Brief Cutting Edge Reports
EPIDEMIOLOGY/GENETICS

Obesity

Eating on Impulse: The Relation Between Overweight and Food-Specific Inhibitory Control

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Objective: Consistent with the idea that impulsivity increases vulnerability to temptations of tasty high caloric food, less effective response inhibition is associated with overeating, overweight, and obesity. However, inefficient response inhibition mainly affects eating behavior when strong motivational urges to consume palatable food are simultaneously present. This study, therefore, examined whether overweight is associated specifically with inefficient response inhibition of food-related responses rather than with a general response inhibition deficiency.

Methods: Eighty-seven female participants (age: M = 26.17, SD = 10.9; body mass index (BMI: kg/m^2): M = 22.28, SD = 4.34, range 13.86-39.86) performed both a Stop-Signal task with general stimuli to measure general response inhibition ability, and a Stop-Signal task with food-related pictures to measure ability to inhibit responses to food pictures.

Results: As expected, a higher BMI was associated with decreased inhibitory control over food-related responses. There was no association between BMI and general response inhibition.

Conclusions: Overweight is not characterized by a general tendency to react impulsively, but instead by impulsive responding toward palatable food. The implication is that weight loss interventions need to focus on decreasing food-specific impulsivity rather than on reducing general impulsivity.

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Introduction

The prevalence of obesity has reached epidemic proportions across the world and continues to rise unabated (1). To tackle this problem, we need to identify what factors promote overeating and obesity, and one such factor is impulsivity (2). Impulsivity is the tendency to think, control, and plan insufficiently, and relies heavily on response inhibition (3). Response inhibition refers to the inability to overrule impulsive reactions, thereby disabling goal-oriented actions. Importantly, less effective response inhibition has been associated with increased food intake and overeating (4), increased weight and obesity (2,5,6), and less weight loss during treatment (7).

Recent evidence, however, shows that inefficient response inhibition does not always relate to overeating and overweight (8-10). Instead, this relation appears to be only evident when people simultaneously experience strong urges to eat, like when they are hungry (11), restricting their food intake (12), or experience strong preferences to consume high caloric food (13). Thus, inefficient response inhibition might particularly affect eating behavior when strong motivational urges to consume palatable food are present that need to be suppressed to maintain a healthy weight. When such appetitive responses toward food are absent, inefficient response inhibition seems unrelated to overeating and overweight (11-13). Hence, overweight people specifically have difficulty inhibiting strong appetitive responses toward food. The same idea was put forward in the hedonic-inhibitory model of obesity, which views overconsumption as the result of failed inhibitory control over the hedonic, appetitive system (14). Since there is a strong link between response inhibition and appetitive motivation in overeating and overweight, it is highly conceivable that obesity is associated with inefficient inhibition of food-related responses rather than with a general response inhibition deficiency.

Some evidence for this premise has already been found in obese children, who display inefficient response inhibition specifically for food but not for other rewarding objects (15). Further, obese participants showed decreased response inhibition relative to lean controls on a Go/No-Go task with food pictures (16). In both studies, however, no general (i.e., neutral) response inhibition task was included to which the food-specific response inhibition task was compared. Hence, it remains unclear whether obesity is associated with differential performance on general versus food-specific response inhibition tasks. Participants in this study therefore performed a general Stop-Signal Task (SST) and a SST with food-related pictures. Participants with a higher body mass index (BMI) were expected to show less efficient response inhibition compared

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to participants with a lower BMI on the food-specific SST but not on the general SST.

Methods and Procedures

Participants

Participants were recruited via advertisements on Internet websites. Participants who were pregnant or currently following a diet were excluded from the study. Ninety-one participants met the inclusion criteria. However, four participants did not perform or did not respond during the Stop-Signal Tasks and were removed from the sample. The final sample consisted of 87 female participants (age: M = 26.17, SD = 10.9). Mean BMI (kg/m^2) was 22.28 (SD = 4.34, range 13.86-39.86), with 15% of participants being underweight (<18.5) and 19.5% being overweight (BMI > 25).

Materials and Measures

Stop-Signal Task. The SST (3) is a measure inhibitory control and involves two concurrent tasks: A go task, which is a choice reaction time task, and a stop task, which involves inhibiting responses to the go task. We used two variants of the SST: One to measure general response inhibition ability, and another to measure response inhibition specifically for food. In both SST tasks, the go stimulus was presented for 1,000 ms, preceded by a 500 ms fixation cross. In the general SST, the go stimuli were the letters X and O. In the food-specific SST, the go stimuli were four pictures of food (crisps, chocolate, party nuts, and chocolate chip cookies) in landscape or portrait format. During go trials, participants responded as fast as possible to the go stimulus using left and right response keys on the keyboard (e.g., press left for X [portrait] and right for O [landscape]). In both SST tasks, a visual stop signal was presented on 25% of the trails. Participants were instructed not to respond when this stop signal was presented. The delay between the go stimulus (X/O or food pictures) and the stop signal was initially set at 250 ms and was subsequently dynamically adapted using a tracking procedure to enable participants to correctly inhibit 50% of the stop trials: Following successful inhibition, the go–stop delay was increased by 50 ms. If participants failed to inhibit their response, the go–stop delay was decreased by 50 ms. Both SST variants consisted of one practice block without stop signals (10 trials), and one test block with stop signals (72 trials). The dependent variable, stop signal reaction time (SSRT), was calculated by subtracting the mean stop delay from mean reaction times. Higher SSRTs indicate decreased inhibitory control.

Procedure

The study was conducted via the Internet. After giving consent, participants self-reported their weight and length. Next, participants performed the general SST and the food-specific SST, in this order. Participants received a gift certificate as remuneration for participating.

Results

The effect of BMI on SST performance (SSRT) was examined with a Univariate analysis of Covariance (ANCOVA) with type of SST (general vs. food-specific) as within-subjects factor and (standardized) BMI as continuous covariate[1]. Means for participants with low BMI versus high BMI were estimated at respectively 1 SD above and 1 SD below mean BMI score. Results showed no significant main effects of type, $F(1, 85) = .28$, $P = 0.60$, $\eta_p^2 < 0.01$, or BMI, $F(1, 85) = 1.89$, $P = 0.17$, $\eta_p^2 = 0.02$. However, the analysis did reveal a significant type×BMI interaction, $F(1, 85) = 6.06$, $P = 0.02$, $\eta_p^2 = 0.07$ (Figure 1). Follow-up analyses were performed separately for the general SST and the food-specific SST. Results showed no significant effect of BMI on general SSRT, $F(1, 85) = 0.05$, $P = 0.82$, $\eta_p^2 < 0.01$, while the effect of BMI on food-specific SSRT was significant, $F(1, 85) = 11.64$, $P < 0.01$, $\eta_p^2 = 0.12$[2]. As shown in Figure 1, participants with a higher BMI (+1 SD) had a significantly higher SSRT on the food-specific SST compared to participants with a lower BMI (−1 SD), indicating that they responded more impulsively to food pictures. F1

Discussion

The present findings show that a higher BMI is associated with lower response inhibition of food-related responses but not with general response inhibition ability. Similar results have been found in obese children, who also showed increased impulsivity toward food, but not toward other rewarding objects (15). Hence, obesity seems to be characterized by impulsive responding toward palatable food rather than a general tendency to react impulsively. One possible explanation for this food-related inefficient response inhibition could be that food cues trigger a strong appetitive response, especially in people who are overweight, which in turn decreases inhibitory control over food-specific responses (17). Thus, exposure to palatable food cues may decrease inhibitory control, increasing the chances of succumbing to temptation. Consistent with this idea, exposure to food specifically affects food-related response inhibition in people who are unsuccessful in maintaining a healthy weight (18).

A limitation to the present findings is that we relied on self-reported height and weight, which is vulnerable to self-presentation bias. However, it is unlikely that this affected our overall conclusions since the rank order of participants' BMI was likely preserved despite self-presentation bias. Further, the study sample consisted of

[1]BMI was entered as a continuous variable instead of creating two groups of participants to minimize loss of power. We also analyzed results with group as a between-subjects factor in the repeated measures ANOVA. All participants with a BMI above 25 were classified as overweight (n = 17). Participants with a BMI below (or equal to) 25 were classified as non-overweight (n = 70). This analysis also showed the same significant two-way interaction between BMI and type of SST, $F(1, 85) = 8.69$, $P < 0.01$. Separate ANOVAs per type of SST showed no effect of BMI on general SSRT, $F(1, 85) = 0.93$, $P = 0.34$, while overweight participants displayed a higher impulsivity (i.e., higher SSRT) on the food-specific SST compared to non-overweight participants, $F(1, 85) = 8.17$, $P < 0.01$.

[2]We also performed within-subjects follow-up analyses to test the effect of type SST (general vs. food-specific) separately for participants high (+1 SD) and low (−1 SD) BMI. For participants with a high BMI, results showed a significant difference between general SSRT and food-specific SSRT, $F(1, 85) = 4.48$, $P = 0.04$, indicating that they responded more impulsively on the food-specific SST compared to the general SST (see Figure 1). For participants with low BMI, in contrast, the difference between general SSRT and food-specific SSRT was not significant, $F(1, 85) = 1.89$, $P = 0.17$).

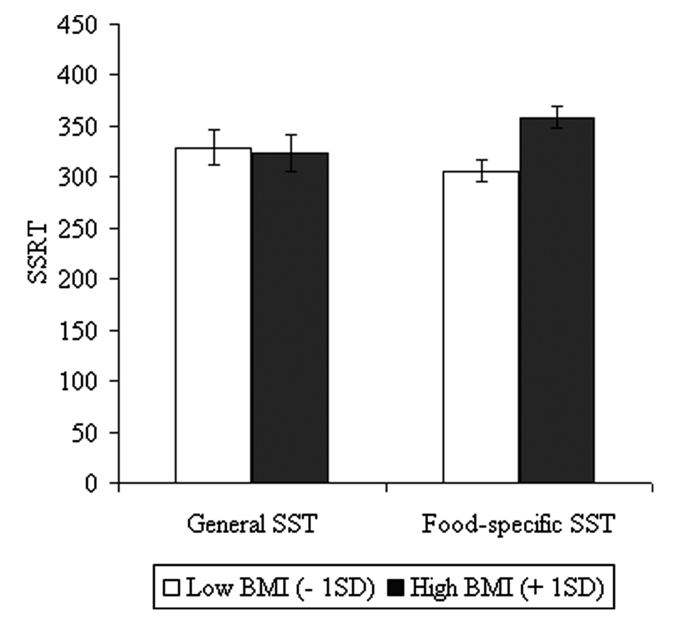

Figure 1 Estimated marginal means (with standard errors) for SSRT on the general SST and the food-specific SST, separately for participants with a low versus a high BMI (respectively 1 *SD* above or below the mean BMI score). Higher SSRT scores indicate increased impulsivity or decreased response inhibition.

only women and it would be interesting for future research to examine whether male participants show the same pattern of results. Finally, the general SST and the food-specific SST were presented in a fixed order. Consequently, it is possible that our findings reflect different transfer effects from the first task to the second (e.g., depletion effects, training effects) for participants with higher versus lower BMIs. At this point, we cannot rule out this possibility and future research needs to further examine this issue.

Nevertheless, the present findings suggest that overweight is associated with less efficient response inhibition over food-related responses. The implication is that weight reduction interventions should focus on decreasing food-specific impulsivity rather than on reducing general impulsivity. Previous endeavors to decrease food intake and overweight by training general inhibition abilities generally showed disappointing results. For instance, food intake was higher following impulsivity induction compared to inhibition induction, but this effect was mainly due to increased food intake in the impulsivity condition, while general inhibition training was unsuccessful in reducing food intake (19). Recent efforts in inhibitory control training specifically for food, however, show more promising effects: Consistently inhibiting responses to palatable food decreases consumption relative to control conditions where participants are allowed to respond to palatable food (20). Hence, inhibition training that is specifically focused on food tends to show larger effects on food intake (and body weight) compared to general inhibition training.

In conclusion, this study shows that overweight people experience more difficulty withholding responses to palatable food, which may trigger overeating and weight gain. Future research needs to further explore the causality of this relationship between weight and food-specific inhibitory control, and examine the effectiveness of food-specific inhibition training to combat overweight and obesity. O

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Katrijn Houben designed the study, performed the statistical analysis, and wrote the first draft of the manuscript. All authors contributed to and have approved the final manuscript.

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