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The role of sensitivity to reward and impulsivity in food-cue reactivity

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ABSTRACT

Exposure to the visual and olfactory characteristics of food can elicit a desire to eat and can stimulate food intake. This study sought to determine the extent to which sensitivity to reward and impulsivity are associated with this 'food-cue reactivity' in two motivational states (food deprived and non-food deprived). Female participants ($N=120$) were exposed to a pizza cue for three minutes whilst food deprived and non-food deprived. Before and after this period, three measures of food-cue reactivity were taken (ratings of desire to eat, craving, and desired portion size of the cued food). Two important findings emerged from the study. Firstly, individuals with higher levels of trait impulsivity experienced greater changes in appetite ratings in both motivational states (food deprived and non-food deprived). They also reported greater changes in desired portion size of a cued food when food deprived. Secondly, individuals with a high sensitivity to reward experienced a greater change in their desired portion of the cued food, but only when non-food deprived. These results indicate that individual differences in food-cue reactivity could be related to variation in sensitivity to stimuli that predict the occurrence of a reward, and to an inability to exercise sufficient self control in the presence of tempting environmental stimuli.

1. Introduction

In humans, exposure to a food cue has been found to stimulate appetite. For example, exposure to food cues has been found to stimulate a physiological preparedness to consume food (see Mattes, 1997), and to increase hunger, desire to eat, and craving for a cued food (Fedoroff, Polivy, & Herman, 1997; Nederkoorn, Smulders & Jansen, 2000). Likewise, studies have also suggested that food intake increases after exposure to the sensory characteristics of food (Cornell, Rodin, & Weingarten, 1989; Fedoroff et al., 1997).

To date, relatively few studies have considered the extent to which individuals *differ* in their sensitivity to the stimulatory effects of food cues. Those that have considered this issue have focused almost exclusively on the association between dietary restraint and food-cue reactivity. Generally, these studies find that restrained eaters consume larger amounts of a cued food than unrestrained eaters after food-cue exposure (Fedoroff et al., 1997; Fedoroff, Polivy, & Herman, 2003; Jansen & van den Hout, 1991; Rogers & Hill, 1989), and experience a relatively greater desire to eat, elevated levels of craving (Fedoroff et al., 1997; 2003), greater increases in salivation (Brunstrom, Yates & Witcomb, 2004; Klajner, Herman, Polivy, & Chhabra, 1981), and a relatively greater increase in blood pressure (Nederkoorn et al., 2000).

More recent studies have also suggested that food-cue reactivity might differ in overweight, relative to non-overweight, individuals. For example, Jansen et al. (2003) found that overweight children are more responsive to the sensory characteristics of food cues than non-overweight children. Likewise, Tetley, Brunstrom, and Griffiths (2009) report that overweight adult females are more likely to select larger portion sizes of a cued food than their non-overweight counterparts. Taken together, these findings suggest that food-cue reactivity might present a risk factor for becoming overweight and/or maintaining an overweight body shape.

Given the possible association between heightened food-cue reactivity and being overweight, it is important to consider how individual variation in this dietary phenomenon might account for this association. One possibility is that overweight individuals' heightened sensitivity to the stimulatory effects of food cues results from a tendency to be impulsive (Nederkoorn, Smulders, Havermans, Roefs, & Jansen, 2006) and to experience a greater sensitivity to reward (Franken, & Muris, 2005; Tetley et al., 2009). Partly consistent with this possibility, Guerrieri, Nederkoorn, and Jansen (2007) found that high levels of impulsivity are associated with overeating in the laboratory. However, despite this, it remains unclear whether impulsivity and sensitivity to reward are in fact associated with heightened food-cue reactivity.

The personality characteristic of sensitivity to reward is assumed to reflect the sensitivity of a neurological system referred to as the

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Behavioural Approach System (BAS) (Gray, 1976, 1981, 1987a,b). The BAS is believed to be a 'reward' or 'approach' system which responds to positive incentives in the environment by activating behaviour to obtain specific rewards. It has been suggested that this system continuously monitors the environment for signals of reward. When a cue associated with the receipt of a reward is encountered, the BAS is initiated through activation of the dopaminergic system (Gray, 1987b), and motor output is then increased towards the reward, further activating the BAS and promoting behaviour to obtain the reward ('approach' behaviour) (Kane, Loxton, Staiger, & Dawe, 2004). One possibility is that greater reactivity of the BAS, as evidenced by high trait sensitivity to reward, will predict the occurrence of greater appetitive motivation after brief exposure to the visual and olfactory characteristics of a food cue.

Previous studies have already established an association between sensitivity to alcohol cues and heightened reactivity of the BAS. For example, Franken (2002) reported that sensitivity to reward is associated with a stronger desire for alcohol after exposure to photographs depicting alcoholic drinks. Likewise, Kambouropoulos and Staiger (2001, 2004) have reported that individuals with a high sensitivity to reward experience a greater urge to drink in the presence of an alcoholic drink.

Importantly, sensitivity to reward has been theoretically associated with heightened 'impulsivity' (Dawe, Gullo, & Loxton, 2004; Dolan & Fullam, 2004). Gray's (1976, 1981, 1987a,b) model suggests that one pathway to poor impulse control might be via hyper-responsiveness to reward (i.e., a strong BAS). According to this model, impulsivity results from the failure of cues to inhibit reward seeking behaviour (Dolan & Fullam, 2004). Thus, it is possible that heightened food-cue reactivity might also be associated with a measure of impulsivity.

The current study aimed to assess the extent to which higher scores on a Sensitivity to Reward Scale (SR) (Sensitivity to Reward and Sensitivity to Punishment Questionnaire; SRSPQ; Torrubia, Avila, Molto, & Caseras, 2001), and Impulsivity scale (EPQ; Eysenck & Esyenck, 1975), are associated with greater changes in appetite after exposure to the visual and olfactory characteristics of a food cue (pizza). Previously, it has been suggested that exposure to a food cue can induce a motivation to eat even in the absence of a physiological need (Cornell et al., 1989; Weingarten, 1985). In this study, we sought to explore differences in food-cue reactivity across the personality scales when participants were both food deprived and non-food deprived. This allowed for the consideration of individual variability in food-cue reactivity across different levels of motivation to eat.

In previous food-cue reactivity studies (Fedoroff et al., 1997, 2003), food-cue reactivity has been assessed using a measure of intake of a cued food. Typically, in these studies, participants are randomly assigned to a 'cued' or a 'non-cued' condition, and subsequent food consumption is compared in an ad-lib intake phase. However, this design has limitations given that even the presentation of food immediately prior to an eating episode acts as a cue to stimulate intake (Weingarten, 1985). Thus, a non-cued condition effectively becomes a cued condition when food is presented for consumption in the ad-lib intake phase. To address this concern, we used a novel measure of desired portion size, previously developed by Tetley et al. (Tetley et al, 2009). Specifically, participants were shown a 'representation' of the cued food. By using a three-dimensional rectangular model (green and made of cardboard) we conveyed the important dimensions of the cued food (pizza) without presenting its visual characteristics.

In summary, this study sought to investigate the association between food-cue reactivity and a measure of Sensitivity to Reward Scale (SR) (SRSPQ; Torrubia et al., 2001), and Impulsivity scale (EPQ; Eysenck & Esyenck, 1975) when individuals were both food deprived and non-food deprived. It was hypothesised that higher scores on the Impulsivity scale of the EPQ and the Sensitivity to Reward Scale of the SRSPQ would be associated with greater changes in appetite after exposure to the visual and olfactory characteristics of a food cue (pizza) in both the food deprived and non-food deprived states.

2. Method

2.1. Participants

To maintain consistency with previous food-cue reactivity research (e.g., Fedoroff et al. 1997, 2003; Tetley et al., 2009) and to eliminate any possible effects of gender, participants in this study were drawn exclusively from a female population. One hundred and twenty participants were recruited via email from the population of female undergraduate students at Loughborough University (UK) (mean age = 20.1, S.D. = 2.2). Ethical approval for the study was obtained from the Loughborough University ethics committee.

2.2. Measures

2.2.1. Cue reactivity

The measures of food-cue reactivity were identical to those employed by Tetley et al. (2009). Food-cue reactivity was assessed using three measures; a rating of craving for the cued food (pizza), a rating of desire-to-eat the cued food, and an assessment of desired portion size of this food. Craving and desire to eat were measured using 100-mm visual-analogue rating scales. Respectively, these were headed 'How strong is your desire to eat pizza right now?' and "How strong is your craving for pizza right now?" Both were anchored with the phrases 'Not at all' and 'Extremely.'

'Desired portion size' was assessed using a rectangular three-dimensional cardboard model of pizza (150 mm × 130 mm × 32 mm). This was identical in size to the pizza slice presented during cue exposure and provided participants with an indication of the depth of the pizza. Participants were told that this model represented a cheese and tomato pizza. Participants were then asked to select the amount of cheese and tomato pizza that they would want to eat at that moment in time, imagining that the depth of the pizza was identical to the cardboard model. They indicated this selection using a 420 mm × 594 mm sheet of card. The card had a diagonal line running from the bottom left to the top right hand corner, and participants were told that the corner of their selected portion size should intersect this line (examples were provided). The area of the selected portion size was then calculated. This methodology was used because it allowed participants complete freedom over their portion size selections because it did not restrict their portion size decisions to a number of pre-cut pizza slices that they desired. This method allowed for the fact that pizzas are not always presented pre-sliced and that even when presented pre-sliced participants may not consume complete slices once full.

2.2.2. Sensitivity to reward

Activity of the BAS was assessed using the Sensitivity to Reward Scale (SR) scale from the Sensitivity to Reward and Sensitivity to Punishment Questionnaire (SRSPQ; Torrubia et al., 2001). This scale comprises 24 items which assess sensitivity to rewards such as money, sex, social power, approval, and appraisal (e.g., Does the good prospect of obtaining money motivate you strongly to do some things?, Do you often do things to be praised?). Participants are requested to respond to each item on the scale with either a 'yes' or 'no.' 'Yes' responses score one point and 'no' responses score zero points. A total score is calculated for the 24 items resulting in a total possible score of 24.

Unlike other similar scales (e.g., BAS scales; Carver & White, 1994), items on the SR scale relate to *specific* rewards. It has previously been reported to have good internal consistency, test–re-test reliability, and construct validity (see Torrubia et al., 2001). In our specific