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Eat your troubles away: Electrocortical and experiential correlates of food image processing are related to emotional eating style and emotional state

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ABSTRACT

Emotional eating, a trait-like style of food intake in response to negative emotion states, represents an important aspect of overeating and eating related psychopathology. The mechanisms of emotional eating both on experiential and neuronal levels are not well delineated. We recorded event related potentials (ERPs) while individuals with high or low emotional eating style (HEE, $n = 25$; LEE, $n = 20$) viewed and rated pictures of high-caloric food during neutral state vs. negative idiosyncratic emotion induction. Craving ratings increased in HEE and decreased in LEE during negative relative to neutral states. ERPs to food pictures showed an enhanced late positive potential (LPP) over parieto-occipital regions for HEE compared to LEE. Emotional state modulated food picture evoked ERPs over right frontal regions in HEE only. This suggests that appetitive food processing is susceptible to both concurrent emotion and habitual eating style which is of relevance for overeating in healthy and abnormal eating.

1. Introduction

In today's industrialized societies, energy dense food is available almost any time and anywhere. It also seems that hedonic factors have become an important, if not predominant factor in food intake: stress, negative moods, and emotions can determine eating even in the absence of homeostatic hunger and energy need. Whereas some individuals decrease their food intake when stressed, others increase it (e.g., Wardle, Chida, Gibson, Whitaker, & Steptoe, 2011), raising the question about the individual difference variables that put someone at risk for weight gain.

Since stress is a very broad and all-encompassing concept, the present study focuses on the modulating effect of negative emotions and moods on appetitive responses. The original concept of emotional eating derives from early obesity theories (Bruch, 1969, 1973) but has since been applied to a wide range of normal and abnormal eating. Emotional eating can be seen as learned emotion regulation strategy through which negative moods increase the motivation to eat, and actual eating reduced these negative moods. In the terms of classical learning theory, the first process would be due to classical conditioning (increased craving in negative mood) and the second one would be due to operant conditioning (eating reinforced by reduction in negative moods, e.g., Booth, 1994). A concurring account explains emotional eating via the disinhibiting effect of emotions on chronic dietary restraint (Ruderman, 1985) since emotions deplete self-control resources that are then missing in the control of eating (Baumeister, Zell, & Tice, 2007).

Since its original postulation, the concept of emotional eating has received considerable empirical support from behavioral, ambulatory, and psychometric studies (Macht & Simons, 2011; Munsch, Meyer, Quartier, & Wilhelm, 2012; van Strien, Herman, Anschutz, Engels, & de Weerth, 2012). For example, van Strien et al. (2012) used the emotionality subscale of the Dutch Eating Behavior Questionnaire, DEBQ (Van Strien, 1986) to classify participants into high emotional eaters (HEE) and low emotional eaters (LEE). Negative mood was induced by means of a sad movie (Study 1) and social stressor task (Study 2). As expected, HEE participants tended to increase food intake whereas LEE participants tended to decrease food intake under the negative mood conditions in both studies (similar results reported by Oliver, Wardle, & Gibson, 2000).

However, the effects obtained in that study were relatively subtle, even in participants with extreme scores on the DEBQ (top and bottom 20% in large screening samples). This might be due to the strong cognitive control many individuals exert over

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their eating behavior, particularly in a laboratory context. More covert (and less regulated) aspects of food cue processing might be uncovered by assessing central nervous system activity. Using functional magnetic resonance imaging, Bohon, Stice, and Spoor (2009) showed that emotional eaters responded with stronger responses in the anterior cingulate cortex to milkshake anticipation and receipt under negative mood whereas non-emotional eaters showed a decrease in reward related areas. Furthermore, in bulimia nervosa patients, negative mood was correlated with regions implicated in reward processing (Bohon & Stice, 2012). To our knowledge, event related potentials (ERPs) have not yet been used to examine the interplay of negative emotions and appetitive food processing. ERPs are particularly promising in this context since they are not only modulated by emotional stimuli but also show sensitivity for food density (Toepel, Knebel, Hudry, le Coutre, & Murray, 2009), food deprivation (Stockburger, Weike, Hamm, & Schupp, 2008; LPP; Stockburger, Schmalzle, Flaisch, Bublatzky, & Schupp, 2009b) and disordered eating (Blechert, Feige, Joos, Zeeck, & Tuschen-Caffier, 2011; Nikendei et al., 2012). Furthermore, ERPs are associated with distinct cognitive processing stages that can speak to underlying mechanisms of emotion-motivation interactions. Thus, the present study examined ERPs and subjective ratings in response to appetizing food pictures as indices of appetitive responding under neutral and negative mood.

An important aspect of this kind of research is the efficient elicitation of negative emotion. How should negative emotional states be triggered in a powerful and yet ecologically valid way and food cue responses assessed simultaneously? Film viewing and social stress tasks make ERP measurements difficult. Furthermore, the individual triggers of emotion-induced eating vary greatly between individuals and a *specific* eating-relevant emotion has not yet been identified (Macht & Simons, 2011). Another line of emotion research has therefore relied on an idiosyncratic emotion elicitation technique. In this approach, participants are asked to report recent highly emotional events from their lives from which emotional or neutral scripts are generated and presented during the experimental task (e.g. Hilbert, Vogele, Tuschen-Caffier, & Hartmann, 2011). Neuroscientific studies have started to use this approach and successfully adapted it to the needs of event related, cue-reactivity designs by presenting cues and emotion elicitation scripts in an interleaved manner (Goldin, Manber-Ball, Werner, Heimberg, & Gross, 2009).

Drawing on these lines of research, the present study examined HEE and LEE participants on experiential and neuronal responding to high-calorie food images under script-driven neutral and idiosyncratic negative moods. We predicted increased food wanting (desire to eat) and food liking (palatability) in HEE and the opposite pattern in LEE (van Strien et al., 2012). Regarding ERPs, assuming that the late positive potential, LPP, reflects attention to stimuli that are salient due to motivational context (Stockburger et al., 2008, 2009b; Blechert, Feige, Hajcak, & Tuschen-Caffier, 2010) or eating habits/pathology (Blechert et al., 2011; Nikendei et al., 2012) we expected more positive amplitudes on this component in HEE relative to LEE. The LPP is also sensitive to cognitive regulation during viewing of emotional images (Hajcak, MacNamara, & Olvet, 2010) and appetitive foods (Meule, Kuebler, & Blechert, 2013; Sarlo, Ubel, Leutgeb, & Schienle, 2013). Thus, if food was rendered more salient under negative emotion, potentially due to its relevance for emotion regulation, HEE (but not LEE) might evidence an emotional modulation of the food-cue elicited LPP. Because of the evolutionary survival relevance of efficient food stimulus processing, earlier ERP activity might also discriminate groups and/or emotion states and will be looked at in an exploratory analysis (cf., Toepel et al., 2009).

Table 1
Means (SD) of sample characteristics.

	LEE-group ($n = 20$)	HEE-group ($n = 25$)	Statistic $t(44)$, p
Age (years)	24.5 (6.01)	22.8 (2.78)	1.14, $p = .260$
BMI (kg/m^2)	21.4 (2.37)	22.5 (4.01)	1.47, $p = .147$
	Range: 17.8–27.3	Range: 17.1–33.8	
DEBQ_Emo	18.6 (3.81)	34.8 (7.73)	8.39, $p < .001$, $d = 2.72$
DEBQ_Re	25.0 (8.33)	29.9 (9.23)	1.91, $p = .063$, $d = 0.62$
DEBQ_Ext	31.2 (5.16)	37.2 (5.44)	3.57, $p < .001$, $d = 1.24$
Hunger Rating	5.15 (1.85)	5.17 (1.87)	<1.00
Deprivation (h)	6.81 (5.26)	6.79 (5.69)	<1.00
FCQ-T	96.4 (21.3)	127 (30.5)	3.64, $p < .001$, $d = 1.20$

Note: HEE, High emotional eating style; LEE, Low emotional eating style; BMI, body mass index; DEBQ_Emo, DEBQ scale emotionality; DEBQ_Re, DEBQ scale restraint; DEBQ_Ext, DEBQ scale externality; FCQ-T, Food Cravings Questionnaire-Trait version.

2. Method

2.1. Participants

A total of 45 participants (83.7% right-handed) were recruited in introductory psychology classes at the University of Salzburg, Austria, and participated in exchange for course credit or € 15. Only female participants were invited since women generally report more cravings than men (Cepeda-Benito, Fernandez, & Moreno, 2003) and are at higher risk for eating disorders (Jacobi, Hayward, Zwaan, Kraemer, & Agras, 2004). Exclusion criteria were current dermatological diseases or diabetes and mental disorders as determined by self report. We used a median split on the German version of the emotionality scale of the DEBQ (Grunert, 1989) to create groups of HEE ($n = 25$, scores 2.4–4.9, $M = 34.4$, SD = 7.87) and LEE ($n = 20$, scores 1.1–2.3, $M = 18.3$, SD = 3.70[1]). Groups did not differ in age, Body Mass Index (BMI), dietary restraint, subjective hunger ratings, and deprivation status (Table 1). Significant group differences were found on the emotionality scale but also on the related scales externality and – at trend level – the restraint scale of the DEBQ, as often observed in the literature (van Strien et al., 2012).

2.2. Procedure

Participants were instructed to abstain from any food or caloric drinks 3 h prior to the laboratory session to control for differences in deprivation and to test participants approximately at the time they would usually have a meal. All laboratory assessments were scheduled around lunchtime (starting between 11 am and 1 pm) to control for daytime and circadian rhythms. After being introduced to the laboratory, participants completed the consent form approved by the ethics commission of the University of Salzburg and an intake questionnaire containing questions about exclusion criteria and food consumption on the testing day. Subsequently, the experimenter interviewed participants about two stressful events they experienced in the last two months (interview duration ~15 min). Each of these two events were edited into four sentences and entered into the stimulus presentation program[2]. The neutral scripts were standardized and contained sequences of everyday behavior such as posting a letter or going

[1] Five individuals had a score on the median of 2.4 and were classified as HEE.

[2] Participants were asked to report situations that had triggered negative emotions. Anger and sadness were given as examples but other negative emotions were accepted as well. Scripts were classified by two raters (interrater reliability: >.86). Analyses revealed that 84% of the situations were interpersonal situations involving family members (35%), friends (24%), partners (25%), co-workers/co-students (11%), others (4%). The remaining situations were non-social situations such as work-stress (11%) and other events (5%). Groups (HEE, LEE) did not differ on frequency of any situation type or the social/non-social ratio.