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Research report

Hunger modulates behavioral disinhibition and attention allocation to food-associated cues in normal-weight controls ☆

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ABSTRACT

Overeating, weight gain and obesity are considered as a major health problem in Western societies. At present, an impairment of response inhibition and a biased salience attribution to food-associated stimuli are considered as important factors associated with weight gain. However, recent findings suggest that the association between an impaired response inhibition and salience attribution and weight gain might be modulated by other factors. Thus, hunger might cause food-associated cues to be perceived as more salient and rewarding and might be associated with an impairment of response inhibition. However, at present, little is known how hunger interacts with these processes. Thus, the aim of the present study was to investigate whether hunger modulates response inhibition and attention allocation towards food-associated stimuli in normal-weight controls. A go-/nogo task with food-associated and control words and a visual dot-probe task with food-associated and control pictures were administered to 48 normal-weight participants (mean age 24.5 years, range 19–40; mean BMI 21.6, range 18.5–25.4). Hunger was assessed twofold using a self-reported measure of hunger and a measurement of the blood glucose level. Our results indicated that self-reported hunger affected behavioral response inhibition in the go-/nogo task. Thus, hungry participants committed significantly more commission errors when food-associated stimuli served as distractors compared to when control stimuli were the distractors. This effect was not observed in sated participants. In addition, we found that self-reported hunger was associated with a lower number of omission errors in response to food-associated stimuli indicating a higher salience of these stimuli. Low blood glucose level was not associated with an impairment of response inhibition. However, our results indicated that the blood glucose level was associated with an attentional bias towards food-associated cues in the visual dot probe task. In conclusion our results suggest that hunger induces an approach bias and is associated with an impairment of response inhibition when normal-weight participants are confronted with food-associated cues. These findings are important as these processes play a crucial role with regard to the control of food-intake and weight gain and are assumed to contribute to obesity. Thus, individualized treatment approaches taking into account the experience of hunger in everyday-life situations should be considered in addition to a training of response inhibition.

Introduction

Overeating, weight gain and obesity are constantly increasing in Western societies (Ogden, Carroll, Kit, & Flegal, 2012; Wang & Beydoun, 2007) and are considered as a major health problem. As increasing body-weight is believed to be the consequence of excessive food intake leading to a positive energy balance, the core of the problem seems to be that many people have difficulties to resist palatable high caloric food. A better understanding of factors that control food intake is thus important for the development of interventions to prevent weight gain and to treat overweight and obesity.

Recently, it has become obvious that an impairment of inhibitory control and impulsive behavior contribute to overeating and weight gain and thus are discussed as factors that play a crucial role for the development of obesity (Lowe, 2003). According to dual process models (e.g., Strack & Deutsch, 2004), higher order cognitive control processes are important to resist food-intake as automatic, affective responses to palatable food illicit a motivational drive to consume that food and this drive needs to be overruled. Thus, two processes are important to consider with regard to food intake: on the one hand, the perception of palatable food triggers cognitive and motivational approach processes (like attention

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allocation towards food-associated cues) resulting in an enhanced salience attribution. On the other hand, self-control processes are necessary to resist the motivational drive to consume the food (e.g., Hofmann, Friese, & Wiers, 2008; Strack & Deutsch, 2004). In support of these assumptions, several studies demonstrated an attentional bias towards food-associated cues. For example, Brignell, Griffiths, Bradley, and Mogg (2009) found that non-clinical normal-weight as well as overweight participants who reported a predisposition to eat in response to food associated cues showed an enhanced attentional bias towards food-associated cues. In line with this, Mogg, Bradley, Hyare, and Lee (1998) and Nijs, Muris, Euser, and Franken (2010) found an attentional bias of obese participants to food-associated cues. In addition, although Pothos, Tapper, and Calitri (2009) found no association between attention allocation to food-associated stimuli and the body mass index (BMI), prospective studies (e.g., Calitri, Pothos, Tapper, Brunstrom, & Rogers, 2010) report that an attentional bias towards food-associated cues predicted an increase in BMI.

With regard to the second process, i.e. self-control processes, an association between an impairment of inhibitory control and increased food-intake was shown in several studies. For example, in questionnaire measures, obese participants often report impulsive behavior when confronted with foods (e.g. Loeber et al., 2012). Several studies also demonstrated an association between behavioral measures of response inhibition and body weight. For example, Guerrieri et al. (2007) found that people with less effective response inhibition ate more during a taste test with palatable high caloric food than did people with effective response inhibition. Even more important, Nederkoorn, Houben, Hofmann, Roefs, and Jansen (2010) reported that normal-weight controls with an impairment of response inhibition showed a significantly larger increase in body weight during a 1 year follow-up period. In line with this, Houben, Nederkoorn, and Jansen (2012) demonstrated that people who were not successful in controlling their body weight in the past, showed behavioral disinhibition and increased food consumption in an experimental approach, which was not found for people who were successful in controlling their body weight. Taken together, these studies underline the importance of response inhibition with regard to the regulation of food consumption and body weight. Consequently, there is an upcoming research interest in the effectiveness of interventions aiming at an increase in response inhibition when people are confronted with food-associated cues and the studies available at present provide promising findings (e.g., Houben, 2011; Houben & Jansen, 2011; Veling, Aarts, & Stroebe, 2011). For example, Houben (2011) reported that when participants with impaired response inhibition underwent an experimental intervention during which food-associated cues were systematically paired with a stop-signal, they consumed less food in a subsequent taste test compared to a control intervention.

However, recent findings suggest that the impact of an impaired response inhibition and salience attribution on food consumption might be more complex. With regard to salience attribution towards food-associated cues there are a number of studies that investigated the influence of hunger on the attentional bias (using for example the visual dot probe task, modified Stroop tasks or eyetracking paradigms) in normal-weight (e.g. Mogg et al., 1998; Forestell, Lau, Gyurovski, Dickter, & Haque, 2012) as well as obese participants (e.g., Castellanos et al., 2009; Nijs et al., 2010). Taken together, the majority of studies demonstrate that hunger enhances attention allocation towards food-associated cues in normal-weight as well as obese participants, although there are also some inconsistent findings. For example, Castellanos et al. (2009) found an attentional bias towards food-associated cues for eye-movement data, but not for reaction time data from the visual dot probe task. In contrast, there is at present only little information available with regard to the effect of hunger on response inhibition. One interesting finding was provided by Nederkoorn, Guerrieri, Havermans, Roefs, and Jansen (2009) who found that participants with an impairment of response inhibition only ate more at a taste test or bought more snack food items in a virtual supermarket when they were feeling hungry. In contrast, no differences were found between participants with effective response inhibition and participants with impaired response inhibition feeling sated. The results of a previous own study (Loeber et al., 2012) also point at the role of hunger as a factor that might modulate the association between response inhibition and body weight. Using a go-/nogo task with food-associated and control stimuli we found that obese participants showed a greater impairment of response inhibition when food-associated words had to be inhibited compared to control stimuli. However, this effect was also observed in normal-weight controls. As both groups were instructed to refrain from eating for at least four hours prior to testing, all participants were moderately hungry at the time of testing which was supported by subjective measures of hunger at the start of the test session. These results thus suggest that hunger, as a motivational drive state, might be associated with an impairment of the inhibition of food-seeking responses. However, to our best knowledge there are at present no studies available that investigate the effect of hunger on response inhibition by comparing hungry and sated participants. Thus, the aim of the present study was to investigate whether hunger modulates not only attention allocation towards food-associated stimuli but also response inhibition in normal-weight controls to enhance our understanding of processes contributing to overeating and weight gain. We assessed response inhibition using self-reported measures as well as a behavioral paradigm (a food-associated go-/no-go task) in which food-associated and control stimuli were used. Attention allocation was assessed using a visual dot probe task with food-associated and control stimuli. To provide detailed information about the impact of hunger on attention allocation and behavioral inhibition, we assessed hunger using several measures. First of all, participants provided a subjective rating of hunger at the beginning of the test session using the Grand Hunger Scales (Grand, 1968). As previous studies demonstrated an association between self-reported hunger and blood glucose level (BGL) (Campfield, Smith, Rosenbaum, & Hirsch, 1996) and animal experiments showed that a decrease of BGL initiated food-seeking behavior and food consumption in rats (Campfield & Smith, 1990; Louis-Sylvestre & Le Magnen, 1996), the BGL was assessed as an objective measure of hunger. Participants received no special instructions with regard to food intake prior to the test session to ensure a broad range of hunger.

Materials and methods

Participants

Forty-eight (27 female, 21 male,) normal-weight participants were recruited from the general population by advertisements and posters asking for study participants. Inclusion criteria were age between 18 and 65 years and BMI between 18.5 and 25. All participants had to be fluent in the German language and be able to fill in questionnaires and complete computerized tasks. Exclusion criteria were: severe psychiatric, neurological, or somatic diseases or untreated endocrine illnesses as well as psychoactive medication. Exclusion criteria were also pregnancy, lactation period or suicidal tendencies. A pre-screening via telephone was conducted with everyone who responded to the call for participants to check for inclusion and exclusion criteria. A final evaluation of inclusion/exclusion criteria using a standardized interview was performed on the day of testing. The study adhered to the Declaration of Helsinki. All participants provided written informed