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Research report

An obesogenic bias in women's spatial memory for high calorie snack food

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ABSTRACT

To help maintain a positive energy balance in ancestral human habitats, evolution appears to have designed a functional bias in spatial memory that enhances our ability to remember the location of high-calorie foodstuffs. Here, we investigated whether this functional bias has obesogenic consequences for individuals living in a modern urban environment. Spatial memory, dietary intentions, and perceived desirability, for high-calorie snacks and lower-calorie fruits and vegetables were measured using a computer-based task in 41 women (age: 18–35, body mass index: 18.5–30.0). Using multiple linear regression, we analyzed whether enhanced spatial memory for high-calorie snacks versus fruits and vegetables predicted BMI, controlling for dietary intention strength and perceived food desirability. We observed that enhanced spatial memory for high-calorie snacks (both independently, and relative to that for fruits and vegetables), significantly predicted higher BMI. The evolved function of high-calorie bias in human spatial memory, to promote positive energy balance, would therefore appear to be intact. But our data reveal that this function may contribute to higher, less healthy BMI in individuals in whom the memory bias is most marked. Our findings reveal a novel cognitive marker of vulnerability to weight gain that, once the proximal mechanisms are understood, may offer new possibilities for weight control interventions.

Introduction

Women have a better and a more chronically active memory for the location of food than men (Krasnow et al., 2011; New, Krasnow, Truxaw, & Gaulin, 2007; though see Stoet, 2011). Both sexes also appear to have better spatial memory for foods that are high versus low in calorie (New et al., 2007). This high calorie bias in spatial memory could be an adaptation for energy efficient foraging within ancestral habitats where variable quality foodstuffs were sparse and widely dispersed (New et al., 2007). Such environments contrast sharply with the modern urban western environment, which is characterized by a proliferation of accessible, low cost, high calorie foods (e.g. Swinburn & Egger, 2004). Here we demonstrate, for the first time, that in the modern western environment, enhanced spatial memory for high calorie snacks versus lower calorie fruits and vegetables is predictive of higher body mass index (BMI) in women.

Existing studies of the cognitive biases associated with eating behavior have focused primarily on perceptual and attentional processes triggered by food related stimuli in the immediate environment. This work has demonstrated that obese (relative to lean) individuals display marked attentional biases towards high calorie foods and food related stimuli (e.g. Castellanos et al., 2009). However, excepting special cases (e.g. amnesic individuals), eating is not simply a function of attention and perceptual processing of the immediate environment. Rather, appetitive behaviors can also be influenced by memory function. For example, Kanoski and colleagues have shown in animal models that high fat diets impair hippocampal long-term memory functions that inhibit appetitive behaviors, resulting in increased eating and weight gain (reviewed recently in Kanoski and Davidson, 2011). Similarly, recent studies by Higgs and colleagues indicate that an individual's memory for recent meals influences what they subsequently consume (e.g. Higgs & Donohoe, 2011; Robinson, Blissett, & Higgs, 2011, 2012), and that information held online temporarily in working memory can modulate attentional biases induced by food-related stimuli (Higgs, Rutters, Thomas, Naish, & Humphreys, 2012). In the present paper, we examine a novel aspect of the relationship between memory function and eating. We investigate whether spatial memory biases adapted to enhance the ability to maintain positive energy balance in ancestral environments may have obesogenic, and therefore maladaptive, consequences in the modern urban context.

We reasoned, following New et al. (2007), that if enhanced spatial memory for high calorie foods allows an individual to locate and consume calorific foods more efficiently, i.e. greater consumption with less energy expenditure, then individual differences in

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the magnitude of this bias might be related to body mass index, an objective marker of energy balance. If high calorie bias in location memory tends to increase the calorie content of what we consume relative to the energy we expend to obtain it, enhanced memory for highly calorific food locations should be associated with a higher, less healthy, BMI. We label this the 'maladaptive consumption' hypothesis. Alternatively, spatial memory for high calorie food might help individuals strategically avoid foods that are inconsistent with their healthy eating intentions, in which case enhanced knowledge of where high calorie foods are located may actually promote dietary regulation. Hence, individual differences in spatial memory for high versus low calorie foodstuffs may predict lower BMI. We label this the 'adaptive avoidance' hypothesis. Finally, the null hypothesis is that individual differences in the ability to retain spatial information about high versus low calorie food will have no significant association with BMI.

To investigate these opposing hypotheses, we asked a group of young women to complete a test of spatial memory for snack foods, fruits and vegetables based on a procedure recently introduced by Nairne, VanArsdall, Pandeirada, and Blunt (2012). A female sample was recruited for this initial study because women have a better memory for the location of 'gatherable' foodstuffs than men (New et al., 2007) and tend to play a greater role in food sourcing (and purchasing) in the modern urban context (e.g. see Beardsworth et al., 2002). Consequently, any effect of high calorie spatial memory bias upon BMI may be more pronounced in women than in men. Participants carried out a spatial memory task that involved viewing images of specific food items, each item associated with a specific location on a map of the local environment. The desirability of each item was rated by asking participants to indicate how willing they would be to travel from their current position to each location to obtain each item. We then tested spatial memory accuracy for each food item. Finally, participants reported their current dietary intentions in regard to snacks, fruits and vegetables. Using multiple regression, we examined whether participants' spatial memory for high calorie snacks versus low calorie fruits and vegetables significantly predicted their BMI, taking into account the rated desirability of each type of food, and participants' current dietary intentions.

Methods

Participants

We recruited 41 female undergraduate students who all reported they were currently trying to maintain a healthy diet (mean age 20.5 years, range 18–35 years, mean BMI 22.4, range 18.5–30). Participants were weighed on electronic scales and had their height measured using a stadiometer. Body mass index was calculated as weight in kilograms/(height in meters)^2. The 18.5–30 BMI range was chosen to avoid confounding factors arising from altered cognition in underweight (<18.5) and obese (>30) individuals (see e.g. Higgs et al., 2012; Tregellas et al., 2011; Yokum, Ng, & Stice, 2011). We recruited individuals who were currently intending to eat healthily for two reasons. Firstly, it was important to ensure that our sample was homogenous in this respect, in order to provide a good test of the adaptive avoidance hypothesis articulated in the introduction. Secondly, any effects of spatial memory bias upon weight gain would be of principle relevance for individuals trying to exert dietary control. The University of Aberdeen School of Psychology ethics committee approved the study.

Apparatus and stimuli

The experiment ran (using EPRIME v2.0) in a computer lab equipped with 24 Windows XP PCs (17 in. monitors, 17 Hz, 1024×768 pixels). We constructed a set of 48 food images, 24 fruits and vegetables and 24 high calorie snack foods. We selected images of familiar examples of snack food items, all at least 225 kcal per 100 g, in accordance with the World Cancer Research Fund/American Institute for Cancer Research (2007) definition for energy dense foods (i.e. foods that contain a high number of calories per weight). Images used depicted common fruits and vegetables presented in full color on plain white backgrounds. All images were pilot tested on a sample of University students to ensure that depicted items were recognizable and identifiable exemplars. Snack images used were generic rather than branded products, to maximize consistency between the high and low calorie image sets. We split each set of 24 images at random into two 12 item sets, and counterbalanced their presentation across participants so that each possible combination of sets occurred approximately equally often. Half of the participants viewed the fruit and vegetable items first, and the remaining participants did the reverse order. The presentation order of items within each set was also newly randomized for each encoding phase and for each participant. All images were displayed onscreen for a fixed period of 3 s, followed by an image of the local university campus map. Campus locations ($N = 24$) were chosen at random, subject to the criterion that a food stall could feasibly be located at that point (excluding locations, for example, that had water fountains). The allocation of food items to specific locations was also fully randomized, differently, for each participant, to remove any systematic but accidental congruence or incongruence between a given item and its location.

Procedure

On arrival, participants were told that the experiment examined how people process the location of food in their environment. They were asked to imagine that an international food fair comprising 24 food stalls was taking place on the University campus. First of all, they would see 12 images either of snack foods or of fruits and vegetables, and then the location of the stall selling each item shown on a campus map. Participants were asked to think about how desirable each food item was, and to rate how willing they would be to travel from their current location to each stall to obtain each item. It was emphasized to each participant, that in making this rating they should use their current location as a fixed starting point on each trial. The desirability rating (using a 10-point Likert scale) was given by mouse-click on a scale bar. After rating the first set of 12 items, and following a 2 min rest, participants were shown the campus map with the location of all 24 stalls indicated. On each of the following 12 spatial memory trials they viewed one of the food images again next to the map, and their task was to click on the item's location. The linear, Euclidian, distance from the indicated location to the true location was calculated automatically on each trial as the dependent measure of memory accuracy. Once this memory test was complete, participants repeated the procedure using items belonging to remaining food-type, shown at the remaining 12 stall locations.

Finally, participants completed a short questionnaire about their current dietary intentions. In line with published guidelines (Francis et al., 2004), participants rated the strength of their current dietary intentions on a seven-point Likert scale (ranging from Strongly Agree to Strongly Disagree) towards two specific healthy-eating behaviors (reducing consumption of snack foods and eating five-portions of fruits and vegetables per day). In total, the whole procedure took 30 min on average.

Results

Spatial memory accuracy for snacks versus fruits and vegetables was measured, following Nairne et al. (2012) by calculating the