulin, leptin and neuropeptide Y (Adam & Epel, 2007; Bazhan & Zelena, 2013). Other models consider the availability of highly palatable food as crucial for whether increased or decreased eating occurs in response to HPA axis activation (Bazhan & Zelena, 2013): orexigenic effects are expected in the presence of a high calorie diet, anorexigenic effects in the absence of such a diet. Thus, it is not surprising that empirical results on the stress-eating relationship are markedly mixed: While experimental and questionnaire based studies (Gibson, 2012; Oliver & Wardle, 1999; Stone & Brownell, 1994; Zellner et al., 2006) found individuals to eat less during stressful compared to non-stressful situations, others observed exactly the opposite, namely increased food consumption during stress (Epel, Lapidus, McEwen, & Brownell, 2001; Gibson, 2012; Oliver & Wardle, 1999; Zellner et al., 2006). The latter is supported by a recent review showing that during negative emotions (including stressful states) enhanced food consumption is more likely (Cardi, Leppanen, & Treasure, 2015).

While not all physiological stress-eating mechanisms have been identified, it is likely that such hormonal pathways operate in parallel or in interaction with *psychological* mechanisms such as learning, coping and emotion regulation. Moreover, large *interindividual differences* in this domain (see below) and the context dependency of human eating behaviors slow the progression toward conclusive stress-eating models (Adam & Epel, 2007). Hence, present research focuses on interrelating subjective indicators of stress and eating, taking into consideration interindividual differences, stress contexts, time pressure and others. In the next step, such models can then be related to neurohormonal indicators in the quest for integrated biobehavioral models of stress, eating and addiction.

According to the *individual difference model* (Greeno & Wing, 1994), several between participants' variables might affect the stress-eating relationship: Eating styles, body mass index (BMI) and gender have frequently been assumed to modify the relationship between stress/negative emotions and eating behavior. In terms of eating styles, *restrained eating* refers to an effort to restrict food intake in order to control body weight. While highly restrained individuals increase their food intake under stress and negative emotions, unrestrained individuals either decrease their intake (Heatherton, Herman, & Polivy, 1991; Mitchell & Epstein, 1996; Rutledge & Linden, 1998) or show no change (Wardle, Steptoe, Oliver, & Lipsey, 2000). Another eating style, *emotional eating*, refers to eating in response to negative affect: high scorers on emotional eating scales tend to consume more, while low scorers consume less food following stress induction in the laboratory (Cardi et al., 2015; van Strien, Herman, Anschutz, Engels, & de Weerth, 2012; Wallis & Hetherington, 2009). However, other studies failed to show an influence of emotional eating on food consumption (Adriaanse, de Ridder, & Evers, 2011; Conner, Fitter, & Fletcher, 1999). Lastly, high *external eating*, referring to eating in response to food cues like its sight or smell, has also been related to increased food intake (Conner et al., 1999; Oliver, Wardle, & Gibson, 2000). Further, with regard to BMI, individuals with obesity tend to consume more when stressed compared to normal weight individuals (O'Connor, Jones, Conner, McMillan, & Ferguson, 2008), although literature is indecisive with respect to a main effect of obesity on food intake (Greeno & Wing, 1994; Torres & Nowson, 2007). Last, *gender* seems to play a role: women report more perceived stress than men (Cohen, Janicki, & Deverts, 2012) and report higher levels of restrained and emotional eating (Conner, Johnson, & Grogan, 2004). Possibly due to these differences, women seem to be more vulnerable to stress-induced eating (Cleobury & Tapper, 2014; Gibson, 2012; Greeno & Wing, 1994; O'Connor et al., 2008; Zellner et al., 2006).

While informative, the above research has mostly taken place in the laboratory, under standardized and isolated conditions. As a result, we know relatively little about how stress and emotions may impact eating behavior in people's daily lives. Laboratory studies of eating behavior are also problematic for a number of additional reason: The heightened self-awareness distorts eating under laboratory conditions as revealed by a recent meta-analysis (Robinson, Hardman, Halford, & Jones, 2015), naturalistic social aspects are missing (e.g. dinner with the partner or family), food choice is limited and not matched to individual preferences (Cardi et al., 2015; Edwards, Hartwell, & Brown, 2013; Grenard et al., 2013; Oliver et al., 2000; Wallis & Hetherington, 2009; Wansink, 2004), and measuring only one eating episode does not capture reactivity to varying stress and emotion intensities as they occur in daily life.

To remedy these limitations, the aim of the current study is to examine the effect of stress and negative emotions on eating behavior in daily life using Ecological Momentary Assessment (EMA). EMA conserves naturalistic conditions by recording information as people engage in their usual activities and thereby seems especially important regarding eating behavior (Smyth et al., 2001). Despite these many advantages, the EMA literature on stress, emotions and eating behavior in non-eating disordered populations is surprisingly limited. As one of the few exceptions, O'Connor et al. (2008) reported that employees increase their snacking when experiencing ego-threatening, interpersonal and work-related stress but decrease it under physical stress. Moreover, the stress-eating relationship was more pronounced in individuals with higher levels of emotional, restrained, and external eating styles (as well as disinhibition), as well as in females and individuals with obesity. In other EMA studies, daily hassles were related to more snacking (Zenk et al., 2014), but Evers, Adriaanse, de Ridder, and de Witt Huberts (2013) showed that positive emotions were more predictive of snacking compared to negative emotions.

The present study goes beyond the existing research in several important ways. First, previous studies failed to draw a clear distinction between purely stress- or emotion-related eating alterations. Although stress and emotions are related constructs, their effects on eating behavior may differ profoundly as do the physiological underpinnings of the two. Thus, the present study separately measured negative emotional states and stress. Second, although positive emotional states were found to correlate with increased food consumption (Cardi et al., 2015; Evers et al., 2013), they have hardly been studied in daily life. Hence, the present research included positive emotions to account for this gap. Third, following the above reviewed literature, eating styles, BMI and gender were considered as (between-participant) moderators of the (within-participant) stress/emotions-eating associations. Fourth, an important, but unstudied component in previous studies in naturalistic settings is *time pressure*: Choosing highly palatable, already prepared foods may be due to insufficient time, energy and planning to purchase and prepare healthier food options during stressful situations (Escoto, Laska, Larson, Neumark-Sztainer, & Hannan, 2012; Jabs & Devine, 2006; Welch, McNaughton, Hunter, Hume, & Crawford, 2009). In order to control for this possible explanation, we measured and analyzed time pressure during eating in the current study. Last and importantly, previously used measures of overt eating behavior (overall calories consumed; macro nutritional composition) confound homeostatic (i.e., more physiological, hunger-driven eating) with hedonic (i.e., taste-driven eating) determinants. Thus, we decided to relate the two key determinants of food consumptions, namely hunger and taste-driven eating to their possible predictors (i.e. stress, negative and positive emotions) rather than predicting actual food consumption, expecting stronger effects of stress and emotions on hedonic taste-based eating. This approach also circumvents the problems with defining snacks (eating for hedonic reasons) and separating them from main meals or meal replacements.

Our methods featured 5 intraday signals across the course of 10 days, allowing for time lagged analyses to support directional interpretations of the effects of stress/emotions on hunger- and taste-driven eating. We hypothesized that taste-driven eating (but not hunger-driven eating) may be enhanced after stressful and highly emotional occasions with this effect being pronounced in female restrained, emotional and external eaters. We had no specific hypothesis regarding BMI, as previous literature has shown inconsistent results as well as regarding time pressure, as this is the first study to our knowledge considering this novel aspect.

2. Method

2.1. Participants

Participants were recruited into the study of "stress and eating in daily life" via several newspaper articles, a television report as well as word of mouth. A total of 66 participants completed initial questionnaires. During the data collection phase, six individuals quit because of time difficulties or smartphone device problems and one participant was excluded because of missing data in the questionnaires and overall low compliance. The resulting 59 individuals, whose data are reported here, ranged from 14 to 65 years with a mean of 39.9 (SD = 11.9). Participants were predominantly women (78%) with a mean BMI of 26.7 (SD = 5.76; range: 17.5–38.6). All participants signed an informed consent form approved by the ethics committee of the University of Salzburg and were compensated for their participation.

2.2. Questionnaire

2.2.1. Dutch eating behavior questionnaire (DEBQ)

The DEBQ (van Strien, Frijters, Bergers, & Defares, 1986) is a frequently used, well validated scale assessing the three eating styles – restrained, external and emotional eating (10 items each). Items are scaled from *1* (=*never*) to *5* (=*very often*) and average scores are calculated. Its German version (Grunert, 1989) showed internal consistencies between α = 0.864–0.898 in the present sample.

2.3. PsyDiary app

The PsyDiary app was especially designed in collaboration with the Smart Health Check research group at the department of MultiMediaTechnology of the Salzburg University of Applied Sciences. Supported platforms are Android and iOS with EMA questions being accessed and defined via Limesurvey (Schmitz, 2015).

2.4. EMA measures

At each of 5 daily signals, participants reported their emotions, stress levels and eating behaviors. Emotions were assessed on visual-analogue scales consisting of continuous horizontal rating sliders ranging from *0–100 (not at all – very much)*, with participants being asked 'How do you feel right now?' followed by a list of 10 emotion items presented in random order. Five positive emotions (cheerful, enthusiastic, awake, calm, relaxed; in German: fröhlich, begeistert, wach, gelassen, entspannt) and 5 negative emotions (irritated, bored, nervous/stressed, distressed, depressed; in German: gereizt, gelangweilt, nervös oder gestresst, bekümmert, deprimiert) were chosen based on previous literature on EMA studies in eating disorders and worded as to represent a low threshold in this mostly healthy and high functioning sample. Stress was assessed with three items of the *Perceived Stress Scale* (PSS; Cohen & Williamson, 1988) adapted for momentary use: 'Do you feel that you can cope with things', 'Do you feel that you're on top of things' as well as the previously mentioned emotional item 'nervous/stressed', being rated on a continuous slider from *0 (not at all)* to *100 (very much)*. For every eating episode that occurred since the last entry (being defined in the instructions as a distinct episode if longer than 30 min apart or contingent on a change of places), participants rated the extent to which they ate because of hunger and the extent to which they ate because of taste on two continuous rating sliders (*0 = not hunger (or taste)-driven* to *100 = solely hunger (or taste)-driven*, respectively). They were instructed to report the extent to which the taste made them eat over and above their hunger-driven eating (i.e. eating despite satiety). They further reported how time pressured they felt during each eating episode (*0 = not at all* to *100 = very much*) on a continuous rating slider. Last, participants classified their eating episode into either 'main meal', being defined as meals eaten regularly to a certain time point, or 'snack'. After completing these questions for their first eating episode in chronological order, they were asked if they had eaten anything else and repeatedly answered these questions for up to four distinct eating episodes. Participants were asked to report eating episodes that occurred after the last signal of the day (9 a.m.) at the first signal the next day.

2.5. Procedure

After completing different diagnostic measures and demographic information (e.g. weight and height for BMI) at an online survey platform, participants were contacted to supervise the installation of the PsyDiary app (developed by the department of MultiMediaTechnology of the Salzburg University of Applied Sciences) on their smartphones. Participants were instructed about relevant variables on the phone as well as the app manual. One to two practice days (data not used in the study) ensured familiarity with the app and provided opportunities to clarify any arising questions (technical-, app- or item-wise). When everything was clear, participants completed 10 days of EMA, with data completeness being monitored closely. If necessary, participants were contacted during this period to give them feedback about low compliance rates. During the 10 days of sampling, the researcher provided mobile phone and email contact possibilities for eventual problems or questions. A final online questionnaires, including questions about reactivity, as well as participating compensation (individualized feedback or a compliance dependent remuneration of 35–60€) closed the study.

Signal-contingent sampling was used, with five equidistant prompts at 9 a.m., 12 a.m., 3 p.m., 6 p.m. and 9 p.m. Diary entries could be delayed if safety was a concern (e.g. while driving) or when there was no possibility to reply. Additionally, participants could delay the required diary entries in response to a signal for one hour with or without reminders every 10 min. However, PsyDiary programming ensured that EMA measures could only be delayed within one hour after the first prompt and later entries for this signal were not allowed and resulted in missing values.

2.6. Data analyses

For every signal, scores of taste-driven food intake (the same for hunger) and time pressure were averaged across eating episodes if more than one was reported, irrespective of classification as main meals or snacks. For the calculation of the experienced stress level, the mean of the reversed two PSS-items, as well as the emotion item 'nervous/stressed' was used. For negative, respective positive affect, the mean of all five negative, respective positive emotion items was computed. While stress and emotions were measured momentarily, eating was assessed retrospectively (in the interval since the last signal). Thus in order to test directionality in the relation of stress/emotions on eating, stress/emotions at the previous signal (t-1, 3 h before) was used as predictor of eating-related entries reported at signal t within one day. Only stress/emotion ratings one signal (t-1) before the eating episode (t) were considered in the analyses in order to restrict stress/emotional variability and to measure more direct stress/emotion effects.

Hierarchical linear models were applied using the software HLM7 (Raudenbush, Byrk, & Congdon, 2011) because of the nested, longitudinal structure of the data. Occasions/signals (Level 1) were nested within participants (Level 2). At Level 1, we separately modeled stress level (lagged by 1 signal) as well as negative and positive emotions/affect (NA and PA; lagged by 1 signal) as predictor of the extent of taste-eating as well as hunger-eating. Afterwards, time pressure was controlled for as a simultaneous Level 1 predictor. Slopes were allowed to vary randomly across participants. At Level 2, we modeled eating styles (restrained, emotional and external eating), BMI and gender (coded 0 = female and 1 = male) as predictors of the intercept (equivalent to between-participant correlations with mean eating variables) as well as moderators of Level 1 slopes. Level 1 predictors were person-mean centered, Level 2 predictors were grand-mean centered.

3. Results

3.1. EMA measures

On average, participants completed 83.6% (SD = 12.3%) of their signal-contingent entries (range 50–100%), reflecting good compliance. Overall, participants provided 2465 separate EMA recordings over the 10 days, including 1726 signals (70.0%) with at least one eating episode. As individuals were allowed to report more than one eating episode per signal, a total of 2071 distinct eating episodes were reported. Among these, participants subjectively classified 801 eating episodes as snacks (equal to 38.68%) and 1270 episodes as main meals.[1] Table 1 shows mean and standard deviations of the included variables. Moreover, at the end of the study when asked about reactivity, participants did not think that the prompts changed their eating behavior ($M = 3.71$, $SD = 2.36$ on a scale ranging from *1 = not at all* to *11 = very much).*

3.2. Taste-eating in relation to snacking and hunger-eating

To validate our dependent variable taste-eating, its relation with snacking was tested. On days with increased taste-eating, participants also reported more snacks ($\beta_{10} = 0.013$, $p = 0.006$), but not more main meals ($\beta_{10} = -0.004$, $p = 0.659$). Taste-eating and hunger-eating correlated negatively $r = -0.46$, $p = 0.001$.

Table 1
Descriptive statistics of variables assessed in the current study.

Variable	*M*	*SD*
Level 1		
Taste-Eating (0–100)	60.5	23.7
Hunger-Eating (0–100)	57.6	27.1
Stress (0–100)	27.5	19.2
Negative affect (0–100)	16.0	14.2
Positive affect (0–100)	47.3	19.8
Time pressure (0–100)	17.6	23.9
Level 2		
Restrained eating (1–5)	2.7	0.73
Emotional eating (1–5)	2.7	0.86
External eating (1–5)	3.1	0.75
BMI (kg/m^2)	26.7	5.76

Note. BMI = Body-mass-index. Restrained, emotional and external eating from the *Dutch Eating Behavior Questionnaire* (van Strien et al., 1986).

Table 2
Associations between taste- and hunger-eating (at t) with stress, positive and negative emotions as Level 1 predictors (at t-1).

Model	β (*SE*)	*p*
Taste-eating with predictors modeled separately		
β_{10}: Stress level $_{(t-1)}$	−0.155 (0.056)	0.007
β_{10}: Negative affect (NA) $_{(t-1)}$	−0.091 (0.064)	0.162
β_{10}: Positive affect (PA) $_{(t-1)}$	0.103 (0.052)	0.051
Taste-eating with predictors modeled simultaneously		
β_{10}: Stress level $_{(t-1)}$	−0.174 (0.074)	0.023
β_{20}: Negative affect (NA) $_{(t-1)}$	0.060 (0.082)	0.467
β_{30}: Positive affect (PA) $_{(t-1)}$	0.055 (0.068)	0.418
Hunger-eating with predictors modeled separately		
β_{10}: Stress level$_{(t-1)}$	0.053 (0.066)	0.426
β_{10}: Negative affect (NA) $_{(t-1)}$	0.072 (0.086)	0.404
β_{10}: Positive affect (PA) $_{(t-1)}$	0.054 (0.052)	0.303

3.3. Taste-eating and hunger-eating and their prediction by stress, negative and positive emotions

A first set of 3 analyses tested the predictive power of stress, negative and positive emotions on taste-based eating separately to test for simple associations. Another set of 3 analyses correspondingly predicted hunger-based eating. If more than one predictor turned out significant, all three predictors were next entered simultaneously in a combined model. The models are expressed by the following equation (exemplified by the prediction of taste-eating as dependent variable and stress as predictor):

Level 1 (occasions):

$$\text{Taste-eating}_{tj} = \pi_{0j} + \pi_{1j}(\text{Stress}_{t-1j}) + e_{tj}$$

Level 2 (participants):

$$\pi_{0j} = \beta_{00} + r_{0j}$$

$$\pi_{1j} = \beta_{10} + r_{1j}$$

At Level 1, the outcome taste-eating$_t$ (participant *j*'s level of taste-eating at time t) was modeled as a function of an intercept (π_{0j}), and a slope (π_{1j}) representing the effect of stress$_{t-1j}$ (participant *j*'s level of his stress at time t-1). Because the lagged predictor was person-mean centered, the intercept (π_{0j}) reflects participant *j*'s level of taste-eating at his/her average level of stress. At Level 2, the intercepts (β_{00}) and (β_{10}) reflect the mean level of taste-eating and the mean effect of stress, respectively. Stress was exchanged for negative emotions and positive emotions respectively, and all analyses were also run with hunger-eating as outcome variable.

Table 2 represents the results of each of these models. The taste-eating intercept as well as the hunger-eating intercept (reflecting the average within-person means of taste- or hunger-eating across

[1] Within the first reported eating episode per signal, 32% (n = 551) of eating episodes have been classified as snacks with mean taste-eating of 63.09 (*SD* = 25.94) and hunger-eating of 42.51 (*SD* = 30.69) versus 68% (n = 1175) main meals with mean taste-eating of 58.23 (*SD* = 23.47) and hunger-eating of 67.68 (*SD* = 22.12). The second reported eating episode consisted of 73% (n = 232) snacks with mean taste-eating of 71.62 (*SD* = 25.79) and hunger-eating of 29.27 (*SD* = 27.90) versus 27% (n = 85) main meals with mean taste-eating of 57.08 (*SD* = 23.56) and hunger-eating of 63.00 (*SD* = 22.55). The third comprised 67% (n = 16) snack episodes with 76.75 (*SD* = 24.03) mean taste-eating and 15.75 (*SD* = 25.00) hunger-eating versus 33% (n = 8) main meals with mean taste-eating of 65.13 (*SD* = 22.32) and hunger-eating of 69.75 (*SD* = 25.54). Finally, if a fourth eating episode has been reported, 2 (50%) were classified as snacks with a mean taste-eating of 77.50 (*SD* = 12.02) and hunger-eating of 34.00 (*SD* = 48.08) versus 2 (50%) main meals with a mean taste-eating of 43.00 (*SD* = 35.36) and hunger-eating 62.00 (*SD* = 26.87). Thus, as participants were instructed to report eating episodes in a chronological order, the later a snack occurred within one measurement period of 3 h the more taste-based it was consumed while no such association occurred for the main meals.

measurement occasions) were significantly different from zero ($\beta_{00} = 62.3$, $p < 0.001$; $\beta_{00} = 56.4$, $p < 0.001$, respectively). The taste-eating – stress slope was negative, meaning that higher stress at the previous signal went along with lower taste-eating at the current signal. This fits with the reverse finding for positive emotions: as they increased, subsequent taste-eating also increased, although at marginal significance level. However, negative affect at the prior signal showed no significant relationship with taste-eating.[2] Because stress as well as positive emotions arose as significant predictors all three predictors were considered together. Only stress level was still significantly associated with taste-eating. Importantly, hunger-eating was not significantly related to any of the predictors assessed at the previous signal (stress level, negative or positive affect, all non-significant).

3.4. Controlling for time pressure as Level 1 predictor

To control for the potential impact of time pressure on results, time pressure was modelled as a simultaneous Level 1 predictor in the relationships of stress and emotions on taste-eating.

Level 1 model with time pressure as predictor:

$$\text{Taste-eating}_{tj} = \pi_{0j} + \pi_{1j}(\text{Stress}_{t-1j}) + \pi_{2j}(\text{Timepressure}_{tj}) + e_{tj}$$

Level 2:

$$\pi_{0j} = \beta_{00} + r_{0j}$$

$$\pi_{1j} = \beta_{10} + r_{1j}$$

$$\pi_{2j} = \beta_{20} + r_{2j}$$

At Level 1, the outcome taste-eating$_{t1}$ was modeled as a function of an intercept (π_{0j}), and two slopes (π_{1j}) and (π_{2j}) representing the effect of stress$_{t-1j}$ and time pressure$_{tj}$, respectively. At Level 2, the intercept (β_{20}) reflects the mean effect of time pressure (controlling for stress) and vice versa for β_{10}. Next, models with time pressure and negative or positive emotions as predictors were estimated. Afterwards, the same analyses were calculated for hunger-eating.

Time pressure was a highly significant predictor for taste-eating independent of stress, positive or negative emotion (all β_{20}s > −0.124, $ps < 0.001$): higher time pressure went along with decreased taste-eating. However, the effect of stress remained significantly related to decreased subsequent taste-eating ($\beta_{10} = -0.130$, $p = 0.023$) even after controlling for the effect of time pressure. Also the relationship between taste-eating and negative emotions remained non-significant when time pressure was added to the equation, whereas the association (at trend level) between taste-eating and positive emotions slightly decreased ($\beta_{10} = 0.086$, $p = 0.099$).

Including time pressure as simultaneous predictor in the relationship between hunger-eating and stress, negative as well as positive emotions did not change the pattern of previous results. However, time pressure significantly predicted hunger-eating itself (all β_{20}s > 0.214, $ps < 0.001$), with more time pressure being related to more hunger-driven eating.

3.5. Inclusion of eating styles (restrained, emotional and external) as well as BMI and gender as Level 2 predictors

To account for differences between participants, we included eating styles as Level 2 predictors. Similar to above, we separately tested restrained, emotional and external eating as well as BMI and gender as moderators of the relationship of stress/emotions and taste-/hunger-eating, and only in case of one or more significant findings were all variables considered simultaneously. Thus, we reran the analyses mentioned above with the following addition to the equation:

Level 2 model to exemplify restrained eating style as predictor:

$$\pi_{0j} = \beta_{00} + \beta_{01}(\text{Eatingstylerestraint}_j) + r_{0j}$$

$$\pi_{1j} = \beta_{10} + \beta_{11}(\text{Eatingstylerestraint}_j) + r_{1j}$$

At Level 2, the intercepts (β_{00}) and (β_{10}) reflect the mean level of taste-eating and the mean slope of stress, respectively, when the eating style restraint$_j$ is at an average level (as eating styles were grand-mean centered). The Level 2 slopes (β_{01}) and (β_{11}) are regression weights representing associations between the person-level predictor eating style restraint$_j$, and the mean level of taste-eating and stress-slope, respectively. The restrained eating style was then exchanged for emotional and external eating, BMI and gender (uncentered and coded with 0 = female, 1 = male), respectively. Afterwards, taste-eating was exchanged for hunger-eating and all predictors tested again.

3.5.1. Taste-eating

The relationship between stress and taste-eating was moderated neither by emotional ($\beta_{11} = 0.084$, $p = 0.215$), or external ($\beta_{11} = -0.010$, $p = 0.887$) nor restrained ($\beta_{11} = 0.102$, $p = 0.146$) eating. Moreover none of them significantly influenced taste-eating itself (all β_{01}s between −2.88–0.652, $ps > 0.268$). BMI ($\beta_{11} = -0.005$, $p = 0.661$) and gender ($\beta_{11} = -0.169$, $p = 0.240$) did not moderate the relationship between stress and taste-eating and did not influence taste-eating itself ($\beta_{01} = 0.494$, $p = 0.165$; $\beta_{01} = -3.04$, $p = 0.424$; respectively). Similarly, the relationship between positive emotions and taste-eating, was moderated neither by emotional ($\beta_{11} = -0.020$, $p = 0.733$), external ($\beta_{11} = 0.048$, $p = 0.525$) nor restrained eating ($\beta_{11} = -0.048$, $p = 0.534$). Neither did BMI ($\beta_{11} = 0.007$, $p = 0.455$) or gender ($\beta_{11} = 0.015$, $p = 0.901$) moderate the relationship between positive emotions and taste-eating.[3]

The non-significant association between negative emotions and taste-eating was significantly moderated by emotional eating style ($\beta_{11} = 0.149$, $p = 0.003$), however. As can be seen in Fig. 1, individuals with low emotional eating style showed decreased momentary taste-eating when experiencing increased negative emotions, whereas high emotional eaters' taste-eating was unaffected by negative emotions. One might ask whether the sample was not high in emotional eating style in total, thus, we explored the responding in high scorers. In fact, individuals above the 75th percentile of emotional eating (green lines in Fig. 1) increased their taste-eating in high compared to low negative affect. Neither external ($\beta_{11} = 0.068$, $p = 0.346$) nor restrained ($\beta_{11} = 0.048$, $p = 0.587$) eating style moderated the association between negative emotions and taste-eating. Additionally, BMI ($\beta_{11} = -0.012$, $p = 0.229$) and

[2] Modeling the effect of distinct emotions (irritated, bored, nervous/stressed, distressed, and depressed) separately on subsequent taste-eating revealed no significant associations. However, all effects were in the same direction: irritated ($\beta_{10} = -0.028$, $p = 0.406$), bored ($\beta_{10} = -0.001$, $p = 0.981$), nervous/stressed ($\beta_{10} = -0.032$, $p = 0.328$), distressed ($\beta_{10} = -0.058$, $p = 0.116$), and depressed ($\beta_{10} = -0.007$, $p = 0.854$).

[3] Controlling simultaneously for the age of participants did not change any of the results for stress or positive emotions on taste-eating, considering eating styles, BMI and gender.

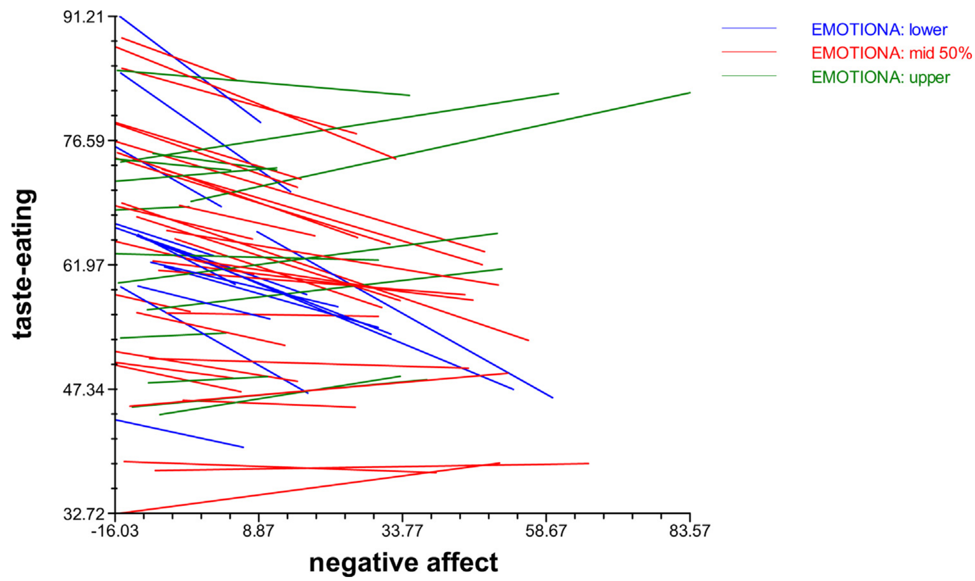

Fig. 1. The relationship between taste-eating and negative affect (Level 1) being moderated by emotional eating style (Level 2). The figure shows individual slopes for each participant with cluster-mean centered negative affect data and group-mean centered emotional eating style data, differentially colored for individuals in the 25th, 50th and 75th percentile. Participants were only divided into subgroups for graphical visualization, however, not for the analyses.

gender ($\beta_{11}=-0.250$, $p=0.172$) did not moderate the relationship between negative emotions and taste-eating.[4]

3.5.2. Hunger-eating

The positive relationship between hunger-eating and stress was not significantly moderated by any eating style, BMI or gender (all β_{11}s between -0.167 and 0.057, *ps* > 0.093). However, while BMI, gender and restrained eating style did not influence hunger-eating itself, emotional and external eating did ($\beta_{01}=-7.58$, $p=0.002$; $\beta_{01}=-9.05$, $p<0.001$; respectively). Thus, higher emotional or external eating style was associated with less momentary hunger-eating. The relationship between hunger-eating and positive emotions was not significantly moderated by any eating style or gender (all β_{11}s between -0.167 and 0.057, *ps* > 0.093). However, BMI moderated the relationship ($\beta_{11}=-0.018$, $p=0.009$), in that stronger positive emotions related to more hunger-eating but less so in individuals with higher BMI. The relationship between hunger-eating and negative emotions was not significantly moderated by gender, restrained or external eating style (all β_{11}s between -0.070 and 0.163, *ps* > 0.246), whereas emotional eating and BMI showed significant moderations ($\beta_{11}=-0.162$, $p=0.015$; $\beta_{11}=0.027$, $p=0.020$; respectively). Thus, whereas individuals with higher BMI increased hunger-based eating during negative emotions, higher emotional eating style reduced the positive association between negative emotions and hunger-eating.[5]

Considering both predictors simultaneously did not change the pattern and significance of results.[6]

4. Discussion

The current study used smartphone based EMA to test the effects of stress as well as negative and positive emotional states on momentary taste- as well as hunger-driven eating in daily life and obtained the following key results. Stress dampened participant's taste-driven eating. Positive affect, by contrast, led to increased taste-eating. Negative affect was not related to taste-eating per se (in the whole sample), only when emotional eating style was considered as moderator: low emotional eaters showed decreased taste-eating after intense negative emotions. An exploratory analysis revealed that only the 25% of individuals particularly pronounced emotional eating style increased taste-driven eating after intense negative emotions. Importantly, hunger-eating was not influenced by stress, negative or positive emotions in the whole sample but BMI and emotional eating style affected these relationships. Another advancement made in the present study was the assessment of time pressure during eating episodes. Time pressure predicted more hunger-driven and less taste-driven eating, however, without further explaining the found relationship between stress and taste-driven eating.

4.1. Stress decreases taste-eating

Contrary to our hypothesis, stressful situations led to *decreased* taste-eating. Despite differences in the operationalization of appetitive behavior (actual food intake vs. subjective determinants of food intake) the present data tentatively support findings of reduced intake under stress (rather than the opposite relationship, reported by Epel et al. (2001), O'Connor et al. (2008). The current

[4] Controlling simultaneously for the age of participants did not change results for negative emotions on taste-eating, considering eating styles, BMI and gender, however, age interacted with negative emotions in predicting taste-eating (all β_{12}s between -0.012 and -0.014, *ps* between 0.009 and 0.026), in that older individuals tended to decrease taste-eating after experiencing stronger negative emotions.

[5] As stress and negative emotions correlate significantly, $r=0.71$, $p<0.001$, because of the overlapping item "How nervous/stressed do you feel right now", we reanalyzed all analyses with stress and negative emotions completely sparing out the overlapping item ($r=0.45$, $p<0.001$). The only changes that occurred are as follows: Negative emotions interacted with gender in predicting taste-eating, however, considering gender simultaneously to emotional eating reduced this interaction to non-significance. Moreover, the interaction between negative emotions and BMI in predicting hunger-eating reduced in significance from 0.020 to 0.099.

[6] Controlling simultaneously for the age of participants did not change any of the results for stress, positive or negative emotions on hunger-eating, considering eating styles, BMI and gender. Again, age interacted with negative emotions in predicting hunger-eating (all β_{12}s between 0.018 and 0.019, *ps* between 0.018 and 0.024), in that older individuals tended to increase hunger-eating after experiencing stronger negative emotions.

findings dovetail with Wallis and Hetherington (2009) as well as Stone and Brownell (1994), who found that the majority of individuals ate less instead of more under stress, but this pertained mainly to the specific and recent stressors they assessed. This might resemble our conditions: our 3 h sampling scheme assessed fairly recent stressors in their effect on taste-eating. This result resonates with physiological stress models emphasizing the appetite dampening effect of SNS and HPA-driven stress hormones (Bazhan & Zelena, 2013; Torres & Nowson, 2007). Possibly, the second physiological pathway of stress-induced *hyper*phagia proposed by Bazhan and Zelena (2013) did not take effect here as highly palatable food was probably not as directly available in this naturalistic study as in laboratory studies. Furthermore, and in line with Stone and Brownell (1994) demonstrating critical stress thresholds for the emergence of stress-eating relationships, the present results indicate that during lightly stressful situations, individuals consumed more out of taste than during highly stressful situations. Thus, distinguishing between different stressor intensities within an individual seems to be an important factor that is rarely acknowledged in laboratory studies.

4.2. Positive emotions increase taste-eating

In contrast, positive emotional states resulted in more taste-eating, in line with previous research on food consumption (Cardi et al., 2015; Evers et al., 2013). This 'happy eating' effect has been attributed to learning or attentional biases and is reviewed by Evers et al. (2013). Despite the documented and robust role of positivity for eating, specific studies are scarce, especially in naturalistic settings. Furthermore, this seemed to be a fairly general effect, since none of our moderators influenced the relationship of taste-eating and positive emotions. This might be due to the fact that positive states are not assessed in any of the eating styles measured in the DEBQ and consequently, only negative but not positive mood increase food intake in high emotional eaters in the laboratory (van Strien et al., 2013). To account for the effect of positive emotions, questionnaires like the *Emotional Appetite Questionnaire* (Nolan, Halperin, & Geliebter, 2010), the *Emotional Overeating Questionnaire* (Masheb & Grilo, 2006), or, more recently, the *Salzburg Emotional Eating Scale* (Meule, Reichenberger, & Blechert, in preparation) have been developed, which could aid in elucidating potential mechanisms. Moreover, social aspects like eating in company versus alone could play a role and should be acknowledged in future studies: Eating with familiar and friendly people makes meals more enjoyable (or implies permissive cues/norms) and thereby leading to increased food consumption (Wansink, 2004). The present study did not have enough power to sample enough weekend vs. weekdays, to examine whether potentially more positive affect on weekends contributes to this effect. However weekend days are also different with regard to circadian rhythms, stress load, social affiliation and eating habits make differential relationships between these variables likely and thus worth studying in future research.

4.3. Emotional eating affects taste-eating in interaction with negative emotions

The diversity of the present sample in eating styles and demographics allowed for the exploration of individual differences in the associations of taste-eating with stress and emotions. Our preliminary findings demonstrate that the non-significant relationship of taste-eating and negative emotions was significantly moderated by emotional eating style, lending support to the individual-differences model (Greeno & Wing, 1994). Experiencing higher intensities of negative emotions dampened subsequent taste-eating in individuals with lower emotional eating but did not affect taste-eating in individuals with higher emotional eating style. When focusing on the 25% of the sample with the highest emotional eating scores, however, negative emotion went along with increased taste-eating. This non-linearity of emotional eating is generally in line with several laboratory studies (Cardi et al., 2015; van Strien et al., 2012; Wallis & Hetherington, 2009). Through the use of multilevel modeling and a naturalistic setting, we were able to obtain such relationships within individuals, while simultaneously accounting for interindividual differences.

Contrary to our hypothesis, none of the assessed eating styles moderated the stress-eating relationship. One could speculate that emotion-eating relationships are more strongly learned in individuals with emotional eating styles whereas the stress-eating relationship is more physiologically driven and contingent on the availability of snack foods (Bazhan & Zelena, 2013). What is interesting though is that solely taste-based eating decreased after stress but not hunger-driven eating. This supports this functional distinction and could be interpreted as a 'protective' mechanism: hunger needs to be responded to, even under stress. Similar to the hunger- vs. taste-based eating distinction, the current study's divergent results for stress vs. negative emotions on the DVs supports the need to distinguish these two constructs, which have previously often been used interchangeably. The moderator emotional eating style uniquely influenced the relationship between negative affect and taste-eating, but not between stress and taste-eating. However, incorporating *trait* questionnaires, which clearly differentiate between stress-related versus emotion-related changes in eating behavior (e.g., *Salzburg Emotional Eating Scale* (SEES) and *Salzburg Stress Eating Scale* (SSES), Meule, Reichenberger, & Blechert in preparation; Reichenberger, Meule, & Blechert, 2016) would facilitate the distinction between the two constructs.

4.4. No moderator role for BMI and gender, time pressure influential but not crucial

Apart from eating styles, the current study tried to shed light on some other established eating-relevant person characteristics, BMI and gender. Unexpectedly, gender did not influence the stress/emotional-eating relationship. Although some previous studies lend support to the hypothesis that female individuals tend to eat more while stressed (O'Connor et al., 2008), other results are in line with our non-significant findings (Oliver and Wardle, 1999). Interestingly, results of taste-eating were unaffected by BMI, despite considerable variance in our sample. Thus, our results are in agreement with the conclusions by Greeno and Wing (1994), who reviewed mixed results for the influence of obesity on stress-eating, and concluded that BMI may not be the best predictor for stress- or emotion-based eating. Controlling for the broad variety in age of the participants revealed that older individuals tentatively decreased taste-eating while increasing hunger-eating following negative affective states.

Previous studies mentioned time pressure as one explanation for unhealthy, already prepared foods intake during stressful periods (Escoto et al., 2012; Jabs & Devine, 2006; Welch et al., 2009). In fact, in a classical study of Popper, Smits, Meiselman, and Hirsch (1989) marines reduced their food intake after a highly stressful situation (i.e. combat) with a lack of time to eat and prepare foods being reported as the main reason. Whereas laboratory studies do not typically vary time pressure between conditions during taste tests, it might be a crucial factor in EMA studies. In this first EMA study which accounted for this variable we showed that intense time pressure led to robust decrease in taste-eating (and increase in hunger-eating) but did not account for the stress- taste-eating effect.

4.5. Different results for hunger-based eating: role for BMI

While the current study focused on taste-eating, it also examined hunger-eating. Preliminary findings showed that in individuals with high emotional or external eating, hunger seems to play a subordinate role as a motive for food consumption, possibly with other reasons like palatability/taste or availability gaining importance. High emotional eaters decreased their hunger-eating (reverse pattern in low emotional eaters), thus partially mirroring the effect on taste-eating (which increased in individuals with very high emotional eating scores). This finding indirectly validates the hunger vs. taste-eating distinction and confirmed that it is the hedonic, not the homeostatic system that is affected by emotional eating. Unlike taste-eating, hunger-eating and its associations with negative and positive emotions were affected by BMI. Low-BMI individuals increased hunger-eating subsequent to positive affect – in line with some of the 'happy eating' literature (Evers et al., 2013). It is possible that some of this eating was in company, which usually goes along with higher positive affect (Wansink, 2004). This might explain why high-BMI individuals did not increase hunger-eating (neither taste-eating): they might have controlled their intake in the presence of others (Herman, Roth, & Polivy, 2003). The reverse pattern was observed for negative emotions: high-BMI individuals increased their hunger-eating with increasing negative affect. This pattern provides an interesting pathway to further BMI increase, especially taking into account the reports of elevated depression rates in overweight/obese populations (Faith, Matz, & Jorge, 2002; Luppino et al., 2010)

4.6. Limitations and conclusions

The following limitations must be acknowledged: First, we did not record a precise food intake, precluding calculation of calories and macronutrient composition, but instead focused on the distinction between hunger- and taste-driven eating. Our choice was conceptually motivated: We focused on the subjective *determinants* of food intake (when it has taken place) since reasons for actual food intake are manifold (anticipatory food intake, social reasons, etc.) and taste-eating (hedonic eating) might be the one that is most sensitive to the effects of stress and emotions (hunger or other reasons mainly driven by other factors). This limits our comparability with studies assessing actual food intake. Future studies assessing both aspects could determine which aspects of appetitive behavior (hedonic intake, snack intake, main meal intake) most strongly related to stress and emotions. Second, our item 'How nervous/stressed do you feel right now' was used for both, stress and negative emotions, thereby creating partial overlap between both scales. Reasons for this overlap were mainly pragmatic ones: to sample various states (stress, negative emotions) with a minimum of items. Third, the current study used a modest sample size. Whereas we found strong results on Level 1, our preliminary results on Level 2 are possibly influenced by the sample size and should be replicated in future studies.

To conclude, the present study shed light on the different implications of stress, as well as negative and positive emotions on eating behavior and supports the notion of a clearer distinction of stress and negative affect in future research. Individual differences, especially emotional eating style, shaped these relationships, thus, utilizing them to tailor prevention and intervention efforts seems important. Emotion regulation and stress coping seem promising candidates to positively alter eating behavior, again, under consideration of eating style. The use of EMA seems important to acknowledge intra- and interindividual differences at the same time and extend or question ecological validity of laboratory studies. Future research should include physiological and hormonal stress indicators to build biobehavioral models of the stress-eating relationship.

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References

Adam, T. C., & Epel, E. S. (2007). Stress, eating and the reward system. *Physiology & Behavior*, *91*(4), 449–458.

Adriaanse, M. A., de Ridder, D. T. D., & Evers, C. (2011). Emotional eating: Eating when emotional or emotional about eating? *Psychol Health*, *26*(1), 23–39.

Bazhan, N., & Zelena, D. (2013). Food-intake regulation during stress by the hypothalamo-pituitary-adrenal axis. *Brain Research Bulletin*, *95*, 46–53.

Berthoud, H. R. (2006). Homeostatic and non-homeostatic pathways involved in the control of food intake and energy balance. *Obesity*, *14*(S8), 197S–200S.

Cardi, V., Leppanen, J., & Treasure, J. (2015). The effects of negative and positive mood induction on eating behaviour: A meta-analysis of laboratory studies in the healthy population and eating and weight disorders. *Neuroscience & Biobehavioral Reviews*, *57*, 299–309.

Cleobury, L., & Tapper, K. (2014). Reasons for eating 'unhealthy' snacks in overweight and obese males and females. *Journal of Human Nutrition and Dietetics*, *27*(4), 333–341.

Cohen, S., & Williamson, G. M. (1988). Perceived stress in a probability sample of the United States. In S. Spacapan, & S. Oskamp (Eds.), *The social psychology of health*. Newbury Park, CA: Sage.

Cohen, S., Janicki, & Deverts, D. (2012). Who's stressed? Distributions of psychological stress in the United States in probability samples from 1983, 2006, and 2009. *Journal of Applied Social Psychology*, *42*(6), 1320–1334.

Conner, M., Fitter, M., & Fletcher, W. (1999). Stress and snacking: A diary study of daily hassles and between-meal snacking. *Psychology & Health*, *14*(1), 51–63.

Conner, M., Johnson, C., & Grogan, S. (2004). Gender, sexuality, body image and eating behaviours. *Journal of Health Psychology*, *9*(4), 505–515.

Dickerson, S. S., & Kemeny, M. E. (2004). Acute stressors and cortisol responses: A theoretical integration and synthesis of laboratory research. *Psychological Bulletin*, *130*, 355–391.

Edwards, J. S. A., Hartwell, H. J., & Brown, L. (2013). The relationship between emotions, food consumption and meal acceptability when eating out of the home. *Food Quality and Preference*, *30*(1), 22–32.

Epel, E., Lapidus, R., McEwen, B., & Brownell, K. (2001). Stress may add bite to appetite in women: A laboratory study of stress-induced cortisol and eating behavior. *Psychoneuroendocrinology*, *26*(1), 37–49.

Escoto, K. H., Laska, M. N., Larson, N., Neumark-Sztainer, D., & Hannan, P. J. (2012). Work hours and perceived time barriers to healthful eating among young adults. *American Journal of Health Behavior*, *36*(6), 786–796.

Evers, C., Adriaanse, M., de Ridder, D. T. D., & de Witt Huberts, J. C. (2013). Good mood food: Positive emotion as a neglected trigger for food intake. *Appetite*, *68*, 1–7.

Faith, M. S., Matz, P. E., & Jorge, M. A. (2002). Obesity-depression associations in the population. *Journal of Psychosomatic Research*, *53*(4), 935–942.

Gibson, E. L. (2012). The psychobiology of comfort eating: Implications for neuropharmacological interventions. *Behavioural Pharmacology*, *23*(5 and 6), 442–460.

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

Grenard, J. L., Stacy, A. W., Shiffman, S., Baraldi, A. N., MacKinnon, D. P., Lockhart, G., & Reynolds, K. D. (2013). Sweetened drink and snacking cues in adolescents: A study using ecological momentary assessment. *Appetite*, *67*, 61–73.

Grunert, S. C. (1989). Ein Inventar zur Erfassung von Selbstaussagen zum Ernährungsverhalten. *Diagnostica*, *35*, 167–179.

Heatherton, T. F., Herman, C. P., & Polivy, J. (1991). Effects of physical threat and ego threat on eating behavior. *Journal of Personality and Social Psychology*, *60*(1), 138–143.

Herman, C. P., Roth, D. A., & Polivy, J. (2003). Effects of the presence of others on food intake: A normative interpretation. *Psychological Bulletin*, *129*(6), 873–886.

Jabs, J., & Devine, C. M. (2006). Time scarcity and food choices: An overview. *Appetite*, *47*(2), 196–204.

Lowe, M. R., & Butryn, M. L. (2007). Hedonic hunger: A new dimension of appetite? *Physiology & Behavior*, *91*, 432–439.

Luppino, F. S., de Wit, L. M., Bouvy, P. F., Stijnen, T., Cuijpers, P., Penninx, B. W. J. H., & Zitman, F. G. (2010). Overweight, obesity: And depression: A systematic review and meta-analysis of longitudinal studies. *Archives of General Psychiatry*, *67*, 220–229.

Masheb, R. M., & Grilo, C. M. (2006). Emotional overeating and its associations with eating disorder psychopathology among overweight patients with binge eating disorder. *International Journal of Eating Disorders*, *39*, 141–146.
Meule, A., Reichenberger, J., Blechert, J. (in preparation) Development and preliminary validation of the Salzburg Emotional Eating Scale.
Mitchell, S. L., & Epstein, L. H. (1996). Changes in taste and satiety in dietary-restrained women following stress. *Physiology & Behavior*, *60*(2), 495–499.
Ng, M., Fleming, T., Robinson, M., Thomson, B., Graetz, N., Margono, C., . . . & Abera, S. F. (2014). Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: A systematic analysis for the Global Burden of Disease Study 2013. *The Lancet*, *384*(9945), 766–781.
Nolan, L. J., Halperin, L. B., & Geliebter, A. (2010). Emotional appetite questionnaire. Construct validity and relationship with BMI. *Appetite*, *54*, 314–319.
O'Connor, D. B., Jones, F., Conner, M., McMillan, B., & Ferguson, E. (2008). Effects of daily hassles and eating style on eating behavior. *Health Psychology*, *27*(Suppl. 1), S20–S31.
Oliver, G., & Wardle, J. (1999). Perceived effects of stress on food choice. *Physiology & Behavior*, *66*(3), 511–515.
Oliver, G., Wardle, J., & Gibson, E. L. (2000). Stress and food choice: A laboratory study. *Psychosomatic Medicine*, *62*(6), 853–865.
Ovaskainen, M. L., Reinivuo, H., Tapanainen, H., Hannila, M. L., Korhonen, T., & Pakkala, H. (2005). Snacks as an element of energy intake and food consumption. *European Journal of Clinical Nutrition*, *60*(4), 494–501.
Popper, R., Smits, G., Meiselman, H. L., & Hirsch, E. (1989). Eating in combat: A survey of U.S. marines. *Military Medicine*, *154*(12), 619–623.
Raudenbush, S. W., Byrk, A. S., & Congdon, R. (2011). *HLM7 for windows [Computer software]*. Skokie, IL: Scientific Software International, Inc.
Reichenberger, J., Meule, A., & Blechert, J. (2016). Development and preliminary validation of the salzburg stress eating scale (SSES). *German Medical Science*, http://dx.doi.org/10.3205/16dgess078
Robinson, E., Hardman, C. A., Halford, J. C., & Jones, A. (2015). Eating under observation: A systematic review and meta-analysis of the effect that heightened awareness of observation has on laboratory measured energy intake. *American Journal of Clinical Nutrition*, *102*(2), 324–337.
Rutledge, T., & Linden, W. (1998). To eat or not to eat: Affective and physiological mechanisms in the stress–eating relationship. *Journal of Behavioral Medicine*, *21*(3), 221–240.
Schmitz, L. P. T. C. (2015). *LimeSurvey: An open source survey tool*. Germany: Limesurvey Project Hamburg. Retrieved from. http://www.limesurvey.org
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.
Stone, A. A., & Brownell, K. D. (1994). The stress-eating paradox: Multiple daily measurements in adult males and females. *Psychology & Health*, *9*(6), 425–436.
Torres, S. J., & Nowson, C. A. (2007). Relationship between stress, eating behavior, and obesity. *Nutrition*, *23*(11–12), 887–894.
van Strien, T., Frijters, J. E. R., Bergers, G. P. A., & Defares, P. B. (1986). The Dutch Eating Behavior Questionnaire (DEBQ) for assessment of restrained, emotional, and external eating behavior. *International Journal of Eating Disorders*, *5*, 295–315.
van Strien, T., Herman, C. P., Anschutz, D. J., Engels, R. C. M. E., & de Weerth, C. (2012). Moderation of distress-induced eating by emotional eating scores. *Appetite*, *58*(1), 277–284.
van Strien, T., Cebolla, A., Etchemendy, E., Gutiérrez-Maldonado, J., Ferrer-García, M., Botella, C., & Baños, R. (2013). Emotional eating and food intake after sadness and joy. *Appetite*, *66*, 20–25.
Wallis, D. J., & Hetherington, M. M. (2009). Emotions and eating. Self-reported and experimentally induced changes in food intake under stress. *Appetite*, *52*(2), 355–362.
Wansink, B. (2004). Environmental factors that increase the food intake and consumption volume of unknowing consumers. *Annual Review of Nutrition*, *24*, 455–479.
Wardle, J., Steptoe, A., Oliver, G., & Lipsey, Z. (2000). Stress, dietary restraint and food intake. *Journal of Psychosomatic Research*, *48*(2), 195–202.
Welch, N., McNaughton, S. A., Hunter, W., Hume, C., & Crawford, D. (2009). Is the perception of time pressure a barrier to healthy eating and physical activity among women? *Public Health Nutrition*, *12*(07), 888–895.
Zellner, D. A., Loaiza, S., Gonzalez, Z., Pita, J., Morales, J., Pecora, D., & Wolf, A. (2006). Food selection changes under stress. *Physiology & Behavior*, *87*(4), 789–793.
Zenk, S. N., Horoi, I., McDonald, A., Corte, C., Riley, B., & Odoms-Young, A. M. (2014). Ecological momentary assessment of environmental and personal factors and snack food intake in African American women. *Appetite*, *83*, 333–341.