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The relationship between eating-related individual differences and visual attention to foods high in added fat and sugar

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ABSTRACT

Objective: Attentional biases for food-related stimuli may be associated separately with obesity, disordered eating, and hunger. We tested an integrative model that simultaneously examines the association of body mass index (BMI), disordered eating and hunger with food-related visual attention to processed foods that differ in added fat/sugar level (e.g., sweets, candies, fried foods) relative to minimally processed foods (e.g., fruits, meats/nuts, vegetables) that are lower in fat/sugar content.
Methods: One-hundred overweight or obese women, ages 18–50, completed a food-related visual search task and measures associated with eating behavior. Height and weight were measured.
Results: Higher levels of hunger significantly predicted increased vigilance for sweets and candy and increased vigilance for fried foods at a trend level. Elevated hunger was associated significantly with decreased dwell time on fried foods and, at a trend level, with decreased dwell time on sweets. Higher BMIs emerged as a significant predictor of decreased vigilance for fried foods, but BMI was not related to dwell time. Disordered eating was unrelated to vigilance for or dwell time on unhealthy food types.
Conclusions: This pattern of findings suggests that low-level attentional biases may contribute to difficulties making healthier food choices in the current food environment and may point toward useful strategies to reduce excess food consumption.

1. Introduction

Food-related problems present both public health (i.e., obesity) and clinical (i.e., disordered eating) challenges. Although findings are mixed, attentional biases for food-related stimuli may be associated separately with obesity, disordered eating, and hunger. Thus, visual attention to food-related information might play a role in problematic consumption. To explore this possibility further, the current study examined an integrative model of these three simultaneous predictors of visual attention to unhealthy foods in a sample of overweight and obese community women.

Attentional biases are tendencies to attend selectively to personally relevant stimuli (Smeets, Roefs, & Jansen, 2009). Overt spatial attention (movements of the eyes to fixate locations in the visual field) can be influenced by two factors relevant to selective biases: vigilance and longer dwell time (see Weierich, Treat, & Hollingworth, 2008). Vigilance refers to facilitated detection of a certain type of object in the presence of multiple stimuli that compete for attention. Increased dwell time occurs when an object class holds attention longer than do other stimuli, delaying the withdrawal of gaze. Vigilance and dwell time components of overt spatial attention are best assessed using visual-search and eye-tracking paradigms with a clearly defined task (see Weierich et al., 2008). Thus, our review focuses on studies using these paradigms in overweight and obese populations.

The role of overt attention to food in overweight and obese participants has been explored only recently in a series of eye-tracking studies, and the results are mixed. Nijs, Muris, Euser, Franken, and Ingmar (2010) found that overweight/obese participants manipulated to be either hungry or sated showed neither greater vigilance for nor greater dwell time on high-calorie food photos relative to non-food photos, when compared to normal-weight participants. However, another eye-tracking study found that obese participants exhibited increased vigilance for high- and low-calorie food images relative to neutral non-food images, regardless of whether they fasted or were fed (Castellanos et al., 2009), whereas normal-weight participants showed vigilance for food images only when fasted. Analyses of gaze duration showed the same pattern. In an additional study, overweight/obese participants, compared to normal-weight participants, displayed greater vigilance for and shorter dwell time during first fixation on high-fat food images relative to images of musical instruments, consistent with

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a vigilance–avoidance pattern of visual attention to food information (Werthmann et al., 2011). Finally, Graham, Hoover, Ceballos, and Komogortsev (2011) found that overweight/obese participants were more likely to fixate initially on low-calorie food pictures (but not high-calorie foods) compared to underweight/normal-weight participants.

Within the disordered eating literature, participants with anorexia and bulimia nervosa exhibited increased dwell time on food-related words compared to neutral words in a visual-search task (Smeets, Roefs, van Furth, & Jansen, 2008), and restrained eaters displayed vigilance for food words relative to neutral words (Hollitt, Kemps, Tiggemann, Smeets, & Mills, 2010). An eye-tracking study found that participants with anorexia nervosa actually were more likely to avoid food pictures relative to healthy controls (Giel et al., 2011).

State hunger also has been examined as a predictor of visual attention to food. Individuals struggling with both obesity and disordered eating frequently vacillate between periods of food deprivation and excessive consumption (Berridge, Ho, Richard, & DiFeliceantonio, 2010), and state levels of hunger may trigger the latter (Polivy & Herman, 2002). Several studies probing the link between manipulated state hunger (fasted vs sated) and visual attention to food have produced mixed findings, however (Castellanos et al., 2009; Giel et al., 2011; Nijs et al., 2010).

In summary, when rigorous paradigms are employed, the findings linking individual differences in eating-related behavior and attentional biases are mixed. The inconsistencies may be due in part to conceptual and methodological variability and to several limitations in the extant literature (Nijs et al., 2010): inattention to the influence of naturally occurring (rather than induced) state hunger, use of word rather than image stimuli, use of inadequate control or neutral stimuli for comparison purposes, and reliance on food stimuli that vary along only a single global dimension (e.g., fat or caloric content, "healthiness"). Thus, we currently do not know the extent to which BMI, disordered eating, and state hunger jointly are associated with visual attention to particular classes of unhealthy foods (e.g., processed foods high in added sugar or fat), relative to healthier foods.

The current study sought to address several limitations of prior studies. First, we explored an integrative model that simultaneously examines the association of BMI, disordered eating, and current hunger with food-related visual attention in a paradigm that differentiates vigilance and dwell time/avoidance processes (i.e., visual-search task). And second, we developed a photo stimulus set that varied along multiple dimensions linked theoretically to overconsumption (see Fig. 1): level of food processing, fat, and sugar (e.g., Gearhardt, Grilo, DiLeone, Brownell, & Potenza, 2011).

2. Material and methods

2.1. Participants

One-hundred overweight and obese women, ages 18–50, were recruited from the community. Mean age was 31.27 (SD = 9.70), and 42.0% of participants identified themselves as Caucasian, 33.0% as African-American, and 13.0% as multiracial. Mean BMI was 35.07 (SD = 8.05), with 28.0% categorized as overweight, 48.0% as obese, and 24% as severely obese.

2.2. Stimuli

Food photos subtended 4.2° of visual angle. See Fig. 1 for an overview of the six food types.

2.3. Procedure

Participants completed a self-report measure of current hunger, the food-related visual-search task, self-report measures associated with eating behavior and pathology, and assessments of height and weight.

2.3.1. Measures

2.3.1.1. Eating Disorders Examination Questionnaire (EDE-Q). The EDE-Q is a well-established measure of eating psychopathology (Fairburn & Beglin, 1994; Luce & Cowther, 1999). Global score was used in subsequent analyses (Mean = 3.91, SD = 1.21).

2.3.1.2. Body Mass Index (BMI). Height and weight were measured to the nearest millimeter and .1 kg, respectively.

2.3.1.3. Hunger rating. Participants rated their present level of hunger on a 100-mm visual analog scale that ranged from Not at All Hungry to Extremely Hungry (M = 31.31, SD = 24.9).

2.3.2. Visual-search task

The visual-search task was programmed using E-Prime software and presented on a 19-inch CRT monitor. The participants were seated approximately 75-cm from the computer screen. Participants initially completed twelve practice trials, followed by 816 experiment trials with four short breaks. Each trial began with a fixation cross for 500 ms, followed by three food pictures in a randomly oriented triangular configuration subtending 10.7° (Fig. 2). In the center of each food picture was a white square with a gap on either the left, right, top, or bottom. Two of the food pictures had a square with a top or bottom (distractors) gap. One food picture had a square with a gap on the left or right (target). Participants searched for target and responded, as quickly as possible, "left" or "right". We assessed both reaction time (RT) and accuracy. Trials with inaccurate responses were not included in analyses.

The visual-search task contained three trial types (see Fig. 2). For Type A trials, the distractors were the same type, and the target was of a different type. For Type B trials, the distractors were two different types, and the target food was one of the distractors. For Type C trials, all three food pictures were of the same type.

RT for Type A and C trials were used to compute individual vigilance and dwell-time indices for each of the food types high in added fat and/or sugar relative to the combined foods types low in added fat and/or sugar (e.g., meats/nuts, fruits, vegetables). To compute vigilance, the median RT on Type A trials (where the target food was high in added fat and/or sugar and the distractor foods were low in added fat and sugar) was subtracted from the median RT for Type C trials (where foods were all low in added fat/sugar). For dwell time, the median RT on Type C trials for foods that were all low in added fat/sugar was subtracted from the median RT on Type C trials for each of the high added fat and sugar foods.

2.3.3. Data analytic plan

One participant was excluded for low accuracy (49% correct), and five others were excluded because median response times exceeded 2 s. Average hunger and BMI were log transformed to rough normality after exclusion of one extreme outlier. The dwell-time scores for "fried foods" also displayed significant skew that was eliminated by dropping two extreme outliers. Vigilance analyses included 93 participants, and dwell-time analyses included 91 participants.

Multivariate linear regression analyses were used to examine the association between multiple predictors (i.e., Hunger, BMI, and EDE-Q) and multiple dependent variables (e.g., vigilance for "sweets", "fried foods", and "candy"), separately for vigilance and dwell time.

3. Results

In the multivariate model for vigilance, Hunger and BMI significantly predicted vigilance for foods high in added fat and/or sugar,

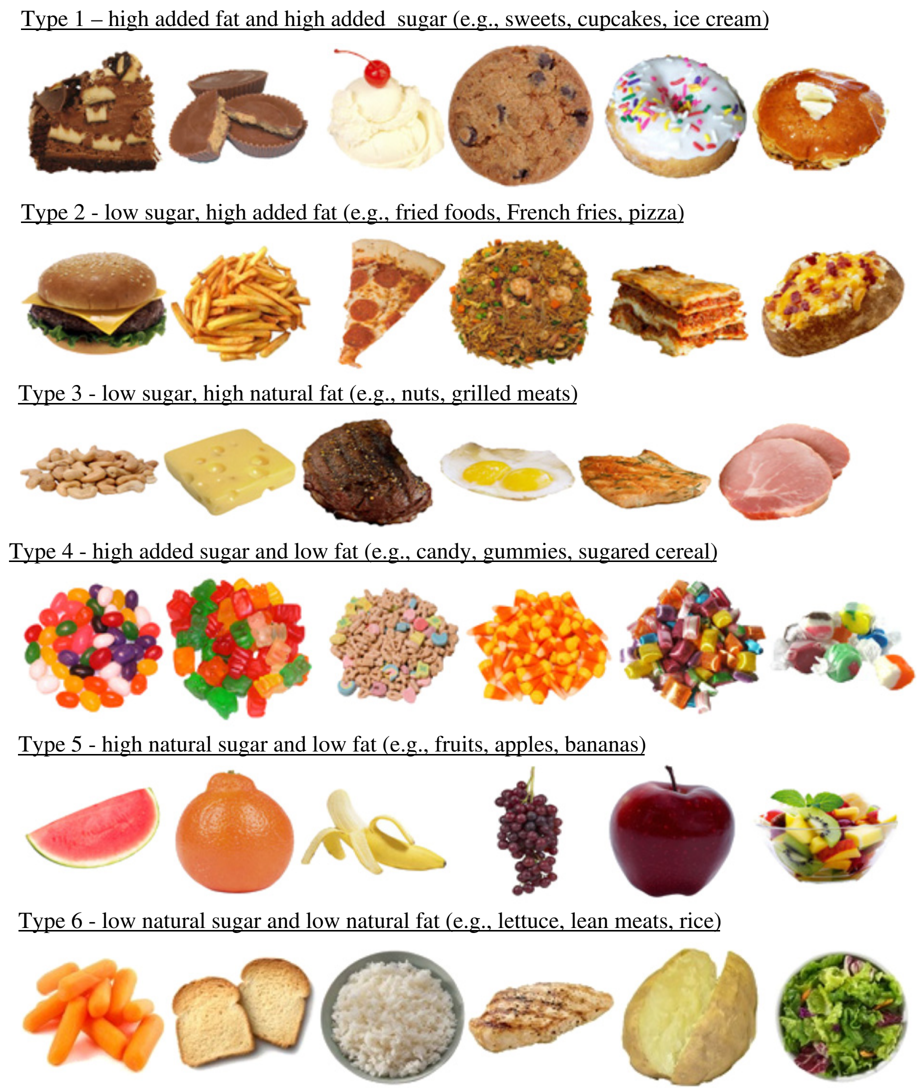

Fig. 1. Sample stimuli for each food type.

Wilks' Lambda = .88, .91, $F(3,87) = 3.93$, 2.89, $ps = .011$, .040, $\eta_p^2 =$ .12, .09, whereas the EDE-Q did not predict vigilance. Univariate analyses found that Hunger positively predicted vigilance for “sweets”, $F(1,89) = 3.12$, $p = .002$, $\eta_p^2 = .10$ and “candy”, $F(1,89) = 1.33$, $p =$ .028, $\eta_p^2 = .05$; hunger also emerged as a trend-level positive predictor of vigilance for “fried foods”, $F(1,89) = 1.15$, $p = .060$, $\eta_p^2 = .04$. BMI negatively predicted vigilance for “fried foods”, $F(1,89) = 2.10$, $p =$ .038, $\eta_p^2 = .05$.

In the multivariate model for dwell time, Hunger emerged as a trend-level predictor of dwell time on foods high in added fat and/or sugar, Wilks' Lambda = .92, $F(3,85) = 2.54$, $p = .062$, $\eta_p^2 = .08$. Univariate analyses indicated that hunger negatively predicted dwell time on “fried foods”, $F(1,87) = 2.17$, $p = .032$, $\eta_p^2 = .05$, and showed a non-significant tendency toward negative prediction of dwell time on “sweets”, $F(1,87) = 1.87$, $p = .065$, $\eta_p^2 = .04$. Neither BMI nor the EDE-Q predicted dwell time.

4. Discussion

In a sample of overweight/obese women, we examined the simultaneous association of BMI, disordered eating, and current hunger with vigilance for and dwell time on foods high in added fat and/or sugar. Higher levels of current state hunger predicted significantly increased vigilance for “sweets” and “candy,” which may speak to the elevated salience of these high-added fat/sugar foods when hungry. Dieting as a weight-loss strategy may increase feelings of hunger (Weigle et al., 2005), which may increase the likelihood that high added fat/sugar foods will grab attention. Moreover, hunger was associated with trend-level increased vigilance for “fried foods” but decreased dwell time on this food type. This pattern has previously been associated with an approach/avoidance tendency (Weierich et al., 2008), where participants might exhibit an approach tendency toward “fried foods” during times of hunger, but then avoid these foods to prevent consumption of potentially forbidden foods.

With regard to body weight, elevated BMI levels were associated with decreased vigilance for “fried foods,” which seems inconsistent with other studies showing that elevated fat levels are a major factor in food preferences for obese individuals (Drewnowski, Kurth, Holden-Wiltse, & Saari, 1992). It may be that participants with higher BMIs try to avoid these particularly appealing foods by covertly detecting their features and slowing their eye movements toward them.

Unlike BMI and hunger, disordered eating was not associated with food-related visual attention processes. Similarly, Placanica, Faunce, and Soames Job (2002) did not find a relation between disordered eating symptoms and visual attention when participants had fasted. Thus, BMI and hunger may be more closely linked with attention to unhealthy

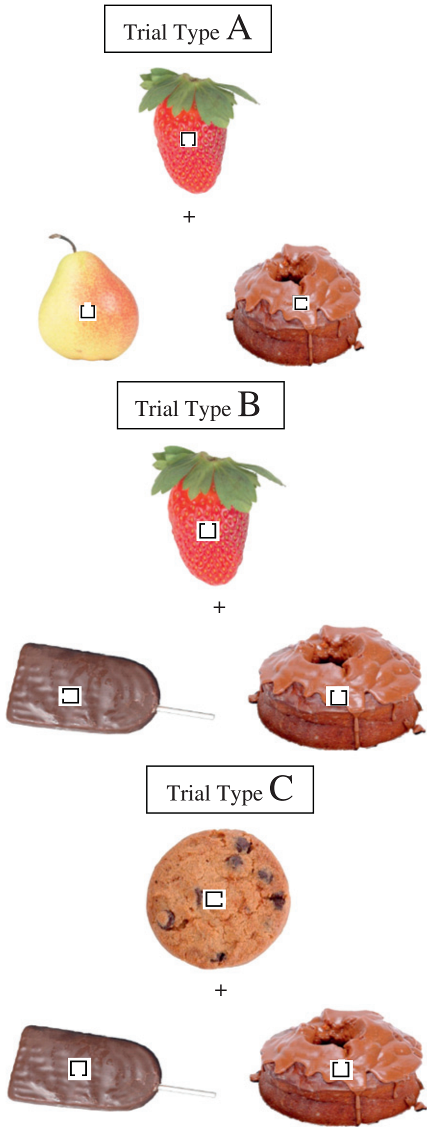

Fig. 2. Sample trial types for food type 1 (sweets).

foods than disordered eating. The introduction of fasting or craving may make the association between visual attention and disordered eating more apparent.

Future studies would benefit from the inclusion of male and normal-weight participants, as well as assessment of interactions between eating-related variables (e.g. hunger by eating disorder symptoms). Future longitudinal studies would also allow for stronger inferences about causal relations among variables. Yet, the current study has many important strengths, including examination of visual attention to multiple classes of unhealthy foods, use of a paradigm that distinguishes between vigilance and dwell time, and examination of multiple independent variables in predicting food-related attentional biases. This more fine-grained approach allowed us to look at unique relations between subcomponents of attentional biases for multiple food groups and multiple eating-related constructs, which may ultimately help us identify the most effective targets for clinical interventions.

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Contributors

All authors participated in the design of the study, and authors Gearhardt, Treat, and Corbin wrote the protocol. Author Hollingworth wrote the program for the visual-search task. Authors Gearhardt and Treat conducted the statistical analyses. Author Gearhardt wrote the first draft of the manuscript and all authors contributed to and have approved the final manuscript.

Conflict of interest

All authors declare that they have no conflicts of interest.

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