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Research report

Double trouble. Trait food craving and impulsivity interactively predict food-cue affected behavioral inhibition ☆

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ABSTRACT

Impulsivity and food craving have both been implicated in overeating. Recent results suggest that both processes may interactively predict increased food intake. In the present study, female participants performed a Go/No-go task with pictures of high- and low-calorie foods. They were instructed to press a button in response to the respective target category, but withhold responses to the other category. Target category was switched after every other block, thereby creating blocks in which stimulus–response mapping was the same as in the previous block (*nonshift blocks*) and blocks in which it was reversed (*shift blocks*). The *Food Cravings Questionnaires* and the *Barratt Impulsiveness Scale* were used to assess trait and state food craving and attentional, motor, and nonplanning impulsivity. Participants had slower reaction times and more omission errors (OE) in high-calorie than in low-calorie blocks. Number of commission errors (CE) and OE was higher in shift blocks than in nonshift blocks. Trait impulsivity was positively correlated with CE in shift blocks while trait food craving was positively correlated with CE in high-calorie blocks. Importantly, CE in high-calorie-shift blocks were predicted by an interaction of food craving × impulsivity such that the relationship between food craving and CE was particularly strong at high levels of impulsivity, but vanished at low levels of impulsivity. Thus, impulsive reactions to high-calorie food-cues are particularly pronounced when both trait impulsivity and food craving is high, but low levels of impulsivity can compensate for high levels of trait food craving. Results support models of self-regulation which assume that interactive effects of low top-down control and strong reward sensitive, bottom-up mechanisms may determine eating-related disinhibition, ultimately leading to increased food intake.

Introduction

Food craving refers to a strong desire to consume specific foods of which chocolate is the most often craved one (Weingarten & Elston, 1990, 1991). The sight, smell, and taste of high-calorie foods and other food-cues elicit cephalic phase responses, which prepare the organism for digestion and are associated with increased craving (Nederkoorn, Smulders, & Jansen, 2000; Rodríguez, Fernandez, Cepeda-Benito, & Vila, 2005). On a neuronal level, those processes are accompanied by strong activation of limbic and paralimbic brain structures associated with reward and incentive salience such as the insula, amygdala, striatum, and orbitofrontal cortex (García-García et al., 2013; Kenny, 2011; Volkow, Wang, Fowler, Tomasi, & Baler, 2012; Volkow, Wang, Tomasi, & Baler, 2013). Thus, food-cue elicited craving along with reward-related hyperactivation is considered a bottom-up mechanism leading to increased food intake (Heatherton & Wagner, 2011).

Accordingly, individual differences in reward sensitivity and susceptibility to food-cue elicited craving have been related to various measures of overeating. For example, studies using self-report measures for the assessment of a general sensitivity to reward such as the *BIS/BAS scales* or the *Sensitivity to Punishment and Sensitivity to Reward Questionnaire* showed that higher reward sensitivity is associated with higher body mass index (BMI), more frequent experiences of food craving, and emotional or external eating behavior (Davis & Fox, 2008; Davis, Strachan, & Berkson, 2004; Franken & Muris, 2005; Matton, Goossens, Braet, & Vervaet, 2013). Similarly, studies using self-report measures specifically assessing food reward sensitivity or frequent experiences of food craving such as the *Power of Food Scale* or the *Food Cravings Questionnaire – Trait* show that higher scores are associated with measures of overeating such as low dieting success, disinhibited eating, binge eating, emotional or external eating, and addiction-like eating (Cepeda-Benito, Gleaves, Williams, & Erath, 2000; Crowley et al., 2012; Davis et al., 2011; Lowe et al., 2009; Meule & Kübler, 2012; Meule, Lutz, Vögele, & Kübler, 2012; Meule, Westenhöfer, & Kübler, 2011; Moreno, Rodríguez, Fernandez, Tamez, & Cepeda-Benito, 2008).

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Overeating is not only determined by strong reward sensitivity, that is, bottom-up impulses, but also by a lack of sufficient top-down control. For example, self-reported impulsivity is positively related to various measures associated with overeating such as frequent experiences of food craving, emotional eating, or low dieting success (Meule, 2013). In behavioral measures of impulsivity, individuals with binge eating behaviors or obesity exhibit lower inhibitory control (i.e. more impulsive reactions) as compared with controls (Mobbs, Iglesias, Golay, & Van der Linden, 2011; Nederkoorn, Smulders, Havermans, Roefs, & Jansen, 2006; Rosval et al., 2006; Wu et al., 2013). Low inhibitory control has also been found to modulate food intake in nonclinical samples such that restrained eaters with low inhibitory performance ate more in a laboratory setting (Jansen et al., 2009; Meule, Lukito, Vögele, & Kübler, 2011). Impulsivity and low inhibitory control are associated with (dorso-)lateral prefrontal hypoactivation (Chambers, Garavan, & Bellgrove, 2009), which, in turn, can also be found in relation to overeating and obesity (Batterink, Yokum, & Stice, 2010; Brooks, Cedernaes, & Schioth, 2013; Brooks, Rask-Andersen, Benedict, & Schioth, 2012).

Recent studies suggest that bottom-up and top-down processes are interdependent. Self-regulatory failure, resulting for example in overeating, can occur due to strong cue-elicited impulses that overwhelm prefrontal control, impaired prefrontal cortex function, or both (Appelhans, 2009; Heatherton & Wagner, 2011). Indeed, neuroimaging studies show that craving regulation involves an interplay of prefrontal cortices and subcortical brain areas (Hollmann et al., 2012; Kober et al., 2010; Scharmüller, Übel, Ebner, & Schienle, 2012; Siep et al., 2012; Yokum & Stice, 2013). Similarly, studies using behavioral and self-report measures of top-down, inhibitory control and bottom-up, reward sensitive processes found interactive effects when predicting laboratory food intake or weight gain. Hofmann, Friese, and Roefs (2009) found that high automatic affective reactions to high-calorie foods were associated with increased candy consumption only when participants also had low inhibitory control. In another study, 1-year weight gain in students was predicted by low inhibitory control only when participants also showed a high implicit preference for high-calorie foods (Nederkoorn, Houben, Hofmann, Roefs, & Jansen, 2010). Finally, in a sample of obese individuals, high food reward sensitivity predicted intake of palatable foods only when inhibitory control was low (Appelhans et al., 2011).

Based on those findings, individuals prone to overeating may show impaired inhibitory control specifically when confronted with highly palatable, high-calorie food stimuli because of their lower inhibitory control and higher reward responsiveness. Indeed, some studies investigated inhibitory control in response to such food-cues, but most of these studies failed to find differential food-cue affected inhibitory control in relation to habitual overeating (for an overview see Meule et al., 2014). For example, in a study by Loeber et al. (2012), commission errors differed between food and neutral blocks, but did not differ between obese and normal-weight participants. One possible explanation for the lack of differences between obese and normal-weight participants is that obesity is a heterogeneous condition. That is, only a subset of obese individuals represents rather an impulsive, reward-sensitive subtype with binge eating behavior (Dalton, Blundell, & Finlayson, 2013) and, thus, particularly those individuals would be expected to show impaired food-cue affected inhibitory control. Thus, taking such individual differences into account may indeed show differential task performance in food-cue related response inhibition tasks as a function of impulsivity and reward sensitivity.

The aims of the current study were twofold: Firstly, to overcome issues in previous studies regarding stimulus selection. Specifically, studies using an *affective shifting task* (see below) contrasted food and neutral stimuli and found differences in commission errors between those categories (Loeber et al., 2012; Mobbs et al., 2011). However, the nature of general differences in commission errors between food and neutral blocks are hard to interpret as they may simply be due to a category size effect (Landauer & Freedman, 1968). Thus, we used pictures of high-calorie foods and contrasted them with low-calorie foods in the present study in order to avoid possible effects of category size. Second, we examined the relationship of individual differences in top-down control (i.e. trait impulsivity) and bottom-up processes (i.e. trait food craving) with food-cue affected response inhibition.

For this purpose, we used an *affective shifting task* (e.g., Mobbs, Van der Linden, d'Acremont, & Perroud, 2008; Murphy et al., 1999) with pictures of high- and low-calorie foods in which participants are instructed to press a button in response to the respective target category, but withhold responses to the other category. Target category is switched after every other block, thereby creating blocks in which stimulus–response mapping is the same as in the previous block (*nonshift blocks*) and blocks in which it is reversed (*shift blocks*). As a result, task performance usually is decreased in shift blocks (e.g., higher number of commission errors) as compared with nonshift blocks.

We expected that task performance (reaction times, omission errors, commission errors) would not differ between blocks with high-calorie and blocks with low-calorie food targets as both stimulus types belong to the same broad category (i.e., food). As low inhibitory control (i.e. high number of commission errors) is regarded as one facet of impulsivity, we expected that the number of commission errors would be positively correlated with self-reported trait impulsivity, particularly in the more challenging shift blocks. As individuals high in reward sensitivity react sensitively in response to and have problems controlling the intake of high-calorie foods, we expected that the number of commission errors would be positively correlated with self-reported trait food craving, particularly in blocks with high-calorie food targets. Finally, we examined if commission errors can also be predicted by an interaction of trait food craving and impulsivity, comparable with studies that assessed actual food intake (e.g., Appelhans et al., 2011). Although our hypotheses referred to commission errors only, we also explored associations with reaction times and omission errors to determine if results were specific for inhibitory control or related to overall task performance.

Methods

Participants

Female participants were recruited among students at the University of Würzburg, Germany, via advertisements posted on campus. A total of $N = 55$ women participated in the study. Mean age was $M = 24.35$ years ($SD = 4.21$) and mean BMI $M = 21.90$ kg/m^2 ($SD = 2.39$). Most participants had normal weight (BMI = 18.50–24.99 kg/m^2, $n = 46$, 83.64%) and few participants were underweight (BMI < 18.50 kg/m^2, $n = 4$, 7.27%) or overweight (BMI > 24.99 kg/m^2, $n = 5$, 9.09%). Sixteen participants indicated that they were currently trying to control their weight (i.e. were dieters). Mean score on the *Eating Disorder Examination – Questionnaire* (EDE-Q, see below) was $M = 1.05$ ($SD = .87$, Range = .00–3.06), indicating that eating disorder psychopathology was low and comparable with other nonclinical samples (Carter, Stewart, & Fairburn, 2001; Hilbert, Tuschen-Caffier, Karwautz, Niederhofer, & Munsch, 2007; Mond, Hay, Rodgers, & Owen, 2006). Ten participants reported to be smokers.[1]

[1] Smokers had higher BIS-15 total and subscale scores than nonsmokers (all $t_{(53)}$s > 2.22, $P < .05$). Controlling for smoking status in the subsequent analyses did not affect results. Smokers did not differ from nonsmokers on any other study variable (all $t_{(53)}$s < 1.74, *ns*).