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Research article

Effects of food exposure on food-related inhibitory control in restrained eaters: An ERP study

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ABSTRACT

Restrained eaters are likely to overeat when pre-exposed to cues such as the sight, smell, thought or taste of palatable food whereas unrestrained eaters remain unaffected. However, the neurocognitive correlates of inhibitory control to food stimuli after food exposure have not been examined. This study examined food-related and food-unrelated inhibitory control with two variants of Go/No-go task by means of event-related potentials (ERPs) before and after food exposure among restrained and unrestrained eaters. Results revealed that there was a reduction of food-related no-go N2a neural response strength in frontal/frontal-central among restrained eaters compared to unrestrained eaters. Meanwhile, for restrained eaters, food-related no-go P3 amplitude increased significantly after exposure in comparison with baseline, but for unrestrained eaters there was no difference. Importantly, the exposure-induced difference in inhibition between restrained and unrestrained eaters was specific for food-related responses. Results indicated that restrained eaters may be less efficient in monitoring conflict over food-related stimuli and require more cognitive resources to inhibit food-specific responses when exposed to cues of attractive food.

1. Introduction

Restrained eaters are chronic dieters who try to cognitively control their eating behavior in order to lose weight or prevent weight gain [1]. Approximately 50% of adolescent girls and young women report engaging in dieting behaviors [2]. Women are 1.5 times more likely to attempt weight loss than men and they start doing so at a lower BMI than men do [3]. However, most people who try to control their body weight by restricting food intake fail in the long term [4]. It has been suggested that a so-called “toxic environment”, where palatable and calorically-dense foods are highly visible and easily available, contributes to these difficulties in weight-regulation [5]. Based on the goal conflict model of eating [6], exposure to food-relevant stimuli primes the goal of eating enjoyment in restrained (but not unrestrained) eaters, resulting in an inhibition of weight control thoughts.

Studies have indicated that restrained eaters (REs) are likely to overeat when pre-exposed to cues such as the sight, smell, thought or taste of palatable food whereas unrestrained eaters (UREs) remain unaffected [7,8]. For instance, Fedoroff et al. found increased eating usually following exposure to the odor of pizza and to thinking about pizza. This elevated consumption was confined to REs but not UREs [7]. REs consumed more than UREs after exposure to forbidden food for 24 h. However, UREs did not show this disinhibition [9]. REs, rather than UREs, displayed less forceful action toward healthy food objects when pre-exposed to tempting food cues [10]. Moreover, perceiving or smelling palatable food triggers preparatory responses like cravings for palatable food and increases salivation in REs [11].

On the other side, inhibitory control is a factor that plays a critical role in eating behavior. A large series of studies have shown direct correlation between inhibitory control and food intake. Lower efficient inhibitory control is related to increased high calorie food intake and overeating [12]. Increasing studies have examined the food-related inhibitory control because it is a more proximal potential mechanism associated with unhealthy eating. A higher BMI is associated with decreased inhibitory control over food-related responses [13]. High-disinhibitive REs showed a decrease of food-related inhibitory control after ego-depletion [14]. Moreover, a poorer performance on the food-based go/no-go task predicts overeating across weight [15].

However, to the best of our knowledge, no work has examined the direct effect of food exposure on the neural correlates of food-related or food-unrelated inhibitory control among REs. Event-related potential (ERP) techniques may be particularly useful in parsing the

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neurocognitive correlates of processing food cues. The goal of the current study is therefore to extend previous work on food exposure among REs and UREs by examining the neurocognitive correlates of both food-related and food-unrelated inhibition with Go/No-go tasks by means of ERPs. N2 and P3 components of ERPs have been consistently linked with the response inhibition in Go/No-go tasks. N2 is an enhanced negative component generated from 180 to 350 ms following the no-go stimuli [16] and may have two functional components. The first is a frontal/fronto-central "control N2", also termed the "N2a". It is thought to reflect the detection and monitoring of response conflict between erroneous and correct responses [17,18]. The second frontal-maximal N2 is named the "N2b" [18,19]. It is related to the attentional detection of a perceptual novelty or deviation from a prevailing visual context [20]. P3 is a more parietally focused positive component occurs anywhere between 250 and 600 ms after stimulus onset and has been linked with response inhibition and response interference [21].

Comparatively few studies have examined the ERP correlates of food cue processing. These reports have generally focused on the P3, while few have examined the N2 component. It has been consistently demonstrated that salient, self-relevant cues influence P3 amplitude [22], an effect that has been reproduced in studies of food-related stimuli. A study, which employed a go/no-go task, showed that food images elicited significantly enhanced P3, suggesting that the salience of food-related stimuli affects ERP indexes of cognitive control [23]. Other studies reported an increased processing of food stimuli in eating-disorder analog samples (e.g. external eaters) compared to controls, and significant positive correlations between self-reported craving and the P3 [24].

Participants in this study therefore performed two variants of Go/No-go task to measure food-related and food-unrelated inhibitory control. Based on previous research, we hypothesized a probable difference existing between REs and UREs in neural processes regarding specifically to food-related response inhibition after food exposure, which may be reflected by decreased food-related no-go N2 and increased P3 in REs compared to UREs.

2. Methods

2.1. Participants

Female students were recruited among students at the Southwest University via questionnaires on the campus and website. 516 females students filled in the Concern for Dieting subscale of the Restraint Scale [1]. Participants who scored in the highest quartile on the RS-CD were classified as REs, and those who scored in the lowest quartile on RS-CD were classified as UREs. The final sample consisted of 40 participants (age: M = 19.93, SD = 1.31; BMI: M = 19.88, SD = 1.82). None of them reported having physical or psychiatric conditions, or taking medication during the past two years.

2.2. Measures

2.2.1. Go/No-go task

We used two variants of the Go/No-go task: one to measure food-unrelated response inhibition, and the other to measure response inhibition specifically for food. In the food-specific no-go task, go stimuli consisted of pictures of flowers, and the no-go stimuli consisted of pictures of high calorie food (e.g. cake, bread, ice cream, chips, chocolate, cookies…). In the food-unrelated no-go task, go stimuli consisted of pictures of high calorie food, while the no-go stimuli consisted of pictures of flowers. High calorie food pictures did not differ from flower pictures in the dimensions of arousal, happiness and familiarity [25]. In the tasks, a fixation appeared 500 ms, followed by a picture of flower or high calorie food presenting 1000 ms, and with an inter-stimulus interval of 1000 ms (Fig. 1). Go stimuli were presented with a frequency of 70%, and the no-go stimuli were presented with a frequency of 30%. Participants were asked to press "J" as soon as possible during go trials but to inhibit responses during no-go trials.

Both tasks consisted of one practice block of 40 trials and three test blocks of 180 trials presented in a pseudo-random order. There was a 2-min rest between each block. Each picture was identical in size (433 by 315 pixels), resolution (71 dots per inch), brightness, and background. Stimuli were presented on a 19 in. TCL computer screen, with the center of the screen set at eye level. Participants were instructed to remain as still as possible and to minimize their eye-blinks to reduce experimental artifacts during data collection.

2.2.2. Food exposure

During food exposure, five bowls of food were presented to participants. Bowls contained potato chips, chocolate, popcorn, egg tart, and bread respectively and were placed in front of participants. First, participants were asked to look at the bowls of food. They were instructed to imagine how the food would taste. Next, they were asked to smell the food thoroughly. Then, participants were asked to evaluate several dimensions of each kind of food on a 5-point Likert scale, including palatability, happiness, smell, and texture. In total, the food exposure lasted 10 min. At the end of the exposure, the bowls of food were placed besides the computer [26].

2.2.3. Dietary restraint

As is recommended in the earlier studies, the Concern for Dieting subscale of the Restraint Scale (RS-CD)[1] was used to assess participants' motivation to restrain their eating because of its higher prediction of eating restraint [27]. The RS-CD consists of six items such as "How often are you dieting?" and scores ranging from 0 to 19, with higher scores indicating an increased intention to restrict food intake. Cronbach's alpha coefficient is 0.71 for RS-CD among female Chinese college students [28].

For the classification of REs and UREs, methods of the scoring above and below the median split [29], scoring 1 SD above and below the mean [30], and scoring in the highest and lowest quartile on the scale [31] have been widely adopted.

2.2.4. PANAS

The state PANAS (Positive and Negative Affect Schedule) [32] is a 20-item questionnaire which assesses current mood state for negative and positive affect. Participants rated on a 5-point scale from 1 (very slightly or not at all) to 5 (extremely) how strongly the 20 adjectives best described their feeling at the moment. Scores are summed separately to get the scores for positive affect and negative affect.

2.2.5. Hunger

Participants rated their hunger on a 100 mm VAS (not at all hungry-very hungry).

2.2.6. Desire to eat

Participants rated their desire to eat on a 100 mm VAS (not desire at all-desire very much).

2.2.7. BMI

Participants' height and weight were measured to calculate the BMI (body mass index = kg/m^2).

2.3. Procedure

Participants were told not to eat anything for 2 h before the experiment. As cover story, participants were told that this study was about attention for food and they would perform computer tasks, and rate food products. After giving consent, participants filled out the PANAS, hunger rating and desire to eat. Then, participants performed two Go/No-go tasks with food and flower pictures as no-go stimuli respectively while EEG data were recorded. Participants rated hunger