Short communication

External eating, impulsivity and attentional bias to food cues[☆]

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ABSTRACT

Cognitive and behavioural responses to food reward, such as attentional biases and overeating, have been associated with individual differences in reward-responsiveness and impulsivity. This study investigated relationships between external eating, impulsivity and attentional bias to food cues, assessed using the pictorial visual-probe task. As previously reported, attentional bias correlated positively with external eating. Additional novel findings were: (i) attentional bias for food cues was positively related to trait impulsivity, (ii) attentional bias remained related to attention impulsivity after controlling for external eating. Our findings highlight the relationship between the ability to control impulsive responding and selective attention to food cues.

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Introduction

According to recent research, a complex neural circuitry, including cortical and subcortical brain regions, controls cognitive and behavioural responses to food cues, and food intake (Beaver et al., 2006; Berridge, 2009; Davis et al., 2007; Rolls, 2010; Stice, Spoor, Ng, & Zald, 2009; Stoeckel et al., 2008). The operation of this integrated network of brain regions provides a balance between involuntary stimulus-driven (bottom-up) processes and reflective goal-driven (top-down) processes, which together determine cognitive representations of the reward value of food cues, attentional responses to such cues, and impulsive behaviours (Rolls, 2010; Winstanley, Theobald, Cardinal, & Robbins, 2004). Perturbation of these processes is likely to underlie a predisposition to overeat (Berridge, 2009; Rolls, 2010; Stice et al., 2009). The extent to which people show enhanced selective attention to food cues (i.e. attentional bias) provides an index of individual differences in reactivity to food reward, as determined by this integrated system. To gain insight into such individual differences, research has used objective methodology, such as the visual probe task, to assess attentional responses to food cues, which has the advantage of not relying on subjective self-report to assess attentional bias (Brignell, Griffiths, Bradley, & Mogg, 2009; Hepworth, Mogg, Brignell, & Bradley, 2010; Mogg, Bradley, Hyare, & Lee, 1998; Pothos, Tapper, & Calitri, 2009).

One trait characteristic which has been identified as a vulnerability factor for overeating is 'external eating'. This refers to an increased tendency to eat in response to external cues, such as sight or smell of food. Findings from recent studies indicate that external eaters have an increased tendency to selectively attend to food cues (Brignell et al., 2009; Hepworth et al., 2010; Nijs, Franken, & Muris, 2009). The first two studies used a well-established behavioural index of attentional bias derived from the pictorial version of the visual probe task, which presented pairs of pictures (e.g. food and non-food pictures), with each pair followed by a probe stimulus to which participants rapidly respond. Both studies showed that high-external eating is associated with faster detection of probes replacing food than non-food cues, indicating a greater attentional bias for pictorial food cues in external eaters.

In the context of the neurocognitive view outlined earlier, such findings may be explained by external eaters having increased sensitivity to food-reward cues and/or a poorer ability to regulate cognitive responses to food cues. This raises the question of the extent to which the attentional bias for food cues in external eaters may relate to a higher-order construct of trait impulsivity, reflecting a general predisposition for impulsive cognitive and behavioural responding to motivationally salient stimuli.

Impulsivity is widely acknowledged to be a complex multi-faceted construct and, as noted by Stanford et al. (2009), one influential definition is as "a predisposition toward rapid, unplanned reactions to internal or external stimuli without regard to the negative consequences of these reactions to the impulsive individuals or to others" (Moeller, Barratt, Dougherty, Schmitz, & Swann, 2001, p. 1784). Impulsivity has been assessed using a

variety of methods including self-report and behavioural measures. One widely used self-report measure, the Barratt Impulsiveness Scale, identifies three components: inability to concentrate and focus attention (attention impulsiveness), acting without thinking (motor impulsiveness) and lack of future planning (non-planning impulsiveness) (Stanford et al., 2009). There has been some debate regarding the relationship between the constructs of impulsivity and sensitivity to reward, such as the extent to which the latter is an aspect of impulsivity or an independent construct (e.g. Franken & Muris, 2006; Guerrieri, Nederkoorn, & Jansen, 2007; Torrubia, Avila, Molto, & Caseras, 2001).

Despite such theoretical controversies, trait impulsivity has been identified as a vulnerability factor for overeating (Guerrieri, Nederkoorn, & Jansen, 2007; Guerrieri, Nederkoorn, Stankiewicz, et al., 2007) and a predictor of treatment outcome in obesity (Nederkoorn, Jansen, Mulkens, & Jansen, 2007). Furthermore, research evidence from three recent studies show significant positive correlations between measures of impulsivity and external eating; e.g., $r = .51$ ($p < .01$) in 442 obese patients (mean BMI 40.5, SD = 5.3) (Elfhag & Morey, 2008); $r = .23$ ($p < .01$) in 145 adult men (mean BMI 28.1, SD = 5.7) (Strimas et al., 2008), and $r = .17$ ($p < .01$) in 549 predominantly overweight or obese women (BMI 33.5, SD = 8.5) (Ouwens, van Strien, & van Leeuwe, 2009).

Thus, external eating has been associated with both increased trait impulsivity and increased attentional bias to food cues. Consequently, the relationship between external eating and increased attentional bias to food cues may not be unique, but may be partly explained by the more general higher-order personality trait of impulsivity (i.e. impulsive individuals may be more likely to allocate attention to reward stimuli). However there is a lack of research evidence concerning the specific nature of these associations because previous studies showing a relationship between external eating and attentional bias for food cues did not assess trait impulsivity.

The overall aim of the present study was to investigate the relationships between external eating, impulsivity and attentional bias to food cues in a sample of healthy volunteers. Following previous research noted earlier, we hypothesized that external eating would be positively correlated with both attentional bias to food cues (Hypothesis 1) and trait impulsivity (Hypothesis 2). Furthermore, we predicted that increased attention to food cues would also be associated with greater impulsivity (Hypothesis 3) and that the relationship between attentional bias and impulsivity will remain even when controlling for external eating (Hypothesis 4).

Methods

Participants

Forty-four participants were recruited from students at the University of Southampton by advertising (e.g., posters and online). They completed an initial online screening using a short general information questionnaire, including items on demographic variables and eating habits, and the external eating scale of the Dutch Eating Behaviour Questionnaire (DEBQ) (Van Strien, Fritjers, Bergers, & Defares, 1986). Recruitment favoured participants with omnivorous eating habits (vegetarians were excluded as they may respond atypically to pictures of meat), and those with high or low external eating scores (in order to minimise the proportion of the final sample with mid-range scores). Two participants were excluded due to outlying data (described later), so the final sample consisted of 29 women and 13 men, with a mean age of 22.0 years (SD = 4.7) years and mean BMI of 21.75 (SD = 3.36). The study was carried out in accordance with approval

from the School of Psychology Ethics Committee, University of Southampton.

Visual probe task

The visual probe task and stimuli, used to measure attentional bias, were similar to those previously used in our lab (Brignell et al., 2009; Hepworth et al., 2010), but used only one stimulus duration of 2000 ms. The main stimuli comprised 20 food pictures (e.g. chocolate, cake, crisps, sandwich, fruit and pizza), each paired with a non-food picture matched as closely as possible for content (e.g., number, colour and shape of items). The non-food pictures depicted objects which are commonly found in the home but unrelated to food (e.g. book, pencils, toy, shampoo and sponge). Each picture pair was presented 4 times. An additional 10 pairs of non-food pictures were used as fillers, and an additional 10 pairs of food-control pictures for practice and buffer trials. Trial events consisted of a central fixation cross (500 ms), replaced by a picture pair (2000 ms), followed by a probe (an asterisk) that appeared in the location of one of the preceding pictures (displayed until response). Participants were required to respond as quickly as possible by pressing one of two buttons to indicate the position of the probe. There were 10 practice trials and then 2 buffer trials immediately before the main block of 120 trials, which consisted of 80 trials with food-non-food picture pairs intermixed with 40 filler trials in random order. The picture pairs were displayed for 2000 ms only in the current study, as eye-movements were assessed while participants completed the task; however, technical problems prevented collection of sufficient eye-movement data for analyses.

Questionnaire measures

Following the attentional task, participants completed several questionnaires including:

(1) Dutch Eating Behaviour Questionnaire (DEBQ) (Van Strien et al., 1986) which is a 33-item questionnaire with three subscales: emotional eating, external eating and restrained eating.
(2) Barratt Impulsiveness Scale (BIS) (Spinella, 2007). This 15-item version assesses trait impulsivity, and retains the 3-factor structure of the full version of the BIS (Patton, Stanford, & Barratt, 1995), which are attention impulsivity (inattention and cognitive instability), motor impulsivity (motor impulsiveness and lack of perseverance), and non-planning (lack of self-control and intolerance of cognitive complexity).
(3) Behavioural activation system (BAS) scale (Carver & White, 1994), which includes three subscales of fun-seeking, reward responsiveness and drive.
(4) Sensitivity to reward (SR) scale of the Sensitivity to Punishment and Sensitivity to Reward (SPSR) Questionnaire (Torrubia et al., 2001).
(5) Grand Hunger Scale (Grand, 1968), which includes ratings of subjective hunger and desire to eat right now (see Brignell et al., 2009, for details). This measure was included as state hunger may influence attention to food cues (Mogg et al., 1998).
(6) A supplementary questionnaire assessed demographic and background information. Also, height and weight were measured to calculate BMI (weight[kg]/height^2[m^2]).

Preparation of data

Reaction time (RT) data from trials with incorrect responses were excluded. RTs less than 200 ms, more than 1500 ms, and then more than 2 SD above each participant's mean were excluded as

outliers. Attentional bias scores were calculated for each partici-
pant by subtracting the mean RT for probes replacing food pictures
from the mean RT for probes replacing control pictures. An
attentional bias for food cues is indicated by a positive bias score,
whereas an attentional bias away from food cues is indicated by a
negative bias score.

Two participants were excluded from the analyses due to
outlying data: one had an unusually high BIS impulsivity score (55)
which was more than 3 SD above the mean of Spinella's (2007)
norms ($M = 32.6$; $SD = 6.9$, $N = 700$); another had an outlying
attentional bias score (-86 ms), which was more than 3 SD below
the sample mean ($M = 4$ ms; $SD = 27$, $N = 44$). Kolmogorov–
Smirnov tests indicated that, for the remaining 42 participants,
the distribution of each score was within normal limits, except BAS
reward, which was consequently reflected (i.e. each score was
subtracted from a constant that was one greater than the highest
score) and log-transformed to remove positive skewness before
analyses.

Results

Pearson correlations were used to assess the relationships
between attentional bias ($M = 6$ ms, $SD = 24$, $N = 42$), external
eating ($M = 3.4$, $SD = 0.5$) and impulsivity (overall BIS: $M = 32.7$,
$SD = 6.8$; attention-impulsivity: $M = 10.6$, $SD = 2.6$; motor-impul-
sivity: $M = 11.1$, $SD = 3.0$; non-planning-impulsivity: $M = 10.9$,
$SD = 2.9$).

External eating correlated significantly with increased atten-
tional bias for food cues ($r = .36$, $p < .05$; i.e. support for Hypothesis
1). External eating also correlated positively with trait impulsivity
measured by the overall BIS score ($r = .56$, $p < .05$; i.e. support for
Hypothesis 2) and particularly with attention and motor impul-
sivity subscales of the BIS (rs were .63 and .45, respectively,
ps $< .05$). External eating also positively correlated with reward
sensitivity (SR subscale of SPSR, $r = .42$, $p < .05$) and the fun-
seeking subscale of the BAS ($r = .51$, $p < .05$).

Attentional bias for food cues significantly correlated not only
with external eating (as noted above), but also with the overall
index of trait impulsivity ($r = .42$, $p < .05$; i.e. support for
Hypothesis 3), including both attention and motor impulsivity
BIS subscales (rs were .48 and .40, respectively, ps $< .05$).
Attentional bias was also associated with greater BAS fun-seeking
($r = .32$, $p < .05$). There were no other significant zero-order
correlations of interest; for example, reward sensitivity (SR) did
not correlate significantly with attentional bias ($r = .22$, ns),
although it was positively associated with external eating and
impulsivity (rs were .42 and .33, respectively, ps $< .05$). In addition,
BAS reward, BAS drive, emotional eating, restrained eating and
self-reported hunger were not significantly correlated with BIS
impulsivity or attentional bias (e.g. bias correlated .03 with BAS
reward and $-.07$ with BAS drive, both ns).

Partial correlations were conducted to clarify the significant
relationships between the attentional bias, external eating and
impulsivity measures. Results showed that the attentional bias to
food cues remained significantly correlated with BIS attention
impulsivity after controlling the effects of DEBQ external eating
($r = .36$, $p = .02$), and BAS fun-seeking ($r = .42$, $p = .01$). The atten-
tional bias showed near-significant trends to correlate positively
with BIS motor impulsivity after removing effects of DEBQ external
eating ($r = .29$, $p = .07$), and BAS fun-seeking ($r = .28$, $p = .08$).

In contrast, the attentional bias to food cues was no longer
significantly correlated with external eating after controlling the
effects of BIS impulsivity (partial correlations between attentional
bias and external eating were $r = .08$, $p = .64$, when controlling
attention impulsivity; $r = .22$, $p = .18$, controlling motor impulsivi-
ty; and $r = .16$, $p = .31$, controlling overall BIS); i.e. support for

Hypothesis 4. The attentional bias to food cues was also not
significantly correlated with BAS fun-seeking ($r = .12$, $p = .46$) after
controlling for BIS impulsivity.

Discussion

The current study is the first, to our knowledge, to show a
significant positive correlation between attentional bias for food
cues and trait impulsivity. Attentional bias also significantly
correlated with external eating, which was expected from prior
research. Partial correlation analyses indicated that the relation-
ship between attentional bias and attention impulsivity remained
significant even after controlling the effect of external eating.

The present finding of the positive correlation between external
eating and attentional bias to pictorial food cues confirmed our
first hypothesis and is consistent with results from two previous
studies from our lab using a similar task (Brignell et al., 2009;
Hepworth et al., 2010). In the latter two studies, the correlation
coefficients between external eating and attentional bias were .42
and .39, respectively, which indicated a large effect size and are
comparable with the correlation of .36 found in the present study.
Thus, the association between self-reported predisposition to eat
in response to external food cues and a bias in selective attention to
food appears to be a robust feature of healthy adults, as indicated
by these non-clinical studies using the pictorial version of the
visual probe task. One recent study using the visual probe task
failed to find a significant relationship between external eating and
attentional bias (Pothos et al., 2009); however, this study used
single words as cues rather than food-related pictures. Images of
food have greater ecological validity than words and, consequent-
ly, may be more potent in eliciting attentional biases.

The significant positive correlation between the self-report
measures of external eating and impulsivity in this study
confirmed our second hypothesis and is also consistent with
previous research findings noted earlier (Elfhag & Morey, 2008;
Ouwens et al., 2009; Strimas et al., 2008). These previous studies
found this association in samples who were predominantly obese
or overweight (mean BMI in the latter studies ranged from 28 to
40). The present results further indicate that external eating and
impulsivity are linked in an average healthy-weight sample (mean
BMI of 22, $SD = 3$). Reward sensitivity was also positively
correlated with both external eating and impulsivity. Thus, in
the present sample, the trait measure of external eating shared a
considerable amount of variance with higher-order constructs of
trait impulsivity (31% shared variance) and reward sensitivity (18%
shared variance), which is consistent with common underlying
mechanisms mediating responses to rewards.

This study also extended previous research by investigating the
extent to which the enhanced attentional bias for food cues in
external eaters was related to trait impulsivity. The significant
positive correlation between attentional bias and impulsivity
confirmed our third hypothesis and suggests that impulsive
individuals are more likely to allocate attention to food-reward
stimuli than non-impulsive individuals. Results from partial
correlation analyses further indicated that the attentional bias
for food cues was significantly associated with attention impul-
sivity, when controlling for external eating. In addition, there was
no association between attentional bias and external eating after
taking account of trait individual differences in attention
impulsivity (partial correlation was close to zero). Thus, the
present results are novel in indicating that attention impulsivity
has a key relationship with attentional bias.

We also examined relationships with specific components of
impulsivity, which have been identified in previous research
(Patton et al., 1995; Spinella, 2007). The two components of
attention and motor impulsivity both significantly correlated with

external eating, which is consistent with significant relationships between these two elements of impulsivity and disinhibited eating reported by Lyke and Spinella (2004). Attention and motor impulsivity were also both significantly related to attentional bias. The lack of association between the non-planning element of impulsivity and either external eating or attentional bias measures in this study suggested that non-planning impulsivity is a functionally distinct measure from motor and attention impulsivity (Fischer, Smith, & Anderson, 2003), and not specifically related to individual differences in cognitive-behavioural responses to food. The differential relationships between BIS impulsivity subscales and other measures are also consistent with the view that impulsivity is not a unitary phenomenon as indicated in previous research (Patton et al., 1995; Spinella, 2007).

The current study has implications for understanding individual differences in cognitive-behavioural responses to external food cues. The present findings may be understood within a neuro-cognitive framework (outlined earlier) in which integrated brain mechanisms determine individual differences in reward sensitivity and cognitive control (Davis, 2009). These systems underlie not only the ability to control cognitive and behavioural responding to motivational salient stimuli more generally (as indexed by the self-report measure of impulsivity measure used here), but also, more specifically, cognitive-behavioural responses to food, as indexed by the measure of attentional bias used in the present study.

Several limitations of the study may be noted. First, the study design was cross-sectional in nature, which prevents causal interpretations of the relationships between impulsivity and attentional bias to food cues. Second, the data were from a selected student sample, the majority of whom were women. Third, the main focus here was on one measure of attentional bias, which was obtained from the visual probe task. It should be noted that attentional bias is not a unitary construct (Mogg & Bradley, 1998) and it would be helpful to see whether the present findings generalise across other measures of attentional bias, such as the modified Stroop task, which has been found to predict weight gain in non-obese individuals (Calitri, Pothos, Tapper, Brunstrom, & Rogers, 2010).

In conclusion, the present study revealed a significant positive relationship between individual differences in trait attention impulsivity and selective attention to food cues in an average healthy-weight sample. Thus, future research is warranted to clarify the role of trait impulsivity in determining cognitive and behavioural responses to food cues not only in non-clinical normal-weight samples, but also in samples with more problematic eating habits. Such research may reveal that training in attention manipulation and impulse control may be potential intervention targets for individuals with obesity.

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