Maladaptive self-reported eating behaviours and attentional bias for food cues

by

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Thesis for the Degree of Doctorate in Clinical Psychology

May 2013

Word count: Literature review 10,341 words, Empirical 9,643 words
Total word count: 19,984 words
ABSTRACT

Worldwide rates of obesity have dramatically increased in the last few decades. The impact on those involved and on health care systems continues to be huge. Psychological research has attempted to understand the factors and processes implicated in maladaptive overeating behaviour with the aim of assisting in alleviating it, whether associated with a physical or mental health need. This thesis investigated the relationship between biases in attention to food-related cues and the self-reported eating style known as ‘external eating’ (eating in response to external food cues). A systematic search of the literature found 15 papers that examined the relationship between these factors. These studies used a range of methodologies and found varying results. The literature review established that there is a significant relationship between external eating and attentional bias for food cues, such that higher levels of bias are linked with higher levels of external eating. An experiment was designed to measure attentional bias to food cues in high and low external eaters from a non-clinical population using an antisaccade methodology. This tool measured attentional bias scores for the 39 participants in the two groups. In addition, participants completed a behavioural task of inhibitory control, as well as a range of questionnaire measures concerned with eating behaviour and mental health. With this novel methodology, a significant positive relationship was identified between external eating and attentional bias for food. Findings are discussed in relation to theoretical models of attentional bias and maladaptive eating behaviour. Clinical implications are explored and cognitive and behavioural interventions for overeating behaviour are discussed. Future research ideas are suggested with the aim of exploring further the role of eating styles and attentional biases in the development and maintenance of overeating behaviour.
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DECLARATION OF AUTHORSHIP

I, ……………Stuart Dobinson……………………………………………………………….,
declare that the thesis entitled

Maladaptive self-reported eating behaviours and attentional biases for food cues

and the work presented in the thesis are both my own, and have been generated by me as the result of my own original research. I confirm that:

☐ this work was done wholly or mainly while in candidature for a research degree at this University;

☐ where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;

☐ where I have consulted the published work of others, this is always clearly attributed;

☐ where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;

☐ I have acknowledged all main sources of help;

☐ where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;

☐ none of this work has been published before submission

Signed: …………………………………………………………………………………………………

Date:………………………………………………………………………………………………
Acknowledgments

I would like to thank my research supervisor, Dr. Catherine Brignell for all her help and support in carrying out this project and for reading through earlier drafts of the work. I would also like to thank Dr. Matt Garner for his invaluable technical support and guidance with the study. Finally, I would like to thank all of the participants that took part in the research and my family and friends for all their support.
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<tr>
<td>AB</td>
<td>Attentional bias</td>
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<tr>
<td>ANOVA</td>
<td>Analysis of variance</td>
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<td>APA</td>
<td>American Psychiatric Association</td>
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<td>AS</td>
<td>Antisaccade</td>
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<td>ASCL</td>
<td>Antisaccade latency for correct trials</td>
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<td>AST</td>
<td>Antisaccade task</td>
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<tr>
<td>BED</td>
<td>Binge eating disorder</td>
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<td>BMI</td>
<td>Body mass index</td>
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<td>DEBQ</td>
<td>Dutch Eating Behaviour Questionnaire</td>
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<td>DSM</td>
<td>Diagnostic and Statistical Manual of Mental Disorders</td>
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<tr>
<td>DV</td>
<td>Dependent variable</td>
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<td>EAST</td>
<td>Extrinsic affective Simon task</td>
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<td>EE</td>
<td>External eating</td>
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<td>EEG</td>
<td>Electro-encephalographic</td>
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<td>EOG</td>
<td>Electro-oculography</td>
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<tr>
<td>ERP</td>
<td>Event related potential</td>
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<td>fMRI</td>
<td>Functional magnetic resonance imaging</td>
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<td>FRS</td>
<td>Food-related stimuli</td>
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<tr>
<td>GP</td>
<td>General Practitioner</td>
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<tr>
<td>HADS</td>
<td>Hospital anxiety and depression scale</td>
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<tr>
<td>IV</td>
<td>Independent variable</td>
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<tr>
<td>NICE</td>
<td>National Institute for Health and Clinical Excellence</td>
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<td>OEB</td>
<td>Overeating behaviour</td>
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<td>PRT</td>
<td>Pleasantness rating task</td>
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<td>RS</td>
<td>Restraint scale</td>
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<td>RT</td>
<td>Response time</td>
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<td>Standard deviation</td>
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<td>SSRT</td>
<td>Stop-signal response time</td>
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<td>SST</td>
<td>Stop-signal task</td>
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<td>TFEQ</td>
<td>Three-Factor Eating Questionnaire</td>
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<td>WHO</td>
<td>World Health Organization</td>
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Literature Review

The relationship between external eating and attentional bias for visual food cues: A literature review

Introduction

According to the World Health Organization (WHO), by 2008, worldwide rates of obesity had nearly doubled since 1980 (2010). To better understand the cognitive-behavioural motivations involved in overeating, trait characteristics and eating styles have been examined in both, people who have adaptive and maladaptive eating patterns. The significance of trait eating style and its influence on maladaptive eating behaviour (and on factors that shape such eating behaviour) has been examined by a range of studies (e.g. Jasinska et al., 2012; Van Strien, Herman, & Verheijden, 2009).

In an attempt to develop successful treatments for problems such as binge eating disorder (BED) and obesity, research has looked to understand the processes by which people perceive and respond to food cues (Nijs, Franken, & Muris, 2010). Studies examining substance misuse, smoking and alcohol dependence have suggested that those dependent on such substances often show a bias in attention for related cues (Drobes, Elibero, & Evans, 2006; Field, Munafò, & Franken, 2009; Lusher, Chandler, & Ball, 2004). Similarly, studies examining those with maladaptive eating behaviours have identified attentional biases (ABs) for food related stimuli (FRS) (Lee & Shafran, 2004, 2008; Nijs, Franken, et al., 2010; Yokum, Ng, & Stice, 2011).

What is less clear is the relationship between ABs for food cues and the main eating styles associated with obesity and eating disorders, particularly what has become known as ‘external eating’ (EE). EE is a term used to describe a tendency to eat more due to a hypersensitivity to external food cues (Van Strien, Frijters, Bergers, & Defares, 1986).

While studies have shown a link between low mood, overeating and obesity (Stice, Presnell, Shaw, & Rohde, 2005), research has shown there is a significantly
greater chance that individuals with higher levels of trait EE will respond to daily stressors by eating more snack food (Macht, 2008; O’Connor, Jones, Conner, McMillan, & Ferguson, 2008). This therefore indicates the importance of individual differences in susceptibility to maladaptive eating in response to external stressors.

**Prevalence**

Obesity and being overweight are now the fifth leading risk involved in global deaths. Indirectly, more than 2.8 million people die each year because of them, as increases in Body Mass Index (BMI) lead to rises in such health problems as stroke, coronary heart disease and diabetes (WHO, 2010). Growth in the availability of high-calorie foods, decreases in levels of physical exercise and a rise in advertising for foods over the same time period are generally seen as being related to increases in food consumption and obesity rates (Harris, Bargh, & Brownell, 2009).

Recent figures show that BED has a lifetime prevalence rate of almost 2% in the world population. Levels of BMI in these individuals show that two thirds are either overweight (BMI > 25) and more than a third are obese (BMI > 30) (Kessler et al., 2013).

**The Clinical context**

As the role of the clinical psychologist changed over the last decade with the advent of the New ways of Working initiative, there was and still continues to be an increasing need for psychological input into the management of clients with BED and long term medical conditions, such as obesity (British Psychological Society, 2007). In addition, a more preventative approach to health care continues to be called upon (Ogden, 2010).

As will be shown, AB for food cues and sensitivity to external food cues are two key mechanisms by which maladaptive eating patterns can occur. From a clinical perspective, investigating the relationship between these processes is therefore key in working with clients with overeating behaviours.

**Definitions**

While obesity and BED are often associated with each other and have similarities (Bean, Stewart, & Olbrisch, 2008), there are clear clinical differences between them and also other eating-associated problems, e.g. bulimia nervosa. Obesity is a medical condition defined as a BMI of 30 or greater, with BMI being determined using the calculation, weight (kg) / height (m²). In addition, BMI scores of 25-29 are generally understood as indicating a person is overweight. Obese
individuals therefore carry excess body weight (usually fat) which can cause numerous health problems. There are a number of factors that can contribute to obesity, e.g. metabolic rate, genetic issues. However, excessive intake of food / drink, often of high calorie / fat content items, is generally understood to be one of the major issues (Ogden, 2010).

BED is characterised by recurring episodes of uncontrolled eating of an amount of food that is greater than most people would consume in the same amount of time. It can often entail overeating despite the absence of hunger. It also involves a sense of a loss of control and the person feeling significant distress from their eating behaviour. Unlike Bulimia Nervosa, BED requires the absence of regular use of compensatory purging behaviours, such as vomiting and the use of laxatives (American Psychiatric Association [APA], 2000, 2010).

For the purpose of this review and within the given context, the term, overeating behaviour (OEB) will be used to refer to the maladaptive patterns of overeating behaviour consistent with obesity and BED (outlined above). As far as the author is aware, this is not a term that has been used elsewhere, but is being used in this paper for ease of reference to the eating patterns associated with these problems.

AB has been defined as “increased sensitivity to and absorption with relevant environmental cues” (Williamson, Muller, Reas, & Thaw, 1999, p. 561). With regard to food specifically, it has been described as “attending differentially towards food-related stimuli in comparison to neutral stimuli” (Veenstra, de Jong, Koster, & Roefs, 2010, p. 282).

As a way to understand psychopathology in eating behaviour, three main styles of eating have been conceptualised. The way they relate to the classified eating disorders in the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) (APA, 2000) has been the source of a significant amount of research (e.g. Castellanos et al., 2009; Stice, 2001).

External eating (EE) has been defined as a tendency to eat more in response to external food cues due to increased sensitivity to them (Van Strien, et al., 1986), and has been identified as a vulnerability factor for obesity (Jasinska, et al., 2012). Restrained eating was first conceptualised by Herman and Polivy (1975) to reflect a person’s desire to restrict their level of eating to avoid putting on weight. While restrained eaters attempt to restrict their diet, they often fail to do so and as a result
become disinhibited in their eating behaviour. This process is called counter-
regulation (Blechert, Feige, Hajcak, & Tuschen-Caffier, 2010). Emotional eating
has been defined as a tendency to eat in response to emotions, for example, anxiety
(Van Strien, et al., 1986). These eating styles and the theories behind them will be
explained further in the text.

Disinhibited Eating (different to the disinhibition mentioned in the context of
restrained eating) is a term that has also been used by some researchers and has been
understood to be a combination of external and emotional eating styles (Veenstra, et
al., 2010).

In summary, the three main eating styles are restrained, emotional and
external eating. Respectively, they relate to overeating prompted by dieting,
affective states and external food cues.

**Remit**

With these definitions in mind, this review will be examining current
understanding of the relationship between self-reported external eating and AB for
food cues. It will not be examining ABs to body-shape stimuli or to the smell of
food (see Eiler, Dzemidzic, Case, Considine, & Kareken, 2012). Nor will it be
examining studies that use quantity of food eaten as their sole dependent variable
(Ferriday & Brunstrom, 2008) as incorporating these topics is beyond the scope of
this paper.

In the following sections the relevant theories relating to AB and overeating
will be outlined and their clinical implications considered. Following the
descriptions of common measures and methodologies used in this field, the search
process will be described and the identified studies will be outlined. The
methodological issues and discussion sections will continue to critique the various
studies, synthesising current theoretical understanding into the review before then
coming to a conclusion.

**Eating styles and OEB**

Numerous studies have identified the three main eating styles as being linked
to a range of eating-associated difficulties. High levels of restrained eating are risk
factors for Bulimia Nervosa (Stice, 2001) and eating disorders generally (Jacobi,
Hayward, de Zwaan, Kraemer, & Agras, 2004). Similarly, higher levels of EE have
been linked to larger BMI (Jasinska, et al., 2012) and obesity (Castellanos, et al.,
2009).
Theories and psychological models of overeating / obesity

As a way to try to explain why and how overeating patterns of behaviour occur, Bruch (1964, 1974) devised Psychosomatic Theory. This emphasised the importance of the role of emotional arousal in an individual, as well as their ability to correctly perceive their own signals of hunger and satiety as factors that can influence overeating. Therefore, those unable to correctly perceive their own level of satiety may use food as a coping strategy to manage challenging emotions, e.g. when depressed. They may also misinterpret such emotions as indicating they are hungry and consequently eat more (Ogden, 2010). This emotion regulation factor is thought to play a key role in the sensitivity of emotional eaters’ cognitive-motivational system for food, and underlies Psychosomatic theory. According to the theory, such people are therefore at greater risk of developing maladaptive eating patterns.

Restraint theory posits that attempts to purposefully limit food consumption can result in recurrent phases of unsuccessful dieting, leading the person to both under and overeat at times (Heatherton, Herman, Polivy, King, & McGree, 1988; Herman & Polivy, 1975). The main factor thought to cause this is that, due to restrained eaters’ tendency to intentionally limit their food intake through cognitive control, they thus become more susceptible to overeat when, for example, an external stressor occurs and weakens such controls. Subsequent overeating is explained by the Boundary Model (Herman & Polivy, 1983), which outlines that once their self-imposed limit of food consumption is broken, their ability to inhibit their desire to eat ends and they overeat as a consequence (Hachl, Hempel, & Pietrowsky, 2003).

Externality Theory posits that individual differences in sensitivity to external food cues influence eating behaviour. It suggests that individuals who are hypersensitive to external food cues, and less sensitive to their own level of hunger and physiological signs of satiety, are more likely to overeat and so be at greater risk of developing obesity (Schachter, 1968; Schachter & Rodin, 1974). For example, if somebody had trait hypersensitivity to external food cues and they walked past a bakery, they would be more susceptible to the visual and olfactory cues they received from the shop. This, and the fact that their internal state would be playing less of a part in their decision to eat, would mean they would be more likely to overeat as a response to external food cues. Eating behaviour is therefore thought to
be influenced by individual differences in responsiveness of the cognitive-motivational system to food-related stimuli in the external environment (Brignell, Griffiths, Bradley, & Mogg, 2009). This is what is thought to underlie externality theory and external eaters’ patterns of behaviour (see also the ‘Theories of addiction relevant to eating behaviour’ and ‘AB and eating’ sections below). High levels of trait EE occur in people of normal-weight, indicating that body-weight is regulated by other issues as well as EE.

While it could be argued that these theories all play a part to varying degrees in OEB, the growth in food manufacturing and the omnipresence of food advertising raises a potentially greater role for externality theory and EE in maladaptive eating. **Clinical implications and intervention approaches from theoretical views**

From psychosomatic theory, it follows that if a client was assessed as being less sensitive to reading their own internal physiological signals and this was putting their physical and psychological health at risk, interventions to help them might focus on increasing sensitivity to these signals. Restraint theory would encourage interventions to focus more on helping the client understand the detrimental effects of their dieting and perhaps make lifestyle change (e.g. exercising more). Lastly, externality theory points to the potential utility of behaviour therapy principles such as stimulus control and cue exposure (Van Strien, 2004).

**Similarities between OEB and addictions**

When considering the relevance of research from other areas of study, similarities have been observed between the addiction literature and studies relating to OEB. Strong parallels have been argued by numerous authors (e.g. Castellanos, et al., 2009; Davis & Carter, 2009; Nijs, Franken, & Muris, 2009), particularly with regard to BED and addictions. Similarities have been noted in terms of the risk factors, for example, individual differences in impulsivity and sensitivity to reward. In addition, difficulties with withdrawal from the problematic substance and sense of losing control have been noted to be consistent across the two areas (Davis & Carter, 2009). Neurobiological research has shown the key role of the dopaminergic network in reward-driven behaviour and the similarity in changes to the neurobiological pathways that occur in both substance addiction and OEB (Grigson, 2002; Kelley, Baldo, Pratt, & Will, 2005). It should however, also be remembered that there are obvious differences to the addiction literature which should be kept in mind. For example, substance addiction programmes often advocate an abstinence
approach which is clearly not suitable for difficulties with OEB (Davis & Carter, 2009).

Theories of addiction relevant to eating behaviour

When attempting to understand maladaptive eating behaviour, a range of theories and models from the addiction literature are potentially useful and will be examined.

Cue reactivity theory offers one explanation for episodes of overeating and supports externality theory. It therefore has implications for those individuals high in trait EE. It states that cues which consistently precede maladaptive eating patterns (e.g. the sight of food or a food advertisement), become associated with such behaviours and so begin to predict their occurrence. When a person is hungry, the natural physiological response that becomes classically conditioned with such cues is even greater for people with a history of overeating, due to the greater physiological reactivity associated with their larger episodes of eating (Nederkoorn & Jansen, 2002). This is consistent with incentive-sensitisation theory which presents a neurobiological explanation for the process and originated from research in substance misuse and addiction (Robinson & Berridge, 1993). It states that stimuli that become associated with a reward, gain the ability to elicit a similar response as the reward itself, simply through exposure to them (Forestell, Lau, Gyurovski, Dickter, & Haque, 2012). Exposure to addictive substances can cause changes to the neurons in the dopaminergic mesolimbic system, the area of the brain commonly known to be involved in directing motivated behaviour. This dopamine system attributes incentive salience to the associated stimuli, causing subjective craving, or ‘wanting’, and is therefore instrumental in sustaining addictive-behaviour patterns. Accordingly, the degree to which drug-related stimuli stimulate the incentive-salience mechanism, may be consistent with the level of attention directed towards such stimuli (Mogg, Bradley, Field, & De Houwer, 2003). ABs for motivationally salient foods have been hypothesised to occur in the same way (Castellanos, et al., 2009).

AB and eating

Both overweight and obese individuals have been shown to display AB for FRS (e.g. Castellanos, et al., 2009; Werthmann et al., 2011). Similarly, within drug addiction research it has been claimed that AB to substance-related stimuli has a central role in explaining addictive behavioural patterns of drugs use (Lubman,
Peters, Mogg, Bradley, & Deakin, 2000). Franken (2003) hypothesised a model which suggests the dopamine generated by a conditioned drug-related cue, causes attention to be directed towards the stimulus. This then causes motor preparation involved in the use of such substances and increases further craving and likelihood of relapse (Franken, 2003). It has also been hypothesised that AB likely has a comparable function in food craving and over-eating (Veenstra, et al., 2010). These attentional processes are thus thought to be amongst the factors underlying external eaters’ behaviour, lending further support for externality theory. Franken’s model could therefore be adapted to show the same process for FRS and maladaptive eating behaviour below (Figure 1).

**Figure 1: Model of attentional bias and overeating behaviour.**
Adapted from Franken (2003, p. 572)

**Food craving and external eating**

Levels of state food craving have been shown to be an important factor when attempting to examine the relationship between EE and OEB. For example, Burton and colleagues (2007) found that EE’s effect on BMI was diminished when cravings for high-calorie foods was taken into account.
Significance of EE

Out of the three main eating styles measured by the Dutch Eating Behaviour Questionnaire (DEBQ; Van Strien, et al., 1986), EE has been shown to be the predominant predictor of levels of food craving (Burton, et al., 2007). A further study, examining the link between daily stressors and snacking, showed that EE was the principal moderator of their relationship. In contrast, emotional and restrained eating styles’ moderating effects were not significant (Conner, Fitter, & Fletcher, 1999). While a relatively new concept, EE is an important trait implicated in psychological mechanisms of eating.

Measures of attentional bias to visual food cues

A range of methodologies have been used to assess AB using visual food cues and will be briefly outlined.

The Stroop test (Stroop, 1935) is a behavioural measure of attentional bias and involves participants being presented with food and non-food words in different colour ink. The participant’s response times to name the colour of the ink used, either through verbally naming it or pressing a corresponding button, are then measured and error rates can also be calculated. The Stroop task is understood to reflect AB to particular types of words (in this case, food words) when response times are comparatively slower compared to neutral words. This is because an attentional bias to an item will result in a greater amount of time being needed for the participant to extricate their attention from the word and name its colour correctly (Pothos, Calitri, Tapper, Brunstrom, & Rogers, 2009).

The dot probe task (MacLeod, Mathews, & Tata, 1986) involves a pair of words/pictures being presented on the screen for a short period of time before they are replaced by a dot in the same location as one of the words/pictures. Participants then have to identify as quickly as possible where the dot is by pressing one of two buttons that represent the placement of the two stimuli previously presented. The rationale behind the task is that faster responses will occur for dots replacing words that have greater emotional salience for the person and therefore are being attended to more (MacLeod, et al., 1986).

The Exogenous Cueing task (Posner, 1980) involves presenting a participant with a fixation cross in the middle of a computer screen with a blank rectangle either side of it. A food or neutral cue is then shown in one of the rectangles. At cue offset, a target briefly appears, either in the corresponding rectangle or in the
opposing one. The participant then has to identify the target’s location by pressing the appropriate button on a response box. Comparatively faster response times reflect enhanced attention. Valid trials occur when the cue and the target appear on the same side while invalid trials occur when the cue and target are on opposing sides. In addition, by varying the cue duration, it is possible to examine enhanced engagement and impaired disengagement aspects of AB to particular types of cues. Cue validity effects can be measured by subtracting valid trial scores from corresponding invalid trial scores. Larger cue validity effects occur when there has been greater attention allocated to the picture used in the two different conditions (Veenstra, et al., 2010).

Another common method of assessing AB is to show participants different stimuli, pictures or words and then measure an aspect of physiological change that can be observed, e.g. in measurements of brain activity. For example, Event Related Potentials (ERPs) are specific negative and positive sections of the electroencephalographic (EEG) brain wave response to a stimulus. The amplitudes of the long latency positive waves are commonly measured to assess AB. In particular, the P300 and Late Positive Potential sections are often measured with larger levels indicating greater AB (Nijs, et al., 2009). Similarly, the body’s startle response, eye blink response, and skin conductance (Drobes et al., 2001; Overduin, Jansen, & Eikkes, 1997) and heart rate variability (Meule, Vögele, & Kübler, 2012) can all be measured in terms of their intensity and compared to others’ responses or responses involving different stimuli. Lastly, while exposing participants to FRS, changes in blood oxygenation level-dependent responses in different areas of the brain can be measured. These identify changes in the physiological connectivity between specific brain structures that are understood to be relevant to the processing of such stimuli. This therefore constitutes a further measure of reactivity to FRS that can be viewed as a measure of AB.

An obvious method of visual attentional bias is the measurement of eye movements themselves. This can include gaze duration and changes in pupil diameter (Giel, Friederich, et al., 2011; Graham, Hoover, Ceballos, & Komogortsev, 2011) as well as eye movement reaction time (Castellanos, et al., 2009).

The Extrinsic affective Simon Task (EAST; De Houwer, 2003) involves presenting participants with words they have to categorise into one of two possible groups, e.g. good and bad, using a keyboard or button-press. By comparing
responses made to the same cue using the good and bad categorisation keys, positive attitudes about the subject can be identified. This is thought to be because faster and more accurate responses with the positive categorisation will occur when the trial content is congruent with the person’s own views about it (Pothos, Calitri, et al., 2009). The stimulus-response compatibility task is similar to the EAST task in the sense that it is a measure of affective valence (or implicit attitude) for something. Participants have to respond to particular types of words or pictures by moving a manikin figure either closer or further away from the stimuli presented. More negative attitudes can be identified when the person moves the manikin away from the word / picture (consistent with the notion of avoidance of undesirable stimuli). Similarly, more positive views can be identified when the manikin is moved closer to the word / picture (consistent with the idea of approaching desirable stimuli) (Mogg, et al., 2003).

These tasks provide a variety of approaches that can be used to assess ABs. While well-established, the Stroop task has predominantly used lexical rather than pictorial stimuli. This reduces its ecological validity and potentially neglects processing of affective information according to De Houwer and Hermans’ (1994) conceptualisation of information processing.

**Self-report measures of eating styles**

A number of measures have been developed to examine eating styles in clinical and non-clinical groups. The Restraint Scale (RS; Herman & Polivy, 1980) was the first to measure restrained eating. This was followed by the Three-Factor Eating Questionnaire (TFEQ) (Stunkard & Messick, 1985) and the DEBQ (Van Strien, et al., 1986) which have a specific measure of dietary restraint as one of their subscales, e.g. “Do you watch exactly what you eat?” (Van Strien, et al., 1986). The RS scale was originally devised to yield a single measure of restrained eating, however, it has been argued that the restraint subscales of the DEBQ and TFEQ relate more specifically to dietary restraint alone, while the original RS measures both overconsumption of food in addition to attempted restraint (Lowe & Thomas, 2009).

The DEBQ also includes separate sub-scales for external eating, e.g. “If you see or smell something delicious, do you have a desire to eat it?”, and emotional eating (Van Strien, et al., 1986). In addition to its restraint subscale, the TFEQ has a subscale for disinhibited eating, relating to situations where someone is predisposed
to eat more, e.g. seeing someone else eating. It also has a subscale for hunger, e.g. “I often feel so hungry that I just have to eat something” (Stunkard & Messick, 1985).

It has already been established that people with obesity and those diagnosed with eating disorders often show an AB for FRS (e.g. Castellanos, et al., 2009; Lee & Shafran, 2008). Examination of this issue has been hypothesised to provide insight into the psychological mechanisms underlying OEB. The aim of this review is to clarify current understanding of the relationship between trait EE, often associated with these problems, and ABs for visual food cues.

Search strategy

Two main strategies were used to conduct a literature review and to ensure that the search systematically identified all key papers. Firstly, a search of three databases (PsycINFO, MEDLINE and Web of Science) was conducted using the internet. Search terms were generated using the keywords and subject words from two key papers that had already been identified (Brignell, et al., 2009; Pothos, Calitri, et al., 2009). Database-appropriate versions of the words were used and the thesaurus utility was used where available. Appendix 1 shows the combinations of the search terms used for each search engine.

Secondly, in reading the full papers, a manual search was undertaken of the studies’ reference lists. Five new articles were identified and generated new search terms (‘information processing’, ‘dietary restraint’). These words were used in a new search, undertaken as before. Appendix 2 shows the combinations used for these new words.

Inclusion criteria for the literature review were as follows: (1) written in English; (2) peer reviewed; (3) a study of adult humans; (4) published in full; (5) examining self-reported EE style; (6) used a measure of attentional bias to visual food cues.

The flow diagram in Figure 2 shows the process of selecting studies and details reasons for exclusions.

Results

15 papers were identified that satisfied inclusion criteria and are listed in Appendix 3. This was deemed to be an appropriate body of research, in part due to the multiple methodologies used in a number of the identified studies (e.g. Brignell, et al., 2009; Nathan et al., 2012) The following review is organised by methodology.
Total number of papers initially produced, $N = 2178$

- New study removed - no measure of attentional bias, $N = 1$
- Duplicates removed, $N = 207$
- Papers excluded at title due to relevance, e.g. advertising/marketing/not related to food/not examining attentional bias, $N = 872$

Total number of papers accepted at title, $N = 1248$

- Papers excluded: $N = 930$
  - Non-English, $N = 38$
  - Non-peer reviewed, $N = 54$
  - Non-human, $N = 828$
  - Pre-1970, $N = 10$

Total number of papers accepted at abstract, $N = 169$

- Studies excluded: $N = 101$
  - Not relevant, e.g. chewing gum, $N = 9$
  - Eating styles not examined, $N = 53$
  - Packaging/marketing, $N = 1$
  - No measure of attentional bias, $N = 20$
  - Duplicate, $N = 9$
  - Eating measured only, $N = 6$
  - Body-shape related only, $N = 3$

Full copies retrieved, read and assessed for eligibility, $N = 68$

- Studies identified in reference lists of papers read, $N = 5$
- Studies found/full copies obtained through searching using additional search terms, $N = 2$
- Study excluded: $N = 59$
  - Reviews, $N = 9$
  - Non-adult, $N = 1$
  - No attentional bias measure, $N = 13$
  - Eating styles not examined, $N = 5$
  - Measured food intake only, $N = 2$
  - No eating style comparison or correlation, $N = 2$
  - Not examining external eating, $N = 27$

- New study removed - no measure of attentional bias, $N = 1$

Studies included in this review, $N = 15$

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Figure 2: Search strategy diagram
Studies examining AB and EE

Stroop studies.

Johansson, Ghaderi and Andersson (2004) examined sensitivity to external food cues and AB to food words using the Stroop task with a normal sample. Testing female university psychology students, they compared low EEs (N=21) and high EEs (N=22), using median split and cut-off point of 3.60 on the DEBQ EE scale. While there was a tendency for high EEs to show an AB towards food words in comparison to low EEs, the difference did not reach statistical significance (Johansson, et al., 2004). In a different study (Newman, O'Connor, & Conner, 2008), the Stroop task was used with a mixed gender sample of students. Participants’ stress levels were manipulated through informing them that they would either be giving a presentation or completing a pen and paper task. High and low EE were operationalized slightly differently from the previous study. A median split was not used and instead high EE participants (N=36, EE > 3.7) were compared with low EE participants (N=30, EE <2.7). While the largest mean bias scores were achieved by the low EE group in the control condition, no significant main effect of EE group was found. Differences between snack food words and meal words were also examined and snack bias scores showed a significant interaction between eating style group and stress condition. This therefore gave some support to their hypothesis that high EEs would show a greater AB for snack food words in comparison to low EEs. While this was the case in the stress condition, in the control condition, low EEs tended to show greater AB to snack words (Newman, et al., 2008). The difference in the group categorisation between these studies is problematic when attempting to compare results. Johansson’s use of a median split with a high boundary relative to Newman’s would have meant that a number of low EE participants from the first study would not have been categorised as low EE participants in the second study. This might also account for Johansson’s lack of significant findings (i.e. there may not have been a larger enough difference between groups to identify a significant result).

Tapper and her colleagues (Tapper, Pothos, Fadardi, & Ziori, 2008) measured the total amount of time it took to identify the colour of food words and compared this to neutral words. Participants were 224 male and female undergraduates at universities in Wales (N=66), Iran (N=98) and Greece (N=60).Processing bias scores were calculated by subtracting neutral times from food times for each
participant. While the focus of the study was on the restrained eating style and looking at people who were and were not currently dieting, one analysis showed that for those not currently dieting, there was no main effect of EE (using a score of 3 as the cut-off for high and low EE). Mean bias scores were comparatively greater however for those in the high EE group (Tapper, et al., 2008). While no significant result was found, again, this could have been due to the use of a median split creating little disparity between the two groups.

In a study examining AB for a mixed gender sample of 20 obese and 20 normal-weight participants, high-calorie food words were used and compared with neutral (office-related) words (Nijs, Franken, et al., 2010). Participants were asked to eat a small meal two hours prior to taking part to the testing session and to not eat anything else until the experiment was over, thereby attempting to control for the effect of state hunger. Mean response time (RT) data were analysed and correlational analyses revealed that higher levels of trait EE were associated with Stroop interference effect (RT bias scores were greater). However, this was only found in the group of participants who were obese. Measurements of ERPs were also taken while participants took part in the Stroop task as an additional measure of attentional bias. No significant correlations between ERPs and any of the three eating styles measured by the DEBQ were observed (Nijs, Franken, et al., 2010). This therefore provides some support to the idea that high EEs show an AB for food cues (although only in the obese participants).

Overall, results from the Stroop test studies provide inconclusive results about high EE being linked with an AB for food cues.

Visual probe studies.

In a correlational study of male and female undergraduate students (N=151), a range of attentional bias measures for food cues were used, including the Stroop test, EAST task and the dot probe task. No significant correlations however were found between bias scores and levels of external eating as measured by the DEBQ (Pothos, Tapper, & Calitri, 2009).

In Johansson and colleague’s study (see above, 2004), they also used a visual probe task to examine attentional bias. Contrary to their predictions, low EE participants showed an attentional bias towards food words while high EE participants showed a bias away from them. This is surprising, however, their use of a high score median split means their low EE group may not have actually been
categorised as low EE according to other studies’ criteria. In addition, they did not control for the effect of hunger which may have been a confound.

Brignell and colleagues (Brignell, et al., 2009) used the pictorial version of the probe task and stimulus presentation conditions of 500ms and 2000ms. The sample comprised 55 predominantly female volunteers from a university and the surrounding community. Normal and over-weight participants were recruited and inclusion criteria included being omnivorous and aged 18-60 years old. 20 pictures of food (both high and low-calorie) and 20 pictures of neutral objects, matched for likeness with a corresponding food picture, were used in the study. The low EE group (N=24) comprised participants that scored less than 3.2 on the EE scale, while the high EE group (N=19) scored more than 3.5. Results revealed a significant main effect of EE group, F (1,39) = 9.41, p < 0.1, with high EEs having greater attentional bias towards food stimuli than low EEs (Brignell, et al., 2009). This result was significant between the groups at the 2000ms stimulus presentation condition, but showed only a non-significant trend at the shorter presentation condition. In addition, comparative to neutral pictures, those in the high EE group had a significant attentional bias to food pictures. While it did not reach statistical significance, the low EE group showed a trend for an attentional bias away from food pictures in comparison to neutral pictures. In post hoc analyses, when those with high emotional eating scores were removed, a main effect of EE group was still found in bias scores between high and low EEs:  F (1,32) = 8.05, p < .05 (Brignell, et al., 2009). This was a better designed study, due to its clearer exclusion criteria and use of matched stimuli. Despite the relatively small between-group differences in EE (only 0.3 potentially between participants) they still found a significant result indicating AB for food cues in high EE participants.

A further visual probe study found contrasting results when examining separate aspects of AB to food cues (Tapper, Pothos, & Lawrence, 2010). Initial orienting speed to and duration to disengage from the food stimuli were both measured in a mixed gender sample of 105 university students. The influence of trait reward drive, as measured on the Behavioural Activation Scale drive subscale (BAS-d; Carver & White, 1994), and hunger levels were also measured and shorter stimulus presentation (compared to Brignell, et al., 2009) were used. Results showed that levels of reward drive and attentional disengagement from food cues were negatively correlated in the 100ms stimulus presentation time condition (r = -
.28, *p < .01) and that there were no significant correlations between levels of EE and biases for foods in any of the time conditions. However, the significant reward drive finding in the attentional disengagement data did not occur in the two longer conditions (500ms and 2000ms), nor was there a significant correlation between levels of BAS-d and orienting speed bias in the 100ms condition (Tapper, et al., 2010).

An eye-tracking methodology was used in conjunction with a dot probe task in a study of obese (N=18) and normal-weight (N=18) adult women (age 18 to 35 years) (Castellanos, et al., 2009). Subjects were presented with high and low-calorie food and non-food pictures. Eye movements (gaze direction and gaze duration) and response times to probes that appeared in the place of one of the pictures were measured. This therefore provided an indicator of attention at the point of picture offset (Castellanos, et al., 2009). Hunger was also manipulated and all participants were assessed twice (after 8 hours of fasting and after drinking a liquid meal until they were no longer hungry). Gaze direction bias represented the proportion of initial fixations that were directed towards food as opposed to non-food pictures, while gaze duration bias was calculated from the length of time participants looked at the different sets of images. Results showed that levels of self-reported EE significantly correlated with gaze direction in the fed condition (*r = .46, *p < .05). Levels of DEBQ emotional eating, restrained eating and TFEQ disinhibition also achieved significance. In addition, significant main effects were found between obese and normal-weight participants in gaze duration (but only in the fed condition) and gaze direction. No statistically significant results were found for the response times to the button-press in relation to the fed or fasting conditions, obese or normal-weight groups or DEBQ scores (Castellanos, et al., 2009). In this study, evidence for an AB for food cues in high EE participants was found in the gaze direction data but not in the RTs.

In another visual probe study, an experimental manipulation of mood was also utilised (Hepworth, Mogg, Brignell, & Bradley, 2010). Participants were 80 female university students with a mean age of 20.7 years. The same pictorial stimuli as those used in Brignell and colleague’s (2009) study were employed and response times measured. Levels of EE significantly correlated with AB scores (*r = .39, *p < .05) and this result remained (*r = .31, *p < .05) when the effects of perceived stress, state hunger levels and dysphoria (as measured on the Beck Depression Inventory II,
Beck, Steer, Ball, & Ranieri, 1996) were controlled for. In addition, partial correlations demonstrated that external and restrained eating were associated with bias scores. Further analyses of the AB scores showed that none of the eating styles as measured by the DEBQ achieved a significant interaction with the mood manipulation (Hepworth, et al., 2010). This study provides good evidence of an AB for food cues in participants with high EE as the significant results still remained after controlling for a range of potentially confounding variables.

In a study of overweight / obese (N = 26) and normal-weight (N = 40) females, multiple methodologies were used to examine AB for pictorial FRS in separate experimental tasks (Nijs, Muris, Euser, & Franken, 2010). The overweight / obese group had a mean age of 21.5 years and mean BMI of 30.00, while the normal-weight group had a mean age of 21.38 years and a mean BMI of 20.63. State hunger was also manipulated by asking all participants to arrive at the experiment, not having eaten for 17 hours. When participants arrived for the experiment, half of all participants were satiated by drinking a milkshake which contained approximately 600kcal. In the visual probe paradigm, pairs of pictures (food and neutral, or neutral and neutral) were presented for either 100ms (examining orienting attention) or 500ms (examining maintained attention). Analyses showed no significant correlations between RTs to the probes and any of the eating styles as measured by the DEBQ (p > .05) (Nijs, Muris, et al., 2010). This study controlled for the effects of hunger well and used both normal-weight and obese participants. However, no significant results were found.

In a correlational study examining AB to food and non-food pictures, 42 (29 women) university students (mean age = 22.0 years; standard deviation [SD] = 4.7) were assessed using the visual probe task (Hou et al., 2011). Other measurements made included trait impulsivity, using the Barratt Impulsiveness Scale (Spinella, 2007), and levels of reward sensitivity, using the Sensitivity to Reward subscale of the Sensitivity to Punishment and Sensitivity to Reward Questionnaire (Torrubia, Ávila, Moltó, & Caseras, 2001). Stimuli were similar to that used in previous studies (Brignell, et al., 2009; Hepworth, et al., 2010) and were presented for 2000ms. Analyses revealed a positive correlation between AB for food cues and EE (r = .36, p < .05). In addition, positive correlations were also found between EE and impulsivity (r = .56, p < .05), and between EE and reward sensitivity (r = .42, p <
.05) (Hou, et al., 2011). This study therefore provides support to the idea of an AB in EE participants.

In a mixed gender study of overweight and obese participants (BMI > 27, mean age = 35.1 years), a visual probe task was used, incorporating 20 food and 20 non-food pictures (Nathan, et al., 2012). Stimuli were presented for either 500ms or 2000ms before then being replaced by a black probe in the position of one of the previous stimuli. Supplementary analyses involving the DEBQ subscales showed that there was a positive correlation between external eating scores and AB scores (an average of the 500 and 2000ms conditions) ($r = 0.41$, $p = 0.043$; two-tailed, $p$ value not adjusted for numerous analyses) (Nathan, et al., 2012).

Overall, evidence from visual probe studies is supportive of the hypothesis of high EE being positively associated with an AB for food cues.

**Brain imaging and EEG studies.**

In a between-groups study design, Nijs, Franken and Muris (2009) measured ERPs to examine the information processing of various pictures, including those of food. In a sample of 49 undergraduate females who were of healthy-weight, 25 were identified as being in the high EE group (EE > 3.50) and 24 in the low EE group (EE < 2.70). Participants were shown 450 images from three picture categories (high-calorie foods, babies, and office items) and asked to silently count the amount of pictures from one particular category. Amplitudes of their P300 ERPs were measured and analyses provided for four right-hemisphere and four left-hemisphere scalp location positions. Food craving was also measured, both pre and post experiment using the state version of the General Food Cravings Questionnaire (Nijs, Franken, & Muris, 2007). Analyses revealed the high EE group had statistically significantly greater bias scores than the low EE group in their responses to food pictures at one of the right-hemispheric EEG placements ($p < .05$). Marginally significant between groups differences were also found at three of the left-hemispheric EEG placements ($p < .10$) showing the same between-group relationship. Larger mean bias scores were found for the high EE group in all of the 8 scalp positions. In addition, due to the strong positive correlation between EE and emotional eating scores of participants, as measured on the DEBQ, further analyses were carried out on the emotional eating scores. These suggested that the significant main effect previously found for an AB for food cues is typical for those with EE behaviours. Finally, post-hoc t-tests showed that while there were no differences in
food craving between the high and low EE groups before the test, the high EE group had significantly greater levels of food craving after the experiment. This is consistent with the idea that people who are more sensitive to external food cues are more likely to have the urge to eat following exposure to FRS (Nijs, et al., 2009).

One study used functional magnetic resonance imaging (fMRI) to examine healthy participants’ responses to photographs of bland and appetizing foods (Passamonti et al., 2009). 11 Males and 10 females (mean age of 25.3 years; age range of 19-39 years old) who had no self-reported history of psychiatric or neurological difficulties or of having eating disorders took part and completed the DEBQ after having fasted for at least two hours before the experiment. Images were displayed for 1000ms and changes in blood oxygenation level-dependent responses between the prefrontal cortex, amygdala and ventral striatum regions of participants’ brains were measured. Analyses showed that these changes correlated with levels of EE on the DEBQ. There was a positive correlation between EE and ventral striatum-amygdala connectivity change ($r = .79, p < .001$) and between EE and ventral striatum-premotor cortex connectivity change ($r = .66, p < .001$). Similarly, there was a negative correlation between EE and ventral striatum-dorsal anterior cingulate cortices connectivity change ($r = .78, p < .001$). These results therefore showed that higher levels of EE were associated with changes in connectivity in parts of the brain that have been shown to be key in eating behaviour in animals (Kelley, et al., 2005). Consequently, Passamonti et al. (2009) hypothesised that decreased connectivity between such regions in the brain could be seen as a “neuronal marker” for susceptibility to maladaptive eating behaviours (p. 50).

In Nijs and colleagues’ paper (Nijs, Muris, et al., 2010), they also made EEG measurements of their obese / overweight and normal-weight female participants while they viewed images of neutral and food pictures. Participants were asked to count the number of a particular type of picture so as to increase concentration on the task and stimuli. The only eating style that showed a significant correlation with the P300 EEG bias scores was EE ($r = .44, p < .01$). This was however, only found in the normal-weight group (N = 40) (Nijs, Muris, et al., 2010). In contrast to the findings from previous studies with obese participants, the EE-AB link was not found in that client-group but was with normal-weight participants. Evidence from brain imaging studies provides strong support for the idea that those with EE have an AB for food cues.
Other methodologies.

In a study using a modified Exogenous Cueing Task, the Restraint Scale (RS; Herman & Polivy, 1980) was used to identify 28 restrained (mean BMI = 24.5) and 27 unrestrained eaters (mean BMI = 20.8) from a pool of female psychology undergraduate students (Veenstra, et al., 2010). Stimuli were five high-fat pictures, five low-fat pictures and ten neutral pictures and were presented for a duration of 500ms and 1500ms. Participants completed the DEBQ after the experiment and restrained eating and disinhibited eating scores were calculated (the latter using the combined scores of the emotional eating and EE subscales). Analyses showed that for the restrained eaters (N=28) in the 500ms condition, there was a significant negative correlation between EE and cue validity effects for high-fat food ($r = -.38$, $p < .05$). However, no significant correlations were found for the low-fat or the neutral pictures. This suggests that, in restrained eaters, greater levels of EE were linked with less attention being directed towards FRS (Veenstra, et al., 2010). While this is a significant result in the opposing direction to previous studies, it should be noted that the participants in the sample all had high levels of restrained eating and were therefore trying to restrict food intake.

In Nijs and colleagues’ experiment (Nijs, Muris, et al., 2010) examining normal-weight and overweight / obese females as mentioned previously, a separate task involved measuring eye movements while showing the participants pairs of high-calorie snack food / neutral pictures. The images were matched in terms of their colour, shape, background and location of the object. Direction bias scores (an index of initial orientation, with scores > .05 indicating a bias in immediate orientation towards FRS) and duration bias scores (an index of maintained orientation, with scores > .05 indicating a maintained attention bias towards FRS) were measured and analyses were conducted. No significant correlations were found between DEBQ eating styles and either of the attention biases (Nijs, Muris, et al., 2010).

In the study by Brignell et al. (2009), a stimulus-response compatibility task was used to assess approach and avoidance biases in their sample of normal and over-weight adults. Pictures of FRS and neutral stimuli were used in two separate

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$^1$ Original published analyses from Veenstra et al. (2010) examined EE and emotional eating combined (to make disinhibited eating). However, through correspondence with the authors, results specifically for EE alone were obtained and are cited above.
assignment tasks that were completed by participants. By subtracting the RTs to put the manikin closer to food and away from neutral images (the first assignment), from the RTs to put the manikin closer to neutral and away from food images (the second assignment), bias scores were determined. As a result, a quicker predisposition to approach as opposed to avoid FRS, in comparison to neutral stimuli, was signified by positive bias scores (Brignell, et al., 2009). Results showed that the high EE group had significantly larger approach bias scores than the low EE group for FRS, $t(39) = 2.15, p < .05, d = .67$. In addition, approach bias scores positively correlated with levels of EE, $r(51) = .32, p <.05$, and also with levels of emotional eating, $r(51) = .35, p <.05$. Subjective levels of hunger (desire to eat their favourite food) and approach bias also positively correlated with approach bias, $r(51) = .30, p <.05$. When the effects of emotional eating and desire to eat were controlled, partial correlations for EE and approach bias were respectively, $r(50) = .24, p <.09$, and $r(50) = .24, p <.09$ (Brignell, et al., 2009). Results support an EE-specific AB to food cues.

Initial summary of studies

While some studies show no relationship between AB for visual food cues and levels of EE, there is a clear tendency for significant results to show that higher levels of EE are linked with greater ABs for food cues. In the fifteen papers identified in this review, 21 separate experiments were conducted using a range of methodologies. Out of these: 10 were supportive of the EE-AB positive relationship; 6 showed non-significant results; 3 showed results in favour of the link but did not reach significance; and 2 studies found the inverse relationship. Broadly, the brain imaging and EEG studies showed the positive association most consistently, with the Stroop studies showing the greatest proportion of non-significant trends / results.

Methodological issues

In critically reviewing this research, a number of methodological issues arise and need to be considered before making more certain conclusions.

Design issues.

A number of studies used a median split to create their high and low EE groups (e.g. Johansson, et al., 2004). However, use of a median split would indicate there may have been participants with very similar EE scores in separate EE groups. Consequently, the quality of results from such a design is limited as it is difficult to
identify a significant effect and to rely on one being a true reflection of a group characteristic, if it does occur.

It should be noted that the effects of state hunger were not controlled for in a range of studies (e.g. Johansson, et al., 2004). This weakens conclusions that can be drawn from such studies because research has shown state food craving to be an “intervening causal variable” linking EE and the development of obesity (Burton, et al., 2007, p. 191).

It is important to note that while these studies are informative, they do not allow causal inferences to be drawn. For example, Nijs and colleagues (Nijs, Muris, et al., 2010) acknowledge that it is not possible to conclude that greater levels of EE caused the significantly greater levels of P300 responses in participants’ brains. Due to the inability to manipulate EE, most prospective studies have to be cross-sectional in design by nature.

**Stimuli issues.**

It has been noted by a number of researchers that pictorial cues are more appropriate stimuli to use than food-related words, because the former are a better representation of real-life experience and therefore have greater ecological validity (Castellanos, et al., 2009; Hou, et al., 2011; Veenstra, et al., 2010). Indeed, Johansson et al. (2004) noted this limitation in their own study and suggested future research should utilise pictures. This is consistent with theory and research highlighting that information relating to images and physical objects is processed in the semantic system which contains more affective material, compared to the lexicon where processing of words occurs (De Houwer & Hermans, 1994; Glaser & Glaser, 1989). The affective component may well be a key part in determining particular ABs for certain stimuli. Therefore, when attempting to understand information processing and potential ABs, it is important that pictorial stimuli are used to ensure examination of any significant affective elements involved during perception. This is therefore another limitation in the studies that used words for stimuli (Johansson, et al., 2004; Tapper, et al., 2008).

There has been much debate about the emotional Stroop test and how to interpret its colour naming latencies (e.g. Boon, Vogelzang, & Jansen, 2000; De Ruiter & Brosschot, 1994). Slower latencies have previously been understood to reflect AB towards food cues as a result of attending to the word content. However, it has been argued that the slower latencies could represent avoidance away from the
stimuli (De Ruiter & Brosschot, 1994). This therefore raises fundamental questions about the appropriateness of the Stroop test as a measure of AB towards FRS and so conclusions from Stroop studies are difficult.

**Population issues.**

As is often acknowledged in the literature, a common limitation is the extent to which results from studies using participants from a particular population, can be generalised to other groups. For example, six of the selected papers only studied females from an undergraduate population. Indeed, the majority of the studies used university students, usually psychology undergraduates in particular. However, gender differences in EE scores have not been identified (Van Strien, 2002). This could indicate that the perceptual processes and motivating behaviours involved in the concept of EE may be similar across genders. If so, then there could be greater flexibility in comparisons of gender-specific studies.

It is notable that three of the studies reviewed used the same picture set of stimuli (Brignell, et al., 2009; Hepworth, et al., 2010; Hou, et al., 2011). These studies also found results consistent with greater levels of EE being associated with greater AB for food cues. It is possible that the use of a quality picture pairing process (where each food picture was carefully matched in appearance with a neutral picture) may have positively contributed to this.

In the study by Veenstra et al. (2010), the participants tested were restrained eaters and therefore attempting to restrict their diets. In this context, it is not unexpected that such a group would show a bias away from high-fat foods they were avoiding. The conclusions in relation to this paper therefore have less direct relevance to the general EE-AB link discussed in this review, and need to be understood as being specific to restrained eaters.
Discussion

This review set out to examine the available research on the relationship between self-reported EE and AB for food cues. Overall, it has shown there is good evidence for a relationship between these two factors such that higher levels of EE tend to be associated with greater levels of AB. Two studies showed significant results indicating the opposing relationship (Johansson, et al., 2004; Veenstra, et al., 2010). However, both studies had methodological / design issues that weakened the conclusions they might have been able to make with regard to the present topic. In addition, a significant proportion of the studies with non-significant and non-significant trends came from the Stroop studies. When considering both the lack of ecological validity of their stimuli and the problems associated with interpreting Stroop effects, their findings have to be viewed with caution. The between-groups studies examining high and low levels of EE (e.g. Brignell, et al., 2009; Newman, et al., 2008; Nijs, et al., 2009) broadly provided better designed investigations into EE.

These findings are consistent with an incentive-sensitisation theory of OEB which emphasises the role of the dopaminergic system in attributing incentive-salience to reward-associated signals, in this case, external food cues (Robinson & Berridge, 1993).

Intuitively, a reciprocal relationship might be expected between EE and AB for food cues. The more that someone has a predisposition to attend to cues they find rewarding, such as the sight of delicious food, the more they will likely desire to consume it. Similarly, the more someone has a tendency to desire food, the more they will attend to it. This complimentary nature supports the model adapted from Franken (2003) and further emphasises the importance of externality theory (Schachter, 1968; Schachter & Rodin, 1974), which also places significance on food-related cues in the environment. Referring to Franken’s adapted model of AB previously discussed (Figure 1), his hypothesised concept of enhanced signalling of food-related cues could be understood as representing EE. Higher levels of EE result in more food being perceived, activation of the dopaminergic system and therefore enhanced AB. This cyclical process is thus connected to craving and the behavioural expression of OEB.

In completing this review, the EE construct has been noted as a valid and valuable measure. For example, it has been linked with higher BMI and obesity.
While there is good evidence for the relationship between AB for food cues and EE, the lack of consistent significant findings in the literature raises the question: are there other important factors that are at play that may be related to AB, eating styles, and OEB? Inhibitory control is one factor that has been linked with obesity (Guerrieri, Nederkoorn, & Jansen, 2008) and deserves experimental investigation.

**Clinical implications**

The studies reviewed provide evidence for the enhanced reactivity of external eaters to food cues. Thus, the significant roles that EE and AB to food cues play in maladaptive eating behaviour continue to highlight the importance of externality theory in this field (Schachter, 1968; Schachter & Rodin, 1974). When considering a client struggling with overeating it could potentially be useful to use the DEBQ and, if possible, a behavioural measure of AB for food cues. If the client scored highly on both measures, the clinical psychologist would be able to incorporate this information into their formulation and help the client understand the processes involved in their OEB.

Following externality theory and incentive-sensitisation theory, strategies originating from behaviour theory would appear to be particularly relevant. Cue-exposure with response prevention (Jansen, 1998) has been adapted to treat compulsive binge eaters for example. This approach emphasises the role that cue reactivity and classical conditioning play and involves the repeated presentation of FRS but with the response of eating behaviour being prohibited. In this way, it is hoped that the classical conditioning and resultant cue reactivity that paired the eating behaviour and the FRS, will be broken. In addition, reducing the availability of binge foods would be a form of stimulus control and another intervention example derived from behavioural and externality theories (Davis & Carter, 2009). The guidelines from the National Institute for Health and Clinical Excellence (NICE) for difficulties such as obesity also highlight behavioural interventions as part of effective treatment (2006). Lastly, the DEBQ and AB measure could also be useful in post-treatment evaluation.

Franken’s (2003) work in substance abuse AB also offers ideas on enhancing assessment and treatment for maladaptive eating. Concerning assessment, in the same way that AB for alcohol-related stimuli has been shown to predict drop-out
from alcohol treatment programmes and relapse (Cox, Hogan, Kristian, & Race, 2002), AB for FRS for people with maladaptive eating behaviours may be able to predict relapse from similar treatment programmes. With regard to treatment, AB modification has shown some promise in the treatment of alcoholism (Schoenmakers et al., 2010) and may be effective for OEB.

Recent research into the use of mindfulness (Segal, Williams, & Teasdale, 2002) is potentially applicable in OEB-related treatment. Levels of mindfulness skills were shown to be inversely related to AB for alcohol in adults recovering from alcohol dependency (Garland, Boettiger, Gaylord, Chanon, & Howard, 2012). Similarly, the application of mindfulness in this context makes intuitive sense in two ways. Firstly, mindfulness increases non-judgemental observing in any environment. If used effectively, mindfulness skills could potentially help individuals with high trait EE / an AB for food. The principles fit well with the model adapted from Franken (2003). Through greater cognitive control, as a result of mindfulness training, individuals would be able to mitigate the increase in food related cognitions and reallocate their attention, as is often standard in many mindfulness exercises. Through practice and repeated application, the person would be able to live more easily in an environment where there were many external food cues, without the previously associated episodes of OEB. Secondly, Schachter’s (1968; Schachter & Rodin, 1974) externality theory not only placed emphasis on hypersensitivity to external food cues being a factor in OEB, but also the under-appreciation of internal signals of satiety. Mindfulness exercises like the body scan encourage people to attend more to the physiological signals they experience. Many of these same signals are instrumental in understanding levels of hunger and telling people when to stop appetitive behaviours. With this sound theoretical base it is not surprising that an initial study found that mindfulness training reduced levels of craving, emotional eating and external eating in an eight week programme (Alberts, Thewissen, & Raes, 2012).

**Recommendations for future research**

Despite the importance of eating styles such as EE and AB for food in maladaptive eating behaviours, there are currently no studies that have examined these variables in individuals with BED. Given its imminent categorisation as a distinct disorder in the forthcoming DSM-V (APA, 2010), it is particularly apt to suggest further research into these factors for individuals with this specific disorder.
It would be useful to examine links between AB and EE in people that have lost weight and successfully maintained the loss, or in people who are, for example, successfully managing BED. According to incentive-sensitisation theory (Robinson & Berridge, 1993), incentive salience is attributed to cues associated with a rewarding behaviour. For appetitive behaviours, AB for FRS is therefore hypothesised to be an index of this attribution process. It would therefore be useful to examine whether this incentive-salience remains for FRS even after sustained weight loss / successful management of OEB, or whether the changes that occurred in the dopaminergic system continue to adapt.

Nijs and colleagues’ study (2009) provides a good template for future research. They attempted to control for confounding variables, e.g. hunger, and utilised a between-groups study design, with group cut-offs at further ends of the EE scale. Brignell and colleagues’ (Brignell, et al., 2009) use of a combination of different methodologies is an efficient and effective way of maximising data collection from a sample. In addition, there is a strong theoretical and evidence base that use of pictorial stimuli is advantageous compared to words (De Houwer & Hermans, 1994; Glaser & Glaser, 1989). Use of more novel methodologies and experimental designs would be welcomed, combined with measures of other important factors, e.g. inhibitory control.
**Conclusion**

This review has shown there is a positive relationship between EE and AB for food cues. Findings have been linked with relevant theories of incentive-sensitisation and externality, as well as an AB model, modified for OEB. It has also considered the empirical evidence from a range of methodologies, showing the relationship between these two factors. Trait EE is a factor potentially relevant to a variety of eating-associated medical conditions and psychological disorders, such as obesity and BED. Findings of this review point to behavioural (e.g. stimulus control and cue-exposure with response prevention), and cognitive strategies (e.g. Mindfulness) to help with OEB. The emphasis this review has placed on the role of externality theory is significant. It is however with a view, not only on its clinical relevance but also on the socio-cultural changes that have developed in recent decades. The external food cues of today are not the same as they were before the advent of powerful IT technologies and sophisticated multi-million dollar advertising campaigns. Coupled with prevalent, high-caloric food, it is clear that further research will be needed to help support clients and services.
Empirical Paper

What is the relationship between self-reported external eating and attentional bias for visual food cues?: An Antisaccade methodology

9,643 words

Introduction

Worldwide, more than 2.8 million people die every year through being overweight or obese and figures show that global rates of obesity almost doubled between 1980 and 2008. The consequent effects of this have been immense, both for individuals and families affected, as well as for health services trying to cope with the myriad of obesity-associated problems, such as coronary heart disease and type II diabetes (World Health Organization, 2010). Numerous issues are associated with a rise in food consumption and the obesity epidemic, such as high-calorie foods being increasingly accessible and socially convenient, as well as a fall in levels of exercise (Harris, et al., 2009). Also of concern is the almost 2% lifetime prevalence rate of binge eating disorder (BED), another problem associated with overeating behaviour (OEB) (Kessler, et al., 2013).

Psychological research has examined multiple factors when attempting to understand what might be contributing to the cognitive-behavioural and motivational factors involved in OEB. Two key areas that have received attention have been individual differences in eating behaviour (also known as trait eating styles) and differences in the cognitive processing of food-related stimuli (FRS). Eating style indices on the one hand have been shown to predict greater food consumption and Body Mass Index (BMI) (Braet & Van Strien, 1997; Van Strien, Herman, & Anschutz, 2012; Van Strien, et al., 2009), while attentional bias indices allow examination of differences in responsivity to the reward associated with appetitive stimuli (Hou, et al., 2011). Not only are these areas important for helping people with OEB, implications from them may also aid a more anticipatory approach and earlier assessment for people at potential risk of developing maladaptive eating
behaviours. Increasingly, this preventative approach is what is being called for from clinical psychologists (Ogden, 2010).

Numerous theories that attempt to explain OEB and obesity have been conceptualised. Externality theory posits hypersensitivity to external food cues results in behavioural responses to overeat (Schachter, 1968; Schachter & Rodin, 1974). Noting the advent of readily available high-calorie foods and drinks, and an international, multi-billion dollar advertising industry keen to take advantage of new information technologies to disseminate food cues, the implications from externality theory take on particular significance today.

Other researchers have looked to the addiction literature to understand OEB (e.g. Joranby, Pineda, & Gold, 2005; Volkow & Wise, 2005). They argue that OEB, and particularly BED, share many characteristics with more commonly known addictions, such as substance misuse. Examples include the difficulties with withdrawal, craving and the sense of loss of control (Davis & Carter, 2009). In addition, as Berridge has argued (2007), activation of the dopaminergic system is integral with reward-driven behaviours, or ‘wanting’, and that this is a neurobiological parallel between food-related addictive behaviour and other addictions (Berridge, 2007; Davis & Carter, 2009). Davis and Carter have equally acknowledged that OEB is similar to other addictions (e.g. gambling), where part of the reward is the activity itself (rather than the biological function of the food or addictive drug acting on the dopaminergic system) (2009). Also originating from the addiction field, incentive-sensitisation theory explains what is hypothesised to occur in terms of neurocognitive processes (Berridge & Robinson, 1998; Robinson & Berridge, 1993). This posits that there are three stages involved in the psychological attainment of an original reward. When the unconditioned reward is first experienced, it becomes ‘liked’, representing the start of the reward-making system and initiating subsequent phases. After repeated occurrences of the unconditioned reward, stimuli associated with it become linked with its memory trace and so become able to predict recurrence of the reward. Lastly, these conditioned stimuli associated with the initial reward have salience attributed to them by the activated dopaminergic system and so in themselves become ‘wanted’ and able to motivate directed behaviour (Berridge & Robinson, 1998). With this process in mind, its application to appetitive stimuli is intuitive, not least because of the ease with which
appetitive and food-related stimuli are able to take advantage of all five human senses (e.g. the smell, sight and sound of cooking).

A common feature amongst psychological theories attempting to explain OEB is that personality traits are heavily implicated in its occurrence and maintenance (Davis & Carter, 2009; Van Strien, et al., 1986; Van Strien, et al., 2012). Considering trait sensitivity to external food cues specifically, one study showed this was the key moderator of the link between quantity of snack food eaten and environmental stressors (so those with greater sensitivity to external food cues ate more when stressed) (Conner, et al., 1999). Such external sensitivity was also shown to predict eating prompted by food commercials in a naturalistic setting (Van Strien, et al., 2012). In a study of adult women (aged 18-35 years), obese participants had significantly higher EE scores than those in the normal-weight group (Castellanos, et al., 2009). A significant positive relationship has also been found in a sample of college students between trait sensitivity to external food cues and Night Eating Syndrome (a syndrome which may be elevated in diagnostic significance in the imminent DSM-V and one that is characterised by prolonged binge eating at night) (Nolan & Geliebter, 2012). However, it should be noted that the original hypothesis formulated by Schachter and Rodin (1974), that overweight individuals are more likely to respond to external food cues, is not quite as clear as it would intuitively seem. A range of studies have found varying results with regards to an association between sensitivity to external food cues and BMI, as some have found a significant positive relationship (e.g. Jasinska, et al., 2012; Rodin & Slochower, 1976) and some have found no relationship(Koenders & Van Strien, 2011; Pothos, Tapper, et al., 2009). Regardless, sensitivity to external food cues is clearly a characteristic worthy of further investigation.

The role of impulsivity and inhibitory control in OEB has also received attention in the literature. Research has shown that obese women and children show poorer inhibitory control compared to non-obese controls on a basic behavioural response task (Nederkoorn, Braet, Van Eijs, Tanghe, & Jansen, 2006; Nederkoorn, Smulders, Havermans, Roefs, & Jansen, 2006). Similarly, in a sample of obese children, performance on the same task showed greater impulsivity was positively associated with BMI. Impulsivity also predicted weight loss whereby those with lower scores lost more weight in the following 12 months (Nederkoorn, Jansen, Mulkens, & Jansen, 2006). In a sample of obese clients, individuals with BED were
found to be more impulsive than those without (Galanti, Gluck, & Geliebter, 2007). It has therefore been hypothesised that inhibitory control is also implicated in the development and maintenance of OEB.

Relating to eating styles, undergraduate females who were attempting to restrict the amount of food they ate showed deficits in inhibitory control (Nederkoorn, Van Eijs, & Jansen, 2004). Lastly, a recent study of male and female undergraduates showed that greater self-reported impulsivity was positively associated with self-reported tendency to eat in response to external food cues (Jasinska, et al., 2012). Evidence relating to eating styles using a behavioural inhibitory control task would therefore be useful to see if it was consistent with evidence involving self-report measures.

Stimuli associated with addictive substances can produce physiological, behavioural and emotional reactions in people with a history of their use. This occurs through standard conditioning processes and the study of this cue reactivity has led to the ability to identify and measure attentional bias (AB) for reward-related stimuli (Giel, Teufel, et al., 2011). AB for such stimuli has been examined in a range of maladaptive and addictive behaviours, for example with smoking (Drobes, et al., 2006; Oliver & Drobes, 2012), with substance abuse (Field, et al., 2009) and with alcohol (e.g. Sinclair, Nausheen, Garner, & Baldwin, 2010; Weafer & Fillmore, 2013). Such research is valuable because it allows greater understanding of the perceptual processes involved and assists in both the assessment and treatment of such maladaptive behaviours (e.g. Schoenmakers, et al., 2010). There is also now clear evidence for AB to FRS in clinical samples of patients with eating disorders (e.g. Faunce, 2002; Giel, Teufel, et al., 2011; Lee & Shafran, 2004, 2008). AB to reward-related stimuli is therefore hypothesised to be involved at least in the maintenance of such addictions and disorders.

In relation to OEB, research has shown that in an experimentally-manipulated state of satiety, obese individuals show greater gaze duration towards FRS than normal-weight individuals (Castellanos, et al., 2009). In other research, overweight individuals’ initial eye movements occurred significantly more often towards FRS than did those of normal-weight individuals (Werthmann, et al., 2011). Once again, the addiction literature is useful in providing models that highlight the role of AB, and can potentially be applied to OEB. Franken’s model of AB and drug use relapse is one such example. He highlights the cyclical relationship between AB,
enhanced signalling of drug cues, perception of drug related stimuli and increased dopaminergic activity, and their effect on drug use (Franken, 2003, p. 572).

When attempting to measure eating styles, a range of potential tools are available to the researcher. The main self-report eating style questionnaires currently used are the Restraint Scale (RS; Herman & Polivy, 1980), the Three Factor Eating Questionnaire (TFEQ; Stunkard & Messick, 1985) and the Dutch Eating Behaviour Questionnaire (DEBQ; Van Strien, et al., 1986). The RS measures only restraint (restricted eating) whilst the TFEQ measures cognitive restraint, disinhibition and hunger and the DEBQ examines constructs of restrained, emotional and external eating (EE). Naturally, constructs similarly-named between them vary due to variance in the statements used in their method of assessment and in conceptualisation of their definition. This provides a challenge when comparing or conducting research relating to eating behaviours and views about food. For example, the RS has come under criticism due to its measure of restraint not being sensitive enough and confounding restraint with overeating (or disinhibition) (e.g. Forestell, et al., 2012; Tapper, et al., 2008). The DEBQ and TFEQ suffer less from this, examining food restriction more specifically (Ogden, 2010). A literature search and review of studies examining the relationship between AB for food cues and various trait eating styles, revealed that out of 42 studies, 20 used the DEBQ, 20 used the RS and 5 used the TFEQ (a few studies used more than one measure).

While most of this research has examined the restrained eating style, over the last ten years there has been a slow but steady growth of studies more informed by the importance of externality theory. These studies have used the EE subscale of the DEBQ which measures individual differences in trait sensitivity to external food cues (e.g. higher scores on the subscale indicate a greater likelihood of eating in response to seeing food or a food advert) (Van Strien, et al., 1986). Recognising that people with obesity and eating disorders often show an AB for food cues, and that eating style traits such as EE, have been linked with maladaptive eating patterns, it seems instructive to examine food-related AB in people with high and low levels of trait EE.

Using a range of different methodologies and experimental conditions, recent experimental research has provided evidence that high external eaters are more prone to show an AB to FRS. For example, significant results of this kind have been found in samples of both normal and overweight / obese participants using the visual probe
(Castellanos, et al., 2009; Hepworth, et al., 2010; Hou, et al., 2011; Nathan, et al., 2012), and in brain imaging and electroencephalography (EEG) studies (Nijs, et al., 2009; Nijs, Muris, et al., 2010; Passamonti, et al., 2009). As well as examining the influence of visual cues, brain imaging research has shown that in response to food aromas, activation of brain areas understood to signal levels of reward (the prefrontal cortex) positively correlated with trait EE (Eiler, et al., 2012). This was in the absence of state hunger and for a sample of both normal-weight and obese participants. Those high in EE have also been shown to judge FRS more favourably and have a greater tendency to approach rather than avoid FRS compared to those low in EE (Brignell, et al., 2009). However, the research has not been unanimous, with one dot probe study finding that low external eaters were significantly more likely to show an AB to FRS than high external eaters (Johansson, et al., 2004). In addition, other studies have found no significant relationship between bias scores and levels of EE (Nijs, Muris, et al., 2010; Tapper, et al., 2010). More research into individual differences in responsiveness of the reward mechanism to appetitive stimuli is therefore needed.

While one study has incorporated an eye-tracking paradigm previously (Castellanos, et al., 2009), the antisaccade task (AST; Hallett, 1978) has not yet been utilised in this field as a measure of AB. In the AST, subjects are asked to inhibit their natural response to look towards a stimulus, and instead look in the opposite direction (antisaccade) as rapidly as possible. Greater error rates and longer latencies on antisaccade trials would therefore indicate an AB to the target stimuli. The AST has been used as a research tool examining cognitive control in a wide range of psychiatric disorders. Part of the significance of the task is that it is a measure of volitional control over a reflexive behaviour (Hutton & Ettinger, 2006).

Although much research involving the AST has used neutral stimuli (e.g. crosses, arrows and squares), some studies have utilised semantic-rich pictures. For example, the AST was used to examine attentional bias and attentional control theory in socially anxious individuals, using pictures of people with different facial expressions (Wieser, Pauli, & Mühlberger, 2009). Antisaccade performance for pictures of fearful facial expressions was worse for all participants compared with non-fearful faces. Therefore, in a task requiring volitional inhibition of a reflexive response, variations in the stimulus’ nature affected the manner in which it was attended to. The AST therefore provides a novel methodology to further understand
AB to appetitive stimuli and also to explore the part that inhibitory control plays in responses to such cues.

The Stop-Signal Task (SST; Lappin & Eriksen, 1966; Vince, 1948) is a test of inhibitory control where participants are asked to make a choice between two options as quickly as possible. However, on randomly selected trials, an auditory stimulus signals the participant to inhibit their selection in the initial task. As the latency between the initial choice task and the auditory signal becomes longer, the likelihood of successfully responding to the auditory stop-signal becomes greater (Verbruggen, Logan, & Stevens, 2008). This process was hypothesised to be explained by the horse-race model (Logan & Cowan, 1984). In this, two competing cognitive-behavioural processes are said to be taking place: one responding to the initial task and one responding to the stop-signal. If the latter is completed first, then the response is inhibited. If the former finishes first, the response to the initial task is made (Logan & Cowan, 1984). The task therefore yields an average stop-signal response time (SSRT), i.e. an estimate of the amount of time needed to successfully inhibit a response. Larger SSRTs are therefore indicative of poorer inhibitory control (Nederkoorn, et al., 2004). The SST has already been shown to be a useful tool in examining inhibitory control in samples of people with disordered / unhealthy eating habits (e.g. Nederkoorn, Jansen, et al., 2006; Nederkoorn, et al., 2004).

Numerous questions lead from the above literature. Is EE linked to poor cognitive control, as indexed by measures of inhibitory control from such tools as the AST and SST? Is it more difficult to inhibit reflexive eye movements towards appetitive stimuli compared to neutral stimuli and is this process influenced by differences in trait eating styles, such as EE? Would a modified antisaccade task be useful in examining this?

Using the same methodology as Garner et al. (2011), the present study therefore used the AST to examine inhibitory control and AB for visual food / non-food cues, for people in a non-clinical population with high and low trait levels of external eating as assessed by the DEBQ.

The key hypotheses being examined were therefore, (1) high external eaters would have poorer inhibitory control, i.e. (i) antisaccade performance (antisaccade error rate, antisaccade latency) would be poorer for the high EE group than the low EE group for both food and neutral stimuli, and (ii) levels of EE and SSRTs would be related such that, participants with higher levels of external eating would have
slower SSRTs on the SST than those with lower levels of external eating. (2) High external eaters’ poorer inhibitory control will be particularly apparent for food stimuli as indexed by poorer antisaccade performance (antisaccade error rate, antisaccade latency) compared to low external eaters (this might be evidenced by a three-way interaction). (3) AB for food cues will positively correlate with level of EE. (4) AB for food cues will positively correlate with levels of state hunger. (5) Food stimuli will be rated as more pleasant by the high EE group compared with the low EE group.
Method

Participants

The study sample was made up of 73 participants (55 females, 18 males) with a mean age of 22.77 years. They were recruited from the University of Southampton through the use of poster advertising (Appendix 4) and the psychology undergraduate participant pool system. Participants were identified through an online eligibility questionnaire that included the DEBQ-EE subscale and demographic questions (Appendix 5). Those meeting criteria were invited to the experimental session. As a result, normal-weight and overweight participants were both obtained. Consistent with Brignell et al. (2009), selection criteria required participants to be between 18 and 60 years old and to not have any special dietary needs that would conflict with any of the foods used in the study. This was done to increase homogeneity in the sample and because some participants’ responses might be uncharacteristic and therefore have a confounding effect, for example, a vegan’s response to a picture of quiche.

Using their scores on the DEBQ-EE subscale, participants were assigned to either the low or high external eating group. Consistent with the approach used in other studies (Nijs, et al., 2009; Van Strien, et al., 2012) and to ensure clear between-group division, cut off scores for the low and high EE group were \( \leq 2.70 \) and \( \geq 3.50 \) respectively. 28 participants’ data were not used due to their EE subscale scores for the full DEBQ not falling within the inclusion criteria. In addition, data from 6 participants were removed due to scoring 10 or more on the depression subscale of the Hospital Anxiety and Depression Scale (HADS; in the moderate or above range). These participants were sensitively advised to discuss any concerns they had about how they were feeling with their General Practitioner (GP). Their data were also not included in subsequent analyses. Electro-oculography (EOG) data for 39 participants was therefore prepared for scoring and analysis, 11 in the low-EE group (with EE scores ranging from 1.70 to 2.70) and 28 from the high-EE group (with EE scores ranging from 3.5 to 4.7 in their EE scores).

Ethics

This research received approval from the School of Psychology Ethics Committee and the University of Southampton Research Governance office (Appendix 6). Participants were taken from a non-clinical population and National Health Service services/staff were not involved, therefore National Research Ethics
Service committee approval was not applied for. Each participant gave written consent after reading the participant information sheet (See Appendices 7 and 8).

**Design**

The study utilised a mixed factorial design to examine the primary hypothesis that higher levels of EE would result in greater AB for food cues. AB measures from the AST were entered into analysis of variance (ANOVA), using level of EE (low vs. high) as the primary between-groups independent variable (IV). In the AST and pleasantness rating task (PRT), stimulus type (food vs. neutral) was used as a within-subjects IV. The AST also had trial instruction (towards/prosaccade vs. away/antisaccade) as a second within-subjects IV. All participants completed the set of tasks and measures in the same order. On the three computer-based tasks, trials / presentation of stimuli were randomised.

The primary dependent variables (DV) in the AST were saccade error rate (number of initial eye movements made that were opposite to that instructed) and eye movement latency. Correlational analyses were also used to assess relationships between measures of AB and other continuous variables.

See Appendix 9 for power calculation.

**Equipment and stimuli**

The pictorial stimuli used in the AST comprised 8 colour photographs of food and 8 colour photographs of non-food items. These were match-paired by size and content (e.g. number, general colour, approximate brightness, shape and size) as much as possible so that each food item corresponded with each non-food item. Examples of pairings included: a bar of chocolate and a paperback book; a donut and a roll of sellotape (see Appendix 10 for examples of the match-paired stimuli). In addition, each stimuli photograph was edited so that the backgrounds used were identical to the rest of the computer screen during each trial. This was done so that participants’ responses were as a result of the stimuli themselves and not in reaction to the edge of the photograph image (particularly important in the AST). These stimuli were used in the AST and the pleasantness rating task. Two additional pictures (one food and one non-food) were used in practice trials in the PRT. During the practice trials of the AST, a yellow rectangle was used as the onscreen stimulus. EOG electrodes were used during the AST to measure the participants’ eye movements. The AST, Stop-task and PRT were run on a Windows Pentium IV desktop computer with a 15 inch screen. Following the same procedure as Garner et
al. (2011), EOG was used to measure horizontal eye movements in the AST, using a sampling rate of 1000 Hz. An MP150-amplifier and AcqKnowledge-3.8.2 computer software (from Biopac-Systems, Goleta, CA) were used for this and stimuli were presented using Inquisit 2 software. Stimuli for the PRT were presented using Presentation version 14.2 software (Neurobehavioral Systems, Albany CA). In the SST, stereo headphones and version 0.8 of the software task described in Verbruggen et al. (2008) was used (available online from Millisecond Software-LLC, Seattle, W.A). Participants made their responses using a standard keyboard. A set of weighing scales and a tape measure were used for the BMI measurements.

**Procedures**

When invited to the experimental session, participants were asked to abstain from eating anything for two hours before arriving. Upon arrival, participants were provided with the information sheet (Appendix 8) and gave written consent to take part in the study (Appendix 7). They then completed the measures and tasks as per Appendix 11, which provides a diagrammatic illustration of the procedural order for the study. The majority of the questionnaires (DEBQ, HADS and Eating Attitudes Test-26 [EAT-26]) were completed between the pleasantness rating task and the stop-signal task to provide a rest for participants and aid focus in the concentration-intensive computer tasks.

**Self-report measures.**

**Dutch Eating Behaviour Questionnaire (DEBQ).**

The DEBQ (Van Strien, et al., 1986) is a widely used standardised self-report measure that examines different eating behaviour styles. It comprises 33 items and responses are given from a 5-point Likert ranging from one (never) to five (very often). The DEBQ has three scales: external eating (10 items), emotional eating (13 items) and restrained eating (10 items). It has been shown to have good reliability (Cronbach’s Alpha coefficients of at least .80), and good concurrent and discriminative validity (Van Strien, et al., 1986). Recent research has provided further support for its predictive validity (Van Strien, et al., 2012).

**Grand Hunger Scale.**

The Grand Hunger Scale (Grand, 1968) is a measure of state hunger. It is a self-report measure that asks subjects to rate their current level of hunger using a 7-point Likert scale and estimate how much of their favourite food they could eat right
now using a 6-point Likert scale. It also asks subjects to estimate when they last ate a meal and when they expect to eat their next meal (to the nearest 15 minutes).

**Hospital Anxiety and Depression Scale (HADS).**

The HADS is a 14-item self-report measure that assesses anxiety and depression in populations of general medical out-patients (Zigmond & Snaith, 1983). It is legitimate to be used with clients living in the community despite the ‘hospital’ reference in its name (Milne, 1992) and was specifically chosen for this study because none of the questions relate to eating or appetite. There are seven items each for depression and anxiety subscales. A four-point scale is used for all items (0-3), with higher scores indicating greater symptom severity. The maximum score for each subscale is 21. As a measure of internal consistency, the HADS has been shown to have significant associations on item-subscale correlations. Concurrent validity also showed significant correlations (Zigmond & Snaith, 1983).

**Experimental tasks.**

**Antisaccade Task (AST).**

The design used by Garner et al. (2011) was utilised for the AST. Eight neutral and eight food stimuli were used. Each participant was prepared for two skin-surface electrodes which were placed on their temples and connected to the bio-pack amplifier. Participants sat in front of a computer screen and used the keyboard in front of them to respond to the task. For each trial, the word ‘TOWARDS’ or ‘AWAY’, appeared at the centre of the screen for 2000ms. This instructed the participant to either prosaccade and look towards the stimuli when it appeared, or antisaccade and look away in the opposite direction. At word offset, the screen was then blank for 200ms. The picture stimulus was then displayed for 600ms, either 6° to the left or right from the word instruction. Participants were asked to respond as quickly as possible by moving their eyes and to keep their heads as still as possible. At the end of each trial, participants were asked to identify the direction (either up or down) of an arrow that appeared 50ms after stimulus offset. On 50% of trials for each trial type, picture-arrow position was congruent. The function of this was to encourage concentration in the task (data relating to the arrow was not analysed). Intertrial intervals ranged from 750ms to 1250ms (mean interval of 1000ms). Each picture stimulus was used in eight trials which were balanced throughout conditions resulting in 128 randomised experimental trials for each participant. Participants also had sixteen practice trials at the beginning of the experiment, whereby they were
asked to saccade towards and away from a yellow rectangle presented in the same way described above (Garner, et al., 2011). See Appendix 12 for two example screen shots of the task.

**Pleasantness rating task (PRT).**

Following a similar approach as Brignell et al. (2009), participants were asked to rate how pleasant they found each of the pictures used in the antisaccade task. Ratings were made on a Likert scale which ranged from very unpleasant (-4) to very pleasant (+4). The pictures were displayed on the computer screen at central fixation for 2000ms. After a delay of 500ms following picture offset, the nine-point anchored rating scale was presented on the screen until the participant made a response using the keyboard. The order of trials on the PRT was uniquely randomized for each participant.

**Stop-Signal Task (SST).**

Following the design described by Verbruggen et al. (2008), the SST began with a 32-trial practice/training stage. The experimental stage was made up of three blocks, each containing 64 trials. In each trial, a fixation circle was displayed in the centre of the screen for 250ms before an arrow then appeared in the centre of the circle. The direction of the arrow instructed the participant to press either the ‘D’ key (for left), or the ‘K’ key (for right). Participants were asked to respond as soon as they could, following the appearance of the arrow. On 75% of trials, only the primary task stimulus (the arrow) was displayed for the no-signal condition. For the remaining 25% of trials, an auditory stop-signal was played after the presentation of the arrow, indicating that the participant should inhibit their response and not press any button. The next task then started after the standard inter-stimulus interval (ISI = 2000ms). On trials involving a stop-signal (the auditory signal to inhibit response), the latency of the stop-signal delay (SSD, the time between the arrow and signal) started at 250ms and changed continuously with a ‘staircase’ tracking protocol. Therefore, SSD increased by 50ms following successful response inhibition and decreased by 50ms following unsuccessful response inhibition. Participants had 10 seconds in between blocks of trials, during which time, they got feedback about their performance in the previous block. Stop-signal reaction times (SSRTs) were calculated by subtracting the mean SSD from the mean total response time for all no-signal trials. SSRTs were therefore recorded for each participant as a measure of inhibitory control (Verbruggen, et al., 2008).
Body Mass Index (BMI).

At the end of the experimental session, participants’ height (in centimetres) and weight (in kilograms) were measured for the BMI calculation (kg/m²).

Participants were then thanked, given the debrief information sheet (Appendix 13) and offered the opportunity to ask any questions they had about the study.

Data preparation

Data for the 39 eligible participants were prepared for analyses by using the Statistical Package for the Social Sciences (version 21). Practice trial data for the AST and SST were discarded.²

Eye-movement data.

Following the same process used by Garner et al. (Garner, et al., 2011), AcqKnowledge 4.1 computer software was used to manually score saccade latency and horizontal direction. Scoring was carried out blind to EE group, stimulus type and trial instruction. Eye movements that did not end in the position or mirror position of the stimuli location (those that subtended a distance smaller than 6 degrees) were excluded from further analyses and accounted for 1.4% of data. Eye movements identified as anticipatory (occurring within 100ms of stimuli onset) were also excluded and represented 2.4% of the data (Garner, et al., 2011). The amount of data excluded was equivalent in all conditions.

The data were checked for outliers and none were identified. Two participants’ data did not satisfy criteria for quantifiable eye movements when processed through the various criteria and so could not be used. One participant was excluded due to their results indicating they looked right for each trial throughout regardless of each presentation.

In the AST, mean saccade latencies on correct trials were measured for each of the four conditions: prosaccade-food, prosaccade-control, antisaccade-food, antisaccade-control. Shorter latencies for prosaccades represented a faster processing of such stimuli and therefore an AB specific to the stimulus type in the condition. Longer latencies for antisaccades represented a greater amount of time

² Practice trial data from the AST were included in the inter-rater reliability analyses to increase the number of trials used and due to the greater likelihood of increased variance in the scoring of the files between experimenters. It was assumed that more errors would be made on these trials due to participants familiarising themselves with the task (therefore making them harder to correctly uniformly score).
needed to look away from the stimuli, therefore indicating an AB towards the stimulus type in that condition. Similarly, saccade error rate scores were calculated for each of the four conditions. These could then be used to examine AB for each participant. AB difference scores were calculated for latency data by subtracting latency for antisaccade-control trials from latency for antisaccade-food trials. AB difference scores were calculated for error data by subtracting the proportion of antisaccade-control errors from the proportion of antisaccade-food errors. Thus, this created two overall measures of AB, with positive scores representing AB for FRS relative to non-FRS.

A third year undergraduate psychology student also assisted in testing some of the participants in this research. Both experimenters followed the same protocol for each part of the experiment. Additional steps were undertaken to ensure there was uniformity between experimenters, both in experimental practice and in the processing of EOG data. Regarding EOG processing, inter-rater reliability was analysed using five participants’ EOG data that both experimenters had scored. Pearson’s correlations were calculated using indices that determined which eye movements were selected in the manualised part of the EOG processing (the times at which the maximum and minimum voltage values were measured). Correlations between experimenters for these five participants / ten values ranged from, \( r = .94, p < .01 \), to, \( r = 1.00, p < .01 \).

**Pleasantness rating task**

Separate mean pleasantness ratings were calculated for each participant for food and control pictures. Explicit preference scores were also calculated by subtracting control preference from food preference. Thus, positive scores represented a preference for food in comparison to control pictures.
Results

Group characteristics

Descriptive statistics for questionnaire measures and demographic details for both external eating groups are shown in Table 1. Separate univariate analysis of variance (ANOVA) were used to assess group differences, using external eating group (low vs. high) as the between-groups independent variable (IV). There was a significant main effect of external eating group on a range of measures. The high external eating group had significantly higher levels than the low external eating group for external eating, $F(1,36) = 218.16, p < .01$ (see Appendix 14 for box plots illustrating the EE groups). In addition, the high external eating group also had higher levels of quantity of favourite food that could be eaten, $F(1,36) = 8.73, p < .05$, and levels of emotional eating, $F(1, 36) = 9.50, p < .01$. Lastly, the high external eating group had an almost significantly greater level of state hunger than the low external eating group, $F(1,36) = 3.82, p < .06$. No other significant results were found, $p > .05$. Fisher's Exact Test was used to assess gender balance between EE groups and it was found that they did not differ significantly, $p > .05$. 
Table 1: Descriptive characteristics of External Eating groups

<table>
<thead>
<tr>
<th></th>
<th>Low-external eating</th>
<th>High-external eating</th>
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<tbody>
<tr>
<td></td>
<td>M</td>
<td>S.D.</td>
</tr>
<tr>
<td>DEBQ - External eating</td>
<td>2.39</td>
<td>0.30</td>
</tr>
<tr>
<td>DEBQ - Emotional eating</td>
<td>2.05</td>
<td>0.79</td>
</tr>
<tr>
<td>DEBQ - Restrained eating</td>
<td>2.55</td>
<td>0.75</td>
</tr>
<tr>
<td>Minutes since last eating</td>
<td>395.45</td>
<td>262.42</td>
</tr>
<tr>
<td>State hunger (1-7)</td>
<td>3.45</td>
<td>1.04</td>
</tr>
<tr>
<td>Quantity of favourite food that could be eaten now (1-7)</td>
<td>3.82</td>
<td>0.98</td>
</tr>
<tr>
<td>Minutes until next meal</td>
<td>152.73</td>
<td>107.92</td>
</tr>
<tr>
<td>HADS - Depression subscale</td>
<td>2.27</td>
<td>2.00</td>
</tr>
<tr>
<td>HADS - Anxiety subscale</td>
<td>6.73</td>
<td>3.17</td>
</tr>
<tr>
<td>EAT-26 Total</td>
<td>7.00</td>
<td>4.60</td>
</tr>
<tr>
<td>BMI</td>
<td>23.33</td>
<td>4.65</td>
</tr>
<tr>
<td>Age</td>
<td>24.73</td>
<td>9.69</td>
</tr>
<tr>
<td>Gender (M:F)</td>
<td>(1:10)</td>
<td></td>
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<tr>
<td>N</td>
<td>11</td>
<td></td>
</tr>
</tbody>
</table>

Note: DEBQ – Dutch Eating Behaviour Questionnaire; HADS – Hospital Anxiety and Depression Scale; EAT-26 – Eating Attitudes Test-26; BMI – Body Mass Index.

Eye movement task data

Eye movement error scores and correct-trial eye movement latencies were entered into two separate 2 x 2 x 2 factorial ANOVA. Picture type (food vs. control) and instruction (prosaccade vs. antisaccade) were entered as within-subjects IVs, and external eating group (low vs. high) was entered as a between-subjects variable.

Levene’s tests for error and latency data were not significant, therefore indicating the assumption of homogeneity of variance was met for these data, $p > .05$.  

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Eye movement errors.

Results showed a significant three-way interaction between picture type x instruction x external eating group $F(1,36) = 4.58, p < .05, \eta^2_p = .11$. Thus, the type of picture did not make a difference to how easy participants overall found the task, whether looking towards or away from the picture. However, the identified effect shows that when level of EE was taken into account, an interaction occurred. Specifically, in the AST, the high EE participants made more errors for food pictures compared to control pictures, while the low EE participants made less errors for food pictures compared to control pictures (see Figures 3a and 3b). There was also a significant main effect of instruction type on error rate, $F(1,36) = 69.48, p < .01, \eta^2_p = .66$. This indicates that, as expected, more errors were made on antisaccade trials compared to prosaccade trials. There were no other significant results.

![Figure 3a. Eye movement error rates and standard errors for low external eaters by picture and instruction type.](image-url)
In order to understand what was driving the three-way interaction, t-tests were conducted post-hoc to assess the effect of stimuli type on the number of antisaccade and prosaccade errors in each EE group. On average, low EE participants made fewer antisaccade errors for food stimuli ($M = 0.381$, $SE = 0.069$) than control stimuli ($M = 0.432$, $SE = 0.067$). This difference was significant $t(10) = -2.32$, $p = .042$; and represented a large effect size $r = .59$. High EE participants made, on average, more antisaccade errors for food stimuli ($M = 0.407$, $SE = 0.043$) than control stimuli ($M = 0.389$, $SE = 0.041$). This difference was not significant $t(26) = 0.87$, $p > .05$, $r = .17$. On average, low EE participants made more prosaccade errors for food stimuli ($M = 0.077$, $SE = 0.020$) than control stimuli ($M = 0.065$, $SE = 0.021$). This difference was not significant $t(10) = 0.54$, $p > .05$, $r = 0.17$. High EE participants made, on average, fewer prosaccade errors for food stimuli ($M = 0.072$, $SE = 0.017$) than for control stimuli ($M = 0.076$, $SE = 0.016$). This difference was not significant $t(26) = -0.32$, $p > .05$, $r = .06$. As these calculations were post-hoc, an appropriate bonferroni corrected critical $p$ value would be $0.05/4 = 0.0125$. Therefore, none of these comparisons met this strict significance criteria level.

Figure 3b. Eye movement error rates and standard errors for high external eaters by picture and instruction type.
Eye movement latencies
Results showed a significant main effect of instruction type on latency, $F(1,34) = 96.77, p < .01, \eta^2_p = .74$. This indicates that, as expected, latencies were shorter for prosaccade than for antisaccade trials. There were no other significant main effects or interactions for eye movement latencies.

Correlations
Relationship between AB, eating styles and questionnaire variables.
Pearsons correlations were calculated between food AB scores (from both the error and latency data), eating style scores and other key questionnaire data (see Table 2). Levels of EE positively correlated with emotional eating, explicit food preference and quantity of favourite food that could be eaten ($ps < .01$), and also with state hunger ($p < .05$).

The one-tailed significant correlation between food AB (errors) and external eating score should be noted due to it being an initial hypothesis ($p < .05$). Thus, higher external eating scores were positively related to levels of AB for FRS. This is shown in Figure 4. Also of note, although EE and emotional eating correlated, emotional eating did not correlate with food AB errors.

There was also a significant positive one-tailed correlation between food AB (latency) and state hunger ($p < .05$).
Table 2. Correlations between food attentional bias measures, eating styles and questionnaire variables

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<th>10</th>
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</thead>
<tbody>
<tr>
<td>1. Food AB - errors</td>
<td>-</td>
<td>.09</td>
<td>.32†</td>
<td>.07</td>
<td>-.18</td>
<td>.30</td>
<td>-.14</td>
<td>.07</td>
<td>.16</td>
<td>.37*</td>
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<tr>
<td>2. Food AB - latency</td>
<td>-</td>
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<td>.25</td>
<td>.21</td>
<td>.18</td>
<td>.29†</td>
<td>-.07</td>
<td>.06</td>
<td></td>
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<tr>
<td>3. DEBQ-External</td>
<td>-</td>
<td>.51**</td>
<td>-.06</td>
<td>.56**</td>
<td>-.19</td>
<td>.37*</td>
<td>.46**</td>
<td>.06</td>
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<td>4. DEBQ-Emotional</td>
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<td>.11</td>
<td>.17</td>
<td>.19</td>
<td>.04</td>
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<tr>
<td>5. DEBQ-Restrained</td>
<td>-</td>
<td>.04</td>
<td>.12</td>
<td>-.07</td>
<td>-.22</td>
<td>.01</td>
<td></td>
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<tr>
<td>6. Explicit food preference</td>
<td>-</td>
<td>-.27</td>
<td>.50**</td>
<td>.56**</td>
<td>.16</td>
<td></td>
<td></td>
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<tr>
<td>7. BMI</td>
<td>-</td>
<td>-.09</td>
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<tr>
<td>8. State hunger</td>
<td>-</td>
<td>.34*</td>
<td>.15</td>
<td></td>
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<tr>
<td>9. Favourite food</td>
<td>-</td>
<td>-.02</td>
<td></td>
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<tr>
<td>10. HADS-Depression</td>
<td>-</td>
<td></td>
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Note: AB – Attentional bias; DEBQ – Dutch Eating Behaviour Questionnaire; BMI – Body Mass Index; HADS – Hospital Anxiety and Depression Scale.

All results from two-tailed tests except where stated. *p < .05, **p < .01.
† p < .05 using a one-tailed test.
Figure 4. Scatterplot from antisaccade error rate data showing relationship of attentional bias scores for food vs. control pictures with external eating scores.

Relationship between inhibitory control measures and eating styles.

Pearsons correlations were also calculated between all inhibitory control measures, AB scores and eating styles (see Table 3). Stop-signal reaction times (SSRT) positively correlated with antisaccade error rates on food trials ($p < .01$), as well as antisaccade latency on correct food trials and latency food AB scores ($ps < .05$). However, no significant correlations were found between SSRTs and antisaccade data for control pictures in two-tailed analyses ($p > .05$).
### Table 3. Correlations between inhibitory control measures, attentional bias scores and eating styles

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<tbody>
<tr>
<td>1</td>
<td>SSRT</td>
<td>-</td>
<td>.42**</td>
<td>.31</td>
<td>.26</td>
<td>.33*</td>
<td>.13</td>
<td>.37*</td>
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<td>.16</td>
</tr>
<tr>
<td>2</td>
<td>AS errors – food</td>
<td>-</td>
<td>.89**</td>
<td>.32</td>
<td>-.05</td>
<td>-.30</td>
<td>.49**</td>
<td>-.02</td>
<td>.23</td>
<td>.33*</td>
</tr>
<tr>
<td>3</td>
<td>AS errors – control</td>
<td>-</td>
<td>-.16</td>
<td>-.28</td>
<td>.50**</td>
<td>.47**</td>
<td>-.17</td>
<td>.20</td>
<td>.43**</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Food AB – errors</td>
<td>-</td>
<td>.40*</td>
<td>.33*</td>
<td>.09</td>
<td>.32*</td>
<td>.07</td>
<td>-.18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>ASCL – food</td>
<td>-</td>
<td>.87**</td>
<td>.15</td>
<td>.13</td>
<td>-.20</td>
<td>-.20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>ASCL – control</td>
<td>-</td>
<td>-.36*</td>
<td>.18</td>
<td>-.26</td>
<td>-.32</td>
<td></td>
<td></td>
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<tr>
<td>7</td>
<td>Food AB – latency</td>
<td>-</td>
<td>-.12</td>
<td>.15</td>
<td>.25</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>8</td>
<td>DEBQ – External</td>
<td>-</td>
<td>.51**</td>
<td>-.06</td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>9</td>
<td>DEBQ – Emotional</td>
<td>-</td>
<td>.19</td>
<td></td>
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</tr>
<tr>
<td>10</td>
<td>DEBQ – Restrained</td>
<td>-</td>
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</table>

Note: SSRT - Stop-signal reaction time; AS – Antisaccade; AB – Attentional bias; ASCL – Antisaccade latency for correct trials; DEBQ – Dutch Eating Behaviour Questionnaire.

All results from two-tailed tests. *p < .05, **p < .01.

### Covariate analyses of eye movement error rate data

Covariate factors were identified as those variables that significantly correlated with EE, i.e. emotional eating, state hunger and quantity of favourite food that could be eaten. The previous factorial ANOVA of eye movement errors was repeated in an analysis of covariance using these factors. Although some
significance was lost, the effect of the three-way interaction was still marginally significant, $F(1,33) = 3.34, p = .077$, $\eta^2_p = .09$.

**Picture Pleasantness ratings data**

Mean pleasantness ratings from the PRT were entered into a 2 x 2 Mixed model ANOVA, using picture type (control vs. food) as a within-subjects variable and EE group (low vs. high) as the between-subjects variable. Results showed a significant interaction effect between type of picture used and EE group, $F(1,36) = 6.07, p < .05, \eta^2_p = .14$. This shows that external eating group had a different effect on pleasantness ratings, depending on the type of picture used (see Figure 5). An independent samples t-test showed that on average, low external eaters rated control pictures as more pleasant ($M = 0.52, SD = 1.14$) than high external eaters ($M = -0.08, SD = 0.78$). This difference was not significant $t(36) = 1.89, p > .05$. On average, high external eaters rated food pictures as significantly more pleasant ($M = 2.75, SD = 0.57$) than low external eaters ($M = 1.24, SD = 1.26$), $t(36) = -5.11, p < .001$.

![Figure 5: Mean pleasantness ratings and standard errors of control and food pictures for low and high external eating groups.](image-url)
Discussion

Summary of results

This study investigated the relationship between trait EE and AB for food cues, looking particularly at inhibitory control on an antisaccade task. Hypothesis 1(i) stated that antisaccade performance (antisaccade error rate and latency), and therefore inhibitory control, would be poorer for high external eaters than low external eaters for both food and neutral stimuli. This was not supported by the results. Hypothesis 1(ii) stated that EE and SSRTs would be related such that, participants with higher levels of EE would have slower SSRTs on the SST (poorer inhibitory control), than those with lower levels of EE. This was not supported by the results as no significant relationship was found between level of EE and SSRT. However, hypothesis 2 stated that poorer antisaccade performance in the high EE group compared to the low EE group would be particularly apparent for food pictures relative to control pictures. This was supported by the results which found a significant three-way interaction. However, post-hoc testing of the data revealed that although those with high EE made slightly more antisaccade errors for food stimuli (compared to control stimuli) and those with low EE made slightly less antisaccade errors for food stimuli (compared to control stimuli), these differences did not meet the strict criteria for significance. Hypothesis 3 stated that AB for food cues would have a positive correlation with level of EE. This was supported by the analysis calculated from the error data, but not from the latency data. Nevertheless, these data indicate an AB for FRS in high external eaters compared to low external eaters. Hypothesis 4 predicted that AB for food cues would positively correlate with levels of state hunger as assessed by the Grand Hunger Scale. This was supported by the analysis from the antisaccade latency data but not from the error data. Lastly, the significant interaction for picture type x external eating group in the pleasantness ratings and the subsequent analyses showed that high external eaters’ ratings of food pictures were more favourable than those of low external eaters. This therefore supports hypothesis 5 which stated that the high EE group would rate food pictures as more pleasant compared to the low EE group.

Caution should however be employed due to the fact that the two EE groups differed in emotional eating, and amount of favourite food that could be eaten at time of testing. In addition, the between-groups difference in state hunger was almost
significant. Correlational analyses also showed positive relationships between these factors and external eating.

While the covariate analyses reduced the significance of the three-way interaction found in the error data, it does not warrant changing the basic conclusion: of an AB for FRS in high external eaters.

The results support previous findings from a range of studies, that hypersensitivity to external food cues is associated with an AB towards food (e.g. Brignell, et al., 2009; Hou, et al., 2011; Jasinska, et al., 2012; Nijs, et al., 2009; Nijs, Muris, et al., 2010). This is consistent with incentive-sensitisation theories of OEB that implicate the dopaminergic system in attributing incentive salience to stimuli associated with reward (Berridge & Robinson, 1998). Similarly, in Franken’s (2003, p. 572) model of AB and drug use, applied to OEB, it could be argued that the enhanced signalling of drug cues is analogous to the concept of sensitivity to external food cues (EE). In addition, Franken’s concepts of increased drug cognitions and no attentional resources being left for alternative cues, also share commonality with definitions of EE, when applied to OEB. Following from this, high EE would increase perception of food stimuli which would generate an increase in dopaminergic activity and in turn lead to greater AB for food cues. This is consistent with the primary finding from this study, of EE and AB for food cues being positively linked with each other.

Another interesting finding was that in the antisaccade error data, AB for food scores significantly correlated with EE (using a one-tailed test) but not with emotional eating. This could be seen as surprising because of the strong significant relationship between EE and emotional eating. It therefore provides some support for the idea that the AB for food finding, was specific to the EE trait. However, it should be kept in mind that the experiment did not involve participants being in an emotionally aroused state. It is possible that if the experiment was repeated using a mood manipulation then the results may be different (i.e. AB for food may have been shown to be linked to emotional eating in addition).

While Jasinska et al. (2012) found that EE and self-reported impulsivity were positively associated with each other, they did not find the same relationship between high EE and poorer performance on a behavioural task of inhibitory control (the Go/NoGo task). Results from the present study using a similar task of inhibitory control are consistent with this with regard to EE. However, results from their
Go/NoGo task showed a positive association with emotional eating, i.e. higher levels of emotional eating were related to poorer performance on the inhibitory control task. No such effect was found in the present research, therefore casting doubt on the hypothesis from Jasinska et al. (2012), that deficits in inhibitory control may initiate OEB more in adverse emotional contexts.

Previous research has shown that measures of inhibitory control often correlate poorly with each other (Barkley, 1991; Marsh, Dougherty, Mathias, Moeller, & Hicks, 2002). However, it is interesting that significant positive correlations were only found between the inhibitory control measure from the SST and the antisaccade conditions involving food, but not control pictures. This could be a product of human evolution resulting in greater incentive value for food in comparison to non-food related objects. However, this is only a hypothesis and it would be interesting to see if these results were replicated in future studies.

Also of note is that the significant findings for AB for food cues with EE were found in the error data of the eye movements, but there were no corresponding results found in the latency data. This could be interpreted as there being an impairment in high external eaters’ performance, rather than a speed-accuracy trade-off. In other words, it was not that this group were rushing to respond faster for food pictures (due to prioritising them more), because there were no differences in latency between the EE groups. High external eaters were actually performing worse, as opposed to responding faster and making more mistakes in the process.

**Study strengths**

Strengths of this research include the use of pictorial stimuli, which has been argued to have more ecological or real-life validity (Giel, Teufel, et al., 2011). In addition, unlike in previous studies, each stimulus photograph was edited to remove the photograph backgrounds and edges. In this way, it ensured that it was the stimulus itself that the eye movement response was being made to, not the side of a photograph nearest central fixation. This is especially important for an antisaccade methodology where the participant is fixating centrally on the screen, waiting to respond to any stimulus that might appear just left or right of their orientation.

**Methodological limitations**

When attempting to identify AB to particular stimuli, one difficulty inherent with the current study design is that different people find different foods desirable. Consistent with the results found in numerous studies (e.g. Brignell, et al., 2009) the
vast majority of pictures selected were foods high in calories / fat. While the food pictures were rated as being more pleasant than the non-food pictures, it is possible that more appropriate foods could have been chosen which would have resulted in more significant findings. In addition, it is interesting to note that the food with the lowest mean pleasantness rating was the one likely lowest in fat / calories (the quiche). As has been noted by other researchers, one option would be to use foods identified as particularly pleasant and rewarding for each person (Pothos, Tapper, et al., 2009). This would also be consistent with incentive-sensitisation theory (Robinson & Berridge, 1993) which would hypothesise that levels of incentive-salience attributed to foods would vary between people, causing one person’s dopaminergic system to respond differently to another person’s. While it would raise issues of participants being tested with different stimuli, it would reflect real-world realities of individual preferences and food tastes.

The study attempted to control for state hunger due to the potentially confounding effect that it is hypothesised to have on processing bias of food stimuli (e.g. Castellanos, et al., 2009; Johansson, et al., 2004). Participants were asked to abstain from eating anything for at least two hours before arriving for the testing session. While there was no difference between the two EE groups in amount of time since last eating, it was not possible to experimentally verify this. The study therefore relied on self-reports from participants. In addition, there was also a great degree of variation in time since last eating, with some participants reporting having abstained for up to fifteen hours. Other methods of controlling satiety levels have been used by researchers and may be more effective. For example, Nijs et al. (2009) requested that participants ate a light meal, e.g. a sandwich two hours before arriving at the experimental session and that they did not consume any food or caloric drinks until the testing was completed. While this would still rely on participants’ self-report of their eating behaviour that day, it would help to reduce large amounts of variance in time since last eating.

It is notable that the high EE group had more than double the number of participants in the low EE group. This does limit the strength of the conclusions that can be made from the data. It is not clear why so few low EE were recruited. The majority of participants came from a psychology undergraduate participant pool, many of whom were taking part in return for course credits which were needed for the students to be able to do conduct their research projects more easily. It is
possible that when completing the initial online EE subscale to assess eligibility, potential participants may have scored themselves significantly higher in the hopes that it would increase chances of being invited to take part in the study and gain the course credits. However, initial EE (from the online criteria questionnaire) and experimental EE subscale scores were not significantly different (in fact the mean initial EE subscale score was slightly lower than at the experimental session).

Another possible explanation for the disproportionate amount of high external eaters is that the advertising used (see Appendix 4) to recruit participants may have been more appealing to this subgroup. Thus, a referral bias may have occurred in the same way as other researchers have considered (e.g. Nijs, Muris, et al., 2010).

Inevitably, due to the research being conducted on a non-clinical sample of university students that were broadly young adults, there is a limit as to the generalizability of its conclusions to other groups. It is however, instructive in guiding understanding of the relationship between variables implicated in OEB and this can be used to guide future research (as will be discussed later in the text).

When considering experimental design for research into OEB, one often-used component is a behavioural measure of eating behaviour (e.g. Guerrieri et al., 2007; Larsen, Hermans, & Engels, 2012). Often called a ‘bogus taste test’, participants are given the opportunity to eat from a dish or bowl provided under the pretence that the quantity of food eaten is not what is being measured. However, it could be hypothesised that once somebody has a bowl of food in front of them, other information-processing mechanisms may become involved. For example, overeating in this situation may be as a result of a lack of attention to the food and a lack of inhibitory control. So AB may be an important factor in initial engagement with starting to eat, and inhibitory control may then play a bigger role as it balances with internal signs of satiety.

Clinical implications

When considering working with a client trying to reduce their OEB (regardless of their clinical diagnosis, e.g. BED or co-morbid obesity) this study raises a range of clinically important issues to consider from assessment to evaluation. Links between the addiction literature and OEB have been made by many researchers due to a range of behavioural, clinical and neurobiological parallels (Davis & Carter, 2009; Volkow, Wang, Tomasi, & Baler, 2013). The
present results can potentially be generalised to issues in addiction. Similarly, the addiction literature is instructive regarding cue reactivity and AB.

Evidence from alcohol abuse studies has shown that those in alcohol-treatment programmes were more likely to relapse if they had greater levels of AB for alcohol-related stimuli (Cox, et al., 2002). Measures of AB for food could potentially be used in similar ways for treatment programmes aimed at reducing OEB, to assess likelihood of / barriers to progress. Thorough assessment could therefore involve the use of the DEBQ and a measurement of AB for food cues. As a result, the above research and present study would highlight the need to take advantage of cognitive interventions in the client’s formulation. These would be aimed at diminishing the unhelpful AB. Research showing that biases in attention towards food can predict change in BMI are, once again, consistent with the addiction literature and point to the need to consider retraining of attention away from food cues (Calitri, Pothos, Tapper, Brunstrom, & Rogers, 2010). In the same way that AB modification has been shown to be effective in clients with alcohol abuse (by training clients to disengage attention away from cues associated with alcohol) (Schoenmakers, et al., 2010), a similar procedure could be used for those with food-related addictive-type behaviours (Wiers et al., 2002). Increased cognitive control with regard to OEB has also been found to result from mindfulness training programmes. While EE is known as a stable trait, there is evidence that mindfulness training can help to reduce sensitivity to external food cues over an eight week course (Alberts, et al., 2012). Following completion of any intervention, the DEBQ and a behavioural measure of AB for food, could then be used as part of a standard post-treatment assessment of change in the client.

This is the first time the antisaccade methodology has been used to investigate the relationship between a trait eating style and AB for food cues. As a result, it may be useful to other researchers wanting to make examinations of eating styles using the same methodology. The implications for this research will help to aid understanding of the role individual differences play when responding to external food cues. This in turn, will build on contemporary understanding of the causes of obesity and eating disorders.

**Future research**

There are numerous experimental designs that could be influenced by the present study. A simple replication of the present study would be useful to establish
if the pattern of results for the inhibitory control measures was repeated, perhaps also incorporating a self-report measure of impulsiveness. If the SSRT on the SST correlated again only with food-related antisaccade performance, but not with performance on non-food-related antisaccade trials then it would help to explore the construct of inhibitory control and point towards further research investigating its role in OEB. It might also show that attempts to reduce OEB could benefit from training in inhibitory control (Houben, 2011).

While research has investigated EE as a trait eating style, emotional eating as measured by the DEBQ still remains relatively neglected in the literature. Recently, a two year study showed that levels of emotional eating and doing sport were the best predictors of change in BMI (effect of EE was just marginally significant) (Koenders & Van Strien, 2011). Again, a similar design to the present study, but examining groups depending on emotional eating scores would be useful in understanding the link between AB and OEB driven more by negative affective states. A mood manipulation would be useful in examining the impact of emotional eating on processing biases as measured by the antisaccade task.
Conclusion

This research has provided further evidence for an attentional bias for food-related stimuli using a methodology novel to the field of eating styles. This supports findings from previous studies that have examined external eating, and points to the role that individual differences in sensitivity to external food cues plays in information processing of FRS. The results are also consistent with theoretical models of addiction and attentional bias applied to eating behaviour, which predict that enhanced signalling of cues (EE) and attentional bias have a reciprocal relationship.

In addition, the study examined measures of inhibitory control. While these measures were not found to be directly related to trait EE, a novel finding was uncovered showing a positive correlation between deficits in inhibitory control from the stop-signal task with antisaccade food conditions, but not with antisaccade control conditions. Further research is needed to see if this is replicable.

Overall, the research has examined the roles that external eating and processing biases appear to play when responding to external food cues. The field of unhealthy eating habits remains a key area of research, particularly when considering societal changes in food availability, advertising strategies and the potential for these trends to continue.
### APPENDIX 1

#### SEARCH TERMS

<table>
<thead>
<tr>
<th>Search terms used</th>
<th>PsycINFO via EBSCO</th>
<th>Medline via EBSCO</th>
<th>Web of Science via Web of Knowledge</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>‘Cues’ or ‘Attention’ or ‘Attentional bias’ or ‘Cognitive bias’</td>
<td>‘Attention’ ‘Cues’</td>
<td>‘Attention*’ or ‘cue*’ or ‘bias*’</td>
</tr>
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## APPENDIX 2

### FOLLOW UP SEARCH TERMS

<table>
<thead>
<tr>
<th>Search terms used</th>
<th>PsycINFO via EBSCO</th>
<th>Medline via EBSCO</th>
<th>Web of Science via Web of Knowledge</th>
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<tbody>
<tr>
<td>'Information processing' AND 'Appetite' or 'Eating attitudes' or 'Eating behavior' or 'Food' or 'Food intake' or 'Food preferences'</td>
<td>'Information processing' AND 'Feeding behavior' 'Hunger' 'Eating' 'Food habits'</td>
<td>'Information processing' AND 'Appetit*' or 'Food*' or 'Eating'</td>
<td></td>
</tr>
<tr>
<td>'Dietary restraint' AND 'Cues' 'Attention' 'Attentional bias' 'Cognitive bias'</td>
<td>'Dietary restraint' AND 'Attention' 'Cues'</td>
<td>Dietary restraint AND 'Attention*' or 'cue*' or 'bias*'</td>
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APPENDIX 3

LIST OF PAPERS INCLUDED IN LITERATURE REVIEW


APPENDIX 4
POSTER ADVERTISEMENT

Participants required for psychology experiment
‘Examining eye movements and eating styles’

What is it about?
• studying the effect of different eating styles on how people respond to different picture stimuli.

What does it involve?
• Your eye movements will be measured as you look at different pictures.
• Completing three simple tasks using a computer and filling out some questionnaires. Your BMI will also be measured.
• A 3rd year psychology undergraduate student is also involved in the project and will be meeting with some of the participants and carrying out some of the testing.

How long will it take?
• 45 minutes at the Shackleton Building on the university campus - Building no. 44

What do I get?
• Participants will receive £4.50 (except undergraduate psychology students who will receive 3 course credits)

I’m interested, what is the next step?
• A very brief online questionnaire can be completed to see if you meet the criteria. Just take the details below and send an email expressing interest.

Many thanks for reading!

Contact person: Stuart Dobinson SLD1g10@soton.ac.uk

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APPENDIX 5

ONLINE ELIGIBILITY QUESTIONNAIRE

Eating Styles and Eye Movements: Research Questionnaire

Please answer the following questions:

Age: ......................

Do you have any special dietary requirements (e.g. vegetarian, kosher) (please circle):
  Yes       No

If yes, please specify the dietary requirements below:

........................................................................................................

The Dutch Eating Behaviour Questionnaire
(Van Strien, Frijters, Bergers, & Defares, 1986)

1. If food tastes good to you, do you eat more than usual?

   1  2  3  4  5
   Never Rarely   Sometimes   Often   Very often

2. If food smells good and looks good, do you eat more than usual?

   1  2  3  4  5
   Never Rarely   Sometimes   Often   Very often

3. If you see or smell something delicious, do you have the desire to eat it?

   1  2  3  4  5
   Never Rarely   Sometimes   Often   Very often

4. If you have something delicious to eat, do you eat it straight away?

   1  2  3  4  5
   Never Rarely   Sometimes   Often   Very often
5. If you walk past the baker do you have the desire to buy something delicious?

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<td></td>
<td>Never</td>
<td>Rarely</td>
<td>Sometimes</td>
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6. If you see others eating, do you also have the desire to eat?

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<td>Sometimes</td>
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7. Do you find it hard to resist eating delicious foods?

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<td>Never</td>
<td>Rarely</td>
<td>Sometimes</td>
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8. If you walk past a snack bar or a café, do you have the desire to buy something delicious?

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<td>Never</td>
<td>Rarely</td>
<td>Sometimes</td>
<td>Often</td>
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9. Do you eat more than usual, when you see others eating?

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<td>Never</td>
<td>Rarely</td>
<td>Sometimes</td>
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10. When you are preparing a meal are you inclined to eat something?

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<td>Never</td>
<td>Rarely</td>
<td>Sometimes</td>
<td>Often</td>
<td>Very often</td>
</tr>
</tbody>
</table>
From: ERGO <ergo@soton.ac.uk>
Sent: 30 November 2012 15:02
To: Dobinson S.L.
Subject: Your Ethics Amendment (Ethics ID:4938) has been reviewed and approved

Submission Number 4938:
This email is to confirm that the amendment request to your ethics form (Examining visual attention bias and inhibitory control for food cue images using an antisaccade task with high and low external eaters from a non-clinical population (Amendment 1)) has been approved by the Ethics Committee.

You can begin your research unless you are still awaiting specific Health and Safety approval (e.g. for a Genetic or Biological Materials Risk Assessment)

Comments
1. All fine. You could change the ethics number on documents to 4938 or add it on after the previous number - xxxx/4938 - so that it can be traced should any issues arise. I hope this approval was fast enough!

Click here to view your submission

------------------
ERGO : Ethics and Research Governance Online
http://www.ergo.soton.ac.uk
------------------
DO NOT REPLY TO THIS EMAIL
APPENDIX 7
PARTICIPANT CONSENT FORM

CONSENT FORM (Version 2, 29/11/2012)

Study title: Examining eye movements and eating style.

Researcher name: Stuart Dobinson, Erin Waites, Dr. Catherine Brignell
Ethics reference: 3337/4938

Please initial the box(es) if you agree with the statement(s):

I have read and understood the information sheet (29/11/2012, Version 2) and have had the opportunity to ask questions about the study.

I agree to take part in this research project and agree for my data to be used for the purpose of this study.

I understand my participation is voluntary and I may withdraw at any time without my legal rights being affected.

Data Protection
I understand that information collected about me during my participation in this study will be stored on a password protected computer and that this information will only be used for the purpose of this study. All files containing any personal data will be made anonymous.

Name of participant (print name)...........................................................................................................

Signature of participant.........................................................................................................................

Date......................................................................................................................................................
APPENDIX 8

INFORMATION SHEET

Participant Information Sheet

Study Title: Examining eye movements and eating styles
Ethics number: 3337/4938

Researcher: Stuart Dobinson (Trainee Clinical Psychologist), Erin Waites (3rd Year Psychology Undergraduate Student), Dr. Catherine Brignell (Supervisor).

Please read this information carefully before deciding to take part in this research. If you are happy to participate you will be asked to sign a consent form.

What is the research about?
I am currently a Trainee Clinical Psychologist and am required to carry out a piece of research to submit as part of my coursework for my Doctoral Programme in Clinical Psychology. This research is studying the effect of different eating styles on how people respond to different picture stimuli. The speed with which you are able to look directly towards and look away from different picture stimuli will be calculated.

Why have I been chosen?
Participation in the study was offered to students who wanted to gain course credits/payment or who were particularly interested in the study. There is a short online questionnaire for potential participants to complete which will establish eligibility for the study.

What will happen to me if I take part?
First, you will be asked to complete a very short questionnaire online to establish if you meet the criteria of the study (you may have already completed this). If you do, a time at your convenience will be arranged for you to come into the psychology department so that you can take part in the research.

During this research, you will be asked to complete a number of tasks and fill out some questionnaires. The tasks involve pictures of objects and the participant trying to look away/look towards the picture as quickly as possible. Your eye movements will then be measured as you perform this task. In addition, you will be asked to complete four questionnaires: the Dutch Eating Behaviour Questionnaire (DEBO, it is written in English), the Grand hunger scale, the Hospital Anxiety and Depression Scale (HADS) and the Eating Attitudes Test-26 (EAT-26) questionnaire. You will also rate how pleasant you find each of the pictures. Your BMI will be calculated from the measurements you provide to the researcher. The final task is the stop signal task where reaction times will be measured. In total, the maximum duration of the experiment will be 45 minutes. A 3rd year psychology undergraduate student (Erin Waites) is also involved in the project and will be meeting with some of the participants and carrying out some of the testing.

Are there any risks involved?
It is not expected that there will be any harm or discomfort from taking part. It is possible that you may experience eye strain from concentrating on the computer screen. In addition, you will be asked about personal eating habits and your measurements will be requested so that your BMI can be measured. The research staff involved will make sure that you are as comfortable as possible throughout.
Are there any benefits in my taking part?
For participating in this study, you will receive 3 credits. Your data will help researchers understand problematic eating behaviours that people have.

Will my participation be confidential?
Yes, your participation and the data you provide in this study will be kept confidential. All data will be stored and managed in a way that is consistent with University of Southampton policies as well as the Data Protection Act. The research staff involved in the project will be the only people who have access to the data. Your data will be labelled with a unique reference code, thereby making it unnecessary for any personal or identifying information to be linked to it.

What happens if I change my mind?
If, at any point during participation, you feel you would like to stop and withdraw from the project, please tell the researcher who will assist you with this. You are perfectly within your rights to stop at any time. Any data you have provided up to that point will be permanently deleted.

What happens if something goes wrong?
If you are unhappy with anything at all or feel you have not been treated appropriately in the course of this research you can contact the Chair of the Ethics Committee, Psychology, University of Southampton, SO17 1BJ. Phone: +44 (0)23 80594663, email slb1n10@soton.ac.uk.

Where can I get more information?
If there is any other information you would like about the research please contact Stuart Dobinson - sld1g10@soton.ac.uk
### APPENDIX 9

**POWER CALCULATION**

**Test Family**
F-Tests

**Statistical test**
ANOVA: repeated measures, within-between interaction

**Type of Power analysis**
A priori: Compute required sample size – given $\alpha$, power, and effect size

**Input parameters**
- Effect size $f$: 0.5248907
- $\alpha$ err prob: 0.05
- Power (1-$\beta$ err prob): 0.95
- Number of groups: 2
- Number of measurements: 2
- Corr among rep measures: 0.5
- Nonsphericity correction $\varepsilon$: 1

**Output Parameters**
- Noncentrality parameter $\lambda$: 17.6326558
- Critical F: 4.6001099
- Numerator df: 1.0000000
- Denominator df: 14.0000000
- Total Sample size: 16
- Actual Power: 0.9736205

- Partial $\eta^2$: 0.216 (Garner, et al., 2011)
- Effect size $f$: 0.5248907

Using the computer programme, G*Power version 3.1.3 (Faul, Erdfelder, Lang, & Buchner, 2007) and assuming a similar effect size to that found by Garner et al. (2011) it has been estimated that at least 16 participants will be needed. However, this effect size estimate was based on a study involving threatening stimuli. The effect size in the current study may therefore be smaller and so at least 26 participants will be used, as per Garner et al. (2011).
APPENDIX 10
EXAMPLE STIMULI
Potential participants complete online eligibility questionnaire with EE subscale of the DEBQ and the demographic questions.

Participants that scored 2.70 or less, or 3.50 or more on EE and satisfied eligibility criteria were invited to attend the experimental session.

Participants that scored more than 2.70 or less than 3.50, and/or did not satisfy eligibility criteria were not invited to attend the experimental session.

Participants arrived for the experimental session, read the information sheet and completed the consent form. Below shows the order of each of the parts of the experiment:

1. Grand Hunger Scale
2. Antisaccade Task (AST)
3. Pleasantness Rating Task (PRT)
4. Dutch Eating Behaviour Questionnaire (DEBQ)
5. Hospital Anxiety and Depression Scale (HADS)
6. Eating Attitudes Test-26 (EAT-26)
7. Stop-signal task (SST)
8. Participants had their height and weight measured to calculate Body Mass Index (BMI)

Participants were provided with the debrief sheet at the end of the experiment and any questions they had about the study were answered.

Participants who scored 10 or more on the HADS depression subscale were also sensitively advised to speak with their GP about any concerns that they had about how they had been feeling. Their data were not included in subsequent analyses.
APPENDIX 12
EXAMPLE SCREEN SHOTS

TOWARDS
Debrief Sheet  'Examining eye movements and eating styles'  

Researcher name:  Stuart Dobinson (Trainee Clinical Psychologist), Erin Waites (3rd Year Psychology Undergraduate Student), Dr. Catherine Brignell (Supervisor).

Ethics reference:  3337/4938

Thank you for taking part in our study examining eye movements and eating styles.

This study is investigating the relationship between self-reported external eating style (how influenced someone is by, e.g. pictures of foods) and attention biases for food cues. Its aim is to examine whether external eating is linked to poor cognitive control, as shown by anti-saccade performance. Lastly, the study is examining whether it is more difficult to inhibit automatic eye movements towards food cues.

Your name or details will not be shown in the report of the study and the data that you have provided will only be viewed by researchers for this study.

As a result of your participation in this study you will be given three credits.

If you have any other questions or interest in the study please contact me, Stuart Dobinson, at sld1g10@soton.ac.uk.

If taking part in this research has raised concerns for you about your eating habits, there are websites that you may find useful to help answer any questions you have, e.g. the NHS Choices website (http://www.nhs.uk), and the website of the Royal College of Psychiatrists, which provides information for the general public about eating problems http://www.rcpsych.ac.uk/mentalhealthinfo/problems/eatingdisorders.aspx. Your GP may be able to help you seek any further support you need.
REFERENCES


