Food-related attentional bias: Word versus pictorial stimuli and the importance of stimuli calorific value in the dot probe task

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Word Count (excluding tables/figures):

Abstract 231

Body 5028

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Highlights

- Biases were measured toward word and picture, and high- and low-calorie stimuli.
- A stimuli type by calorific value interaction effect was found.
- For pictures, biases were toward high-calorie food and away from low-calorie food.
- For words, biases were toward low-calorie food and away from high-calorie food.
- No associations between biases and BMI, restraint, or external eating were found.

Abstract

Objective. The primary aim of this study was to extend previous research on food-related attentional biases by examining biases toward pictorial vs. word stimuli, and foods of high vs. low calorific value. It was expected that participants would demonstrate greater biases to pictures over words, and to high-calorie over low-calorie foods. A secondary aim was to examine associations between BMI, dietary restraint, external eating and attentional biases. It was expected that high scores on these individual difference variables would be associated with a bias toward high-calorie stimuli. Methods. Undergraduates (N = 99) completed a dot probe task including matched word and pictorial food stimuli in a controlled setting. Questionnaires assessing eating behaviour were administered, and height and weight were measured. Results. Contrary to predictions, there were no main effects for stimuli type (pictures vs. words) or calorific value (high vs. low). There was, however, a significant interaction effect suggesting a bias toward high-calorie pictures, but away from high-calorie words; and a bias toward low-calorie words, but away from low-calorie pictures. No associations between attentional bias and any of the individual difference variables were found. Discussion. The presence of a stimulus type by calorific value interaction demonstrates the importance of stimuli type in the dot probe task, and may help to explain inconsistencies in prior research. Further research is needed to clarify associations between attentional bias and BMI, restraint, and external eating.

Keywords: Attentional bias; Dot probe; Stimuli; Food; Eating behaviour; Cognition

Introduction

The phenomenon of selective attention towards personally relevant stimuli has been documented across a range of health concerns, such as anxiety (for a review, see Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007), chronic pain (for reviews, see Crombez, Van Ryckeghem, Eccleston, & Van Damme, 2013; Schoth, Nunes, & Liossi, 2012), substance use (for reviews, see Cox, Fadardi, & Pothos, 2006; Field & Cox, 2008; Franken, 2003), and eating disorders (for reviews, see Brooks, Prince, Stahl, Campbell, & Treasure, 2011; Faunce, 2002; Giel et al., 2011), such that individuals suffering from these conditions are more likely to attend to behaviour-related cues. Attentional biases have also been found toward food cues in non-clinical populations under conditions of hunger (Mogg, Bradley, Hyare, & Lee, 1998; Nijs, Muris, Euser, & Franken, 2010). In this case the salience of food stimuli is increased by the physiological drive for hunger, signalling the body's need for food. Such findings have given rise to interest in how other variables, such as weight status, restraint and external motivation for food might influence attentional biases. For example, if overweight patients are more likely to attend to food cues, then this attention could act as a trigger for eating and lead to over-eating which could contribute further to weight gain. However, differences in the stimuli and paradigm parameters that are used between studies has made it difficult to determine under what conditions these biases are found. If such biases exist this has implications for not only our understanding of attentional bias and its role in the development and maintenance of food-related behaviours but also for designing interventions to help people manage their food intake. One aim of the current study was to clarify these inconsistencies in the literature on non-clinical populations. As the majority of studies on food-related attentional bias have used reaction time data, when referring to previous studies we are reporting reaction time data, unless otherwise stated.

Early investigations into food-related attentional biases generally employed a modified Stroop (1935) colour naming task. In this paradigm, participants are presented with a series of words printed in different colours. They are asked to inhibit their tendency to read the word and instead name the colour in which each word is printed. Reaction times for colour-naming target words (e.g., unhealthy food) are compared with reaction times for colour-naming control words (e.g., non-food). Longer reaction times for target words are interpreted as indicating that the emotional relevance of the word category has caused interference. The presence of such an effect has typically been attributed to an attentional bias toward the target stimuli. Investigations of attentional biases towards food-related stimuli using the Stroop task have largely focussed on individuals with eating disorders. Reviews and meta-analyses indicate that such individuals generally take longer to colour-name food-, and weight/shape-related words than other words (Brooks et al., 2011; Dobson & Dozois, 2004; Johansson, Ghaderi, & Andersson, 2005; Lee & Shafran, 2004). However, one of the difficulties with the Stroop task is determining the source of the interference effect. It has been suggested that the delay in colour naming may occur as a result of either heightened attention to stimuli, or contrastingly, avoidance of stimuli (De Ruiter & Brosschot, 1994). To overcome the limitations of the Stroop task, a growing number of investigators have employed the dot probe task (MacLeod, Mathews, & Tata, 1986). This task involves brief presentations of picture or word pairs on-screen (one experimental and one neutral). Then, a probe (commonly a dot, asterisk, or letter) appears in the location of one of the previously shown stimuli, and participants are required to indicate the location of the probe as quickly as possible. This allows differentiation between attention directed toward stimuli and attention directed away from stimuli, providing a more precise measure of attentional allocation. Further, stimuli presentation durations can be modified as a means to test for initial orienting toward a target stimulus (short duration, ≤ 200 ms) or sustained attention (longer duration, ≥ 500 ms) (Field & Cox, 2008). Therefore, an attentional bias towards target stimuli exists when there is faster detection of probes replacing such stimuli. In contrast, attentional avoidance of target stimuli exists when there is slower detection of probes replacing such stimuli.

Increasingly, investigators have employed the dot probe task to assess food-related attentional bias, particularly to assess whether certain groups are more prone to attentional bias than others. Yet, evidence for the existence of an effect remains equivocal. For example, in some cases all individuals appear to selectively attend toward dot probe food cues irrespective of how they are grouped, for instance, by level of dietary restraint (Ahern, Field, Yokum, Bohon, & Stice, 2010; Werthmann et al., 2013), or body weight (Nijs et al., 2010). A summary tabulation of existing dot probe research, excluding attentional training studies, indicates that inconsistent findings may in part be due to wide variation in sample sizes, stimuli, and task parameters across studies (Supplementary Material, Table S1). However, while these factors may explain why some studies yield positive effects and others do not, it is also possible that methodological factors (e.g., the use of word or picture stimuli), physiological variables (e.g., body weight), and/or behavioural variables (e.g., dietary restraint) may also contribute to inconsistencies between studies.

The question of whether words and pictures are equally useful as stimuli for the food dot probe task has not yet been examined in the literature. Pictures may be considered more ecologically valid than words because they more closely approximate real-world cues. Indeed, it has been shown that pictures are more strongly related to affective information than words (De Houwer & Hermans, 1994). Moreover, high-calorie food pictures can induce gustatory responses in brain regions for taste and reward (Simmons, Martin, & Barsalou, 2005). The issue of word versus pictorial stimuli in the dot probe has been tested in other contexts, such as in assessments of attentional biases among patients with chronic pain (Dear, Sharpe, Nicholas, & Refshauge, 2011). Specifically, patients with chronic pain and matched pain-free controls were asked to complete one picture-based and one word-based dot probe task. An attentional bias toward pictorial stimuli was found, although only when pictures were rated as self-relevant. There was no reported attentional bias toward word stimuli. No such study has been conducted using food stimuli.

A second methodological issue that may contribute to inconsistencies between studies is the calorific value of food stimuli. While some studies have compared biases toward high- and low-calorie food stimuli and reported null effects when using dot probe response latencies (Castellanos et al., 2009; Tapper, Pothos, & Lawrence, 2010), others have reported an attentional bias toward high-calorie foods (Johansson, Ghaderi, & Andersson, 2004; Kemps & Tiggemann, 2009; Nijs et al., 2010) or toward foods in general (Brignell et al., 2009; Hou et al., 2011; Mogg et al., 1998) over neutral non-food cues. It is important to test whether participants respond differently to high- versus low-calorie food stimuli as such information may be hidden when using mixed calorie stimuli.

The relationship between food-related attentional bias and various physiological and behavioural variables also appears to be inconsistent across studies, and may account for some of the discrepancies in findings. It is commonly hypothesised that overweight/obese individuals selectively attend toward foods, especially high-calorie foods, and that this tendency may contribute to outcomes such as cravings, overeating and weight gain. In line with this argument, Nijs and colleagues (2010) found higher initial orientation at 100ms stimulus presentation towards dot probe food cues in overweight/obese versus normal-weight individuals. Other studies have, however, failed to replicate weight-based differences when using dot probe response latencies (Castellanos et al., 2009; Loeber et al., 2011; Werthmann et al., 2011). Hence, BMI was a variable of interest in the present study.

The eating behaviour variables of dietary restraint and external eating have been tested in the context of the food dot probe, again with mixed results. Dietary restraint refers to the intention to restrict food intake in order to control body weight (Herman & Mack, 1975). As this intention may lead to preoccupation with food, it is reasonable to speculate that an attentional bias, especially toward high-calorie ‘forbidden’ foods, may follow. However, support for this relationship is limited. Five dot probe studies (Ahern et al., 2010; Boon, Vogelzang, & Jansen, 2000; Lee, Shafran, & Fairburn, 2004; Papies et al., 2008; Werthmann et al., 2013) have investigated the relationship between restrained eating and attentional biases. Only two of these studies (Lee et al., 2004; Papies et al., 2008) found a relationship, and of those, the latter included pre-exposure to food words before the dot probe task, which may have primed participants to the stimuli.

Inconsistent findings have also emerged regarding external eating tendencies and attentional bias. According to the externality theory of overeating, certain individuals are more sensitive to external food cues (e.g., sight, smell, and taste of food) than others, and more likely to eat in response to these cues, irrespective of internal physiological signals of hunger and satiety (Schachter & Rodin, 1974). As such, it may be expected that an association exists between external eating and attentional bias toward food stimuli. This prediction has been supported by several studies (Brignell et al., 2009; Hepworth, Mogg, Brignell, & Bradley, 2010; Hou et al., 2011), however others report no associations (Newman, O'Connor, & Conner, 2005; Pothos, Tapper, & Calitri, 2009), or counterintuitive results. For example, Johansson, Ghaderi, and Andersson (2004) found that high externally motivated eaters had a tendency to direct their attention away from food words whilst low externally motivated eaters directed attention towards food words in the dot probe task. To assist in clarifying these issues, dietary restraint and external eating were included in the present study.

Objective. In light of the literature outlined above, the primary aim of the present study was to examine the relationships between food-related attentional bias and two methodological variables, namely stimuli type (words vs. pictures) and stimuli calorific value (high vs. low) in the dot probe task. In addition, a secondary aim was to examine relationships between food-related attentional bias and specific behavioural (dietary restraint, external eating) and physiological (BMI) variables.

It was hypothesised that:

1. There would be a greater attentional bias toward pictorial stimuli than word stimuli.
2. There would be a greater attentional bias toward high-calorie food than low-calorie food.
3. Higher levels of dietary restraint would be associated with increased attentional biases toward high-calorie food stimuli.
4. Higher levels of external eating would be associated with increased attentional biases toward high-calorie food stimuli.
5. A higher BMI would be associated with increased attentional bias toward high-calorie food stimuli.

Method

Participants

The sample consisted of 99 undergraduate students (79 female) from a wide range of courses an Australian university, recruited via the University's online participant recruitment system. Inclusion criteria were 18 years of age or older, and fluency in English. The mean age was 19.34 years (*SD* = 2.95) and mean BMI was 21.96 (*SD* = 2.88). The majority were Caucasian (54%) and lived with their parents (65%). The study was approved by the University Human Research Ethics Committee. Participants were reimbursed with course credit in exchange for participation.

Stimulus material

One set of word stimuli and a matching set of pictorial stimuli were developed for this study. The word stimuli set consisted of:

- 5 high-calorie food–neutral (household items) pairs, e.g., bacon-towel
- 5 low-calorie food–neutral (household items) pairs, e.g., apple-boxes
- 5 high-calorie food–low-calorie food filler pairs, e.g., sausage-carrots. The filler pairs were designed as such to juxtapose high- vs low-calorie foods and thereby lead to increased salience of the calorific value of food stimuli.

• 5 neutral (music-related)–neutral (travel-related) filler pairs, e.g., guitar-camera

Words that referred to meals or foodstuffs with ambiguous calorific value, e.g. ‘yoghurt’, or ‘spaghetti’, were avoided. Word pairs were matched in length and frequency of usage. Frequency data was sourced from the British National Corpus, a representative sample of spoken and written late 20th Century British English words.

The pictorial stimuli consisted of four sets of colour image pairs that directly reflected the word stimuli pairs. Pictures were acquired from copyright-free stock image websites. All images were re-sized to 300 x 300 pixels. Image pairs were matched as closely as possible in brightness, colour, and shape. An additional 5 neutral (animals)–neutral (clothing) word and corresponding picture pairs were developed for use in task practice trials.

A pilot test of the word and picture stimuli was conducted (n = 18) to ascertain (i) whether the images clearly reflected the food and non-food words they were assigned to; (ii) whether participants could discriminate reliably between high-calorie and low-calorie foods; and (iii) whether image pairs appeared matched in appearance. Participants correctly identified 19.2 of 20 food images (SD = 0.99), and 28.5 of 30 non-food images (SD = 1.20). Participants also correctly classified the calorific value of 18.7 of the 20 stimuli foods as high-calorie or low-calorie (SD = 1.23). In response to qualitative feedback from the pilot test, several images were replaced or altered in brightness or shape, in order to strengthen the degree of pair matching. The final stimuli used can be found in the online Supplementary Material (Table S2).

Procedure

Upon arrival at the laboratory, participants provided informed consent and completed a demographics questionnaire and hunger scale. The dot probe task was then administered, followed by completion of the self-report eating behaviour measures. Height and weight were then measured by the experimenter. At the conclusion of testing, participants were debriefed. The duration of each testing session was approximately 25 minutes.

Measures

Demographics. Age, gender, living conditions, and ethnicity data were collected. A question regarding whether participants were vegetarian was also included.

Hunger. State hunger was measured by asking participants 'How hungry are you right now?' in a pre-task questionnaire. Responses were rated on a scale of 1 (not hungry at all) to 7 (extremely hungry).

Dutch Eating Behavior Questionnaire (DEBQ; van Strien, Frijters, Bergers, & Defares, 1986). The DEBQ is a well-established measure of dietary restraint (10 questions), external eating (10 questions), and emotional eating (13 questions). Items are scored on a 5-point Likert scale ranging from 1 (never) to 5 (very often). The DEBQ has been shown to have good internal consistency and factorial validity (van Strien et al., 1986). Only the restraint and external eating subscales were of interest in the present study.

Body Mass Index (BMI). Weight was measured to the nearest .1 kg and height to the nearest .5cm. BMI was calculated using the formula [weight] kg/[height] m^2.

Dot probe task (MacLeod et al., 1986). The task was programmed using Inquisit software, version 3.0.6.0, and presented on a wide screen 26-inch LCD monitor. Participants were seated approximately 60 cm from the computer screen. The task consisted of ten practice trials, followed by one block of 160 trials. Each trial began with presentation of a central fixation cross ('+'; 1cm in height) for 500ms, followed by a pair of words or pictures for 500ms. A 500ms stimulus duration was chosen as it reflects the duration most commonly used in the existing food dot probe literature (see Supplementary Material Table S1). The stimuli pair was presented with one word (in capital letters; 1 cm in height) or picture (8 cm x 8cm) in the upper half of the screen and another in the lower half, with 4.5 cm of space between the two stimuli. A visual probe ('p' or 'q'; 1cm in height) then appeared in place of either the upper or lower picture or word and remained until participants pressed the 'p' or 'q' response keys as quickly as possible to indicate the letter they had seen. The inter-trial interval was 500 ms. Reaction time (ms) for each trial was recorded by the task software.

Each stimulus pair appeared on screen once as pictures and once as words in each of the following four combinations: (i) target upper, probe upper, (ii) target upper, probe lower, (iii) target lower, probe upper, (iv) target lower, probe lower. The order of trials was uniquely randomised for each participant. The probe appeared in the upper or lower halves of the screen randomly and with equal probability. There were 80 critical trials (target-neutral) and 80 filler trials in total.

Pleasantness. The food stimuli used in critical trials of the dot probe task were rated on a scale of 1 (extremely pleasant) to 7 (extremely unpleasant) in a post-task questionnaire.

Data preparation

Data from practice and filler trials were removed. Trials with errors were discarded (5.6% of data). In accordance with previous food dot probe studies (di Pellegrino, Magarelli, & Mengarelli, 2011; Hou et al., 2011; Mogg et al., 1998) trials with response latencies < 200 ms or >1500 ms, and trials with latencies more than 2 SD above the participant's mean latency were then excluded as outliers (4.0% of data). One participant with an exceptionally high error rate (91.4%) was excluded. Trials targeting meat-based foods were removed from vegetarian participants' (*n* = 5) data sets. Four attentional bias scores were calculated for each participant, one for each stimuli category: high-calorie words, high-calorie pictures, low-calorie words, and low-calorie pictures. Bias scores were calculated using the formula 0.5*[(TuPl – TlPl) + (TlPu – TuPu)], where T = target stimulus, P = probe, u = upper, and l = lower (MacLeod & Mathews, 1988). In congruent trials (TlPl and TuPu), the probe replaces the target image/word, and in incongruent trials (TuPl and TlPu), the probe replaces the neutral image/word. A positive attentional bias score indicates a bias towards the target (food) stimulus whereas a negative attentional bias score indicates a bias away from the target (food) stimulus.

Data analysis

Analyses were performed using SPSS version 21. Two variables were transformed to improve normality using established methods (Osborne, 2010): BMI (inverse computed, distribution reversed, then a constant added to each score), and external eating (natural logarithm). Whilst the transformed variables were used in the data analysis, the untransformed means and SDs are provided to facilitate comparisons with previous research.

A paired samples t-test was conducted to compare average pleasantness ratings of high- and low calorie foods.

To explore the presence of attentional bias differences, mean attentional bias scores were entered into a 2 (Stimuli: word vs pictures) x 2 (calorific value: high vs low) repeated measures ANOVA. We also conducted a paired samples t-test to compare the biases towards higher calorie foods for words vs pictures. Pearson's correlations were conducted between bias scores and BMI, dietary restraint and external eating. Due to non-normality of the hunger variable distribution, Spearman's Rho correlations were conducted between bias scores and hunger.

Results

Pleasantness

On average, low calorie foods (M = 2.05; SD = .70) were rated as more pleasant than high calorie foods (M = 2.94; SD = .98), $t(98) = 8.035$, $p < .001$.

Hypotheses 1 and 2: Stimuli type and calorific value

There were no main effects for stimuli type, $F(1,98) = .006$, $p = .938$, partial $\eta^2 = .00$; or calorific value, $F(1,98) = .008$, $p = .927$, partial $\eta^2 = .00$; however, there was a significant interaction between these variables, $F(1,98) = 4.30$, $p = .041$, partial $\eta^2 = .042$. The conventions for partial η^2 are small = 0.01; medium = 0.06; and large = 0.14. The interaction effect (Figure 1) suggests an overall bias toward high-calorie stimuli compared to low-calorie stimuli for pictures, but towards low-calorie stimuli and away from high-calorie stimuli for words. Follow-up t-tests were conducted to determine the nature of the interaction. None of the t-tests reached significance ($t < 1.586$, $p > 0.116$). As such, we can conclude that these are relative effects, rather than absolute effects.

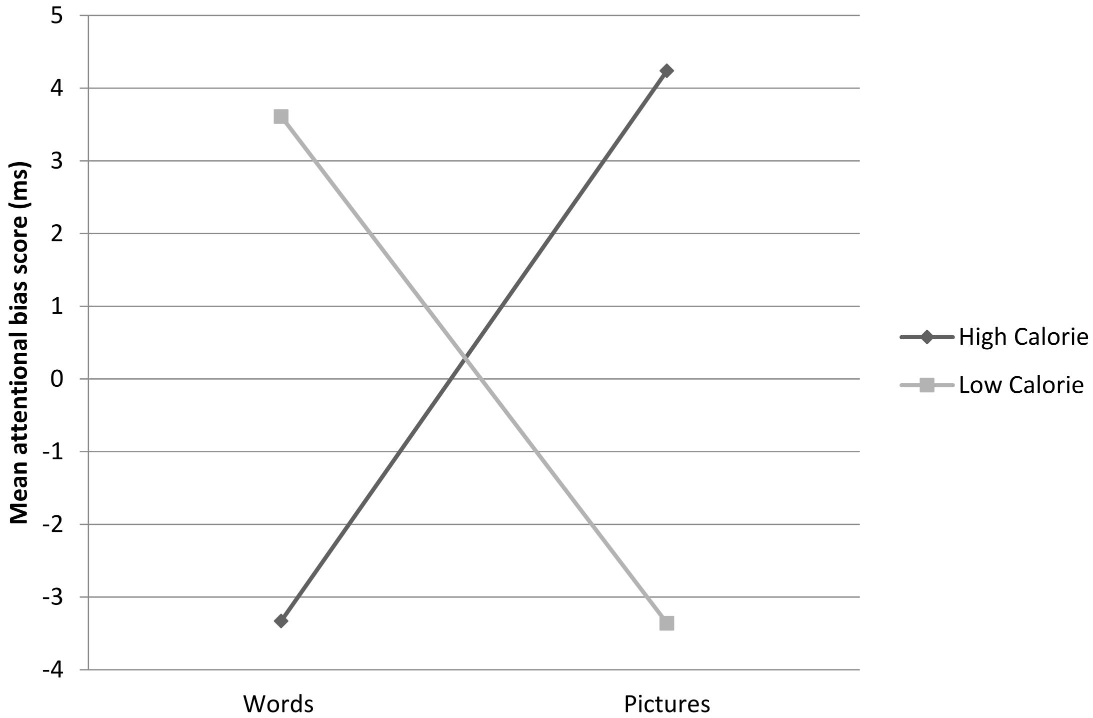

Figure 1. **Interaction effect between stimuli type and calorific value in food dot probe**

Note: A positive score indicates a bias toward the target stimulus; a negative score indicates a bias away from the target stimulus

Hypotheses 3, 4, & 5: Dietary restraint, external eating, and BMI

Pearson's correlations between the study variables were conducted. These, and means for all study variables are presented in Table 1. No significant associations were found. Spearman's Rho correlations between hunger ($M = 2.47$, $SD = 1.64$) and all attentional bias indices were non-significant, *p*s > .22.

Overall bias to food stimuli

Biases toward high- and low calorie stimuli were averaged, confirming no significant overall bias toward food pictures ($M = .439$; $SD = 29.216$) or words ($M = .139$; $SD = 24.504$). Similarly, in the trials including high and low calorie food, there was no difference in the biases towards high calorie words (*M* = -.0038, *SD* = 38.61) or pictures (*M* = .7885, *SD* = 38.10), (t(1,98) = -0.153, p = 0.878). Further, the only significant correlation was between the attention bias towards high vs low calorie words and the bias towards low calorie vs neutral words (r = -.213, p = .034).

Table 1

Pearson's correlations and descriptive statistics for study variables

	1	2	3	4	5	6	7
1. AB high-calorie words	–						
2. AB high-calorie pictures	-.02	–					
3. AB low-calorie words	-.07	.04	–				
4. AB low-calorie pictures	-.07	.21*	.07	–			
5. BMI	.13	.18	.13	-.11	–		
6. External eating	-.05	.16	-.03	.06	.04	–	
7. Restrained eating	-.02	.01	-.13	-.13	.11	.03	–
Mean	-3.33	4.24	3.61	-3.36	21.96	3.44	2.77
SD	35.63	37.90	36.73	37.76	2.88	.55	.89
Range	-84.08 to 129.88	-90.35 to 134.75	-114.73 to 80.73	-94.05 to 112.08	17.75 to 31.06	2.10 to 5.00	1.10 to 5.00
N	99	99	99	99	99	99	99

* significant at 0.05 level (2-tailed); AB = attentional bias (ms)

Discussion

The aim of the present study was to investigate whether differences in attentional bias exist between word and pictorial stimuli, and between high- and low-calorie stimuli. In addition, relationships between attentional bias and BMI, dietary restraint, and external eating were examined. The results indicated that neither stimuli type nor calorific value alone affected attentional bias, however, a significant interaction between these variables was found. When using pictures, a bias toward high-calorie foods and away from low-calorie foods was seen, whereas when using words the opposite pattern was observed. As low calorie foods were rated as more pleasant than high calorie foods on average, palatability of high calorie food cannot account for the findings. There were no associations between attentional bias and restraint, external eating, or BMI.

The significant interaction observed between stimuli type and calorific value provides new evidence for the importance of stimuli type in the food dot probe task, indicating that attentional bias outcomes vary depending on whether words or pictures are used, and whether they are high or low-calorie. The decision to incorporate task filler pairs that juxtaposed high- vs low-calorie foods may have led to increased salience of the calorific value of food stimuli and thereby contributed to the reported effect. We do not know whether participants would have responded differently to each set of words had they been presented separately. Nonetheless, the influence of calorific value on attentional bias outcomes may help to clarify inconsistencies in previous dot probe research. It may be that in studies that used a mixture of high and low-calorie picture stimuli (e.g., Loeber et al., 2011), participants selectively attended toward high-calorie pictures, and away from low-calorie pictures and this discrepancy would not have been detected as the stimuli used were of mixed calorific value. Calculation of an overall attentional bias score toward a mixed set of pictures would collapse together the biases toward high-calorie stimuli and away from low-calorie stimuli, leaving a negligible attentional bias index and potentially, a null effect. Indeed, the current data indicate negligible overall biases toward food pictures (0.44 ms), and words (0.14 ms). Similarly in previous food dot probe studies using word stimuli of mixed calorific value results may have been masked (e.g., Boon et al., 2000). For this reason it is recommended that in future studies, high- and low-calorie stimuli be grouped and analysed separately.

The pattern of the interaction effect, particularly the biases toward high calorie pictures and low calorie words, may be explained by existing research that indicates differential cognitive processing of pictures and words. Stimuli presented in picture form are more easily recalled (e.g., Noldy, Stelmack, & Campbell, 1990; Paivio & Csapo, 1973) and recognised (e.g., Shepard, 1967; Snodgrass, Volvovitz, & Walfish, 1972) than stimuli presented in word form; this phenomenon is known as the picture superiority effect. Pictures are more strongly related to affective information than words (Glaser & Glaser, 1989). In line with this prediction, De Houwer and Hermans (1994), Experiment 1 reported that the affective categorisation of a word was slowed down when the word was accompanied by a distracting picture. Words, however, did not interfere with affective categorisation of pictures. Moreover, pictures were categorised much faster than words. According to Glaser and Glaser (1989) such results indicate that pictures have privileged access to the network in which affective information is stored, known as the semantic executive system. Given that high calorie picture stimuli are biologically relevant and may reinforce previously experienced affective states such as pleasure, images of such foods in the dot probe task may be particularly visually attractive for participants. This may help to explain why there was an overall bias toward high calorie picture stimuli in the present study. Glaser and Glaser (1989) propose that the while the semantic executive system controls perception of pictures and action on objects, the lexical executive system controls perception and production of spoken and written language. Words can only access semantic (and thus affective) information after they have passed the lexicon. Electrophysiological responses to word and picture stimuli have shown that affective information indeed modulates the processing of pictures yet has little influence on the processing of words (Hinojosa, Carretie, Valcarcel, Mendez-Bertolo, & Pozo, 2009). Early stage processing of words is therefore more likely to draw on analytical rather than affective information. Assuming that participants had prior knowledge of low calorie foods (in this case fruits and vegetables) being a healthier choice than high calorie foods, this may explain why there was an overall bias toward low calorie word stimuli in the present study. It should be noted that the current results reflect the biases of a majority-female sample of undergraduates who, on average, rated low calorie, healthy foods as more pleasant than high calorie foods, and that other groups of individuals (such as overweight or those scoring high on restraint) may show a different pattern of biases when exposed to the same stimuli.

In this study no associations between food-related attentional bias and any of the individual difference variables were found. The lack of association between hunger and attentional bias is inconsistent with previous dot probe research (Mogg et al., 1998; Nijs et al., 2010), however this result was likely due to the majority of participants rating themselves as not hungry, therefore it is likely that the result was due to a restriction in range.

With regard to restraint, the current result supports prior research in which no relationship between restraint and attentional bias was found (Ahern et al., 2010; Boon et al., 2000). It has been suggested that the dot probe task may not be sensitive enough for non-clinical restrained eaters and is instead a better measure of attentional bias among patients with eating disorders (Boon et al., 2000). Certainly, the existence of attentional biases toward food and body-related cues is well documented in the latter population (Brooks et al., 2011; Faunce, 2002; Giel et al., 2011). Further, in a non-clinical sample, Diamantis (1992) found that rather than being linked with attentional bias, restraint was linked with a memory bias for food words, especially ‘forbidden’ food words. This relationship has been tested by Israeli and Stewart (2001), who found a relative memory bias for ‘forbidden’ food words in highly restrained eaters when compared to those with low levels of restraint. Therefore, whilst the present results indicate that relationship between restraint and attentional bias appears weak and difficult to detect, it may be worthwhile exploring other cognitive biases, such as memory bias, in restrained eaters.

There was no association between BMI and attentional bias, which may be in part due to the sample being predominantly of healthy weight. However, the lack of effect of BMI on attentional bias generally confirms existing research based on dot probe response latencies (Castellanos et al., 2009; Loeber et al., 2011; Pothos, Tapper, et al., 2009; Werthmann et al., 2011). Further, food-related attentional bias, as measured by the dot probe, has failed to predict changes in individuals' BMI at one-year follow up (Calitri, Pothos, Tapper, Brunstrom, & Rogers, 2010). As indicated by studies that combined the dot probe with eye-tracking (Castellanos et al., 2009; Werthmann et al., 2011), an association between BMI and attentional bias may only be detectable when using eye-tracking as it is a more sensitive measure of attentional allocation. Thus it may be worthwhile to add eye tracking to future dot probe studies to increase precision of measurement.

The finding of no association between external eating and attentional bias is consistent with some evidence (Pothos, Tapper, et al., 2009) yet conflicts with other reports (Brignell et al., 2009; Hepworth et al., 2010; Hou et al., 2011). In previous studies assessing attentional bias toward food pictures, external eating correlation coefficients were .42 (Brignell et al., 2009), .39 (Hepworth et al., 2010), and .36 (Hou et al., 2011). In contrast, the correlation coefficients found in the present study (.16 for high-calorie pictures and .06 for low-calorie pictures) are comparatively low. The mean scores for external eating, however, remain similar between this study and others (Hou et al., 2011; Hepworth et al., 2010). The relationship between external eating and attentional bias thus remains unclear and warrants further attention. Separating out high and low-calorie stimuli before conducting correlations with external eating may help to facilitate comparisons with the current findings.

The limitations of the current study should be considered when interpreting the results. Although there was a significant interaction effect indicating that relative to low calorie food stimuli, participants focussed more on high calorie stimuli when pictures were presented, whereas the reverse was true when words were presented. However, the absolute differences between response times to these stimuli did not differ from one another, as indicated by the follow-up t-tests. Further, the effect size of the significant interaction was small. We acknowledge that using 'plates' as a neutral word and picture stimulus may have elicited food-related thoughts, however options were limited as each food word was paired with a household object of matched word length and frequency.

Conclusions

In summary, the present study yielded a novel finding regarding the importance of stimuli in the dot probe task and is the first to examine stimuli type and calorific value of stimuli together. It was found that attentional bias outcomes vary depending on whether words or pictures are used, and whether they are high- or low-calorie. This finding may help to explain null effects in prior studies that mixed high- and low-calorie food stimuli together. Based on the finding it is recommended that in future high- and low-calorie stimuli be analysed separately. In the current study, no relationships were found between attentional bias and BMI, restraint, or external eating. Further research is therefore needed to clarify these associations, or lack thereof. In particular, it is advised that in future dot probe studies concurrent eye-tracking be employed in order to increase measurement precision. The present study has highlighted the complex nature of food-related attentional bias, and is a step toward a greater understanding of this phenomenon.

Acknowledgements

The authors would like to thank the University of Sydney Health Psychology Lab group for their helpful comments on an earlier draft of this manuscript

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Table S1

Summary of food dot probe attentional bias (AB) studies

Reference and country	Groups	*N*	Age *M (SD)*	Gender	BMI *M (SD)*	Measures	Dot probe stimuli	Parameters	Relevant results	AB found?
Ahern, Field, Yokum, Bohon, and Stice (2010) UK	High restraint (HR) Low restraint (LR)	63 across both groups	20.3 (0.47) 20.06 (0.35)	63/63 female	23.97 (0.64) 21.43 (0.53)	Dot probe BMI (self-reported) Height/weight DEBQ-R SRC task FRT THT POFS SPSRQ EDDS	Pictures: food. Foods rated least and most appetizing were used. Each food paired with household object.	Fixation cross 500ms Picture pair 500ms ITI 500ms 10 x practise 2 x buffer 1 block x 80 trials	No relation between restraint scores and AB. Both high and low scorers attended toward food cues over control stimuli	NO
Benas and Gibb (2011) USA	Healthy normal (HN)	202	18.93 (1.17)	202/202 female	23.25 (3.53)	Dot probe IAT EDE EDE-Q HRSD BDI-II Height/weight	Pictures: positive or negative facial expressions, food, and body. Each paired with neutral image, non-specified.	Fixation cross 1000ms Picture pair 1000ms ITI n.r. Trials n.r.	Neither depressive nor ED symptoms were correlated with any ABs	NO
Boon, Vogelzang, and Jansen (2000) The Netherlands	HR LR	29 30	n.r.	29/29 female 30/30 female	n.r.	Dot probe Restraint scale Word recognition Hunger	Words: 24 food paired with 24 home; and 24 weight/shape paired with 24 office.	Fixation stimulus n.r. Word pair 500ms 10 x practise 48 trials	No hyperattention or avoidance of food or weight/shape cues among restrained eaters.	NO

Reference and country	Groups	*N*	Age *M (SD)*	Gender	BMI *M (SD)*	Measures	Dot probe stimuli	Parameters	Relevant results	AB found?
Brignell, Griffiths, Bradley, and Mogg (2009) UK	High external eaters (HEX) Low external eaters (LEX)	19 24	30.58 (12.04) 36.5 (16.12)	17/19 female 18/24 female	26.53 (8.18) 29.03 (9.28)	Dot probe DEBQ-Ex BMI Grand hunger SLIM satiety scale EAT-26 Desire to eat Hrs between meals SRC Pleasantness rating task	Pictures: 20 food (mixture of high calorie and low calorie) paired with non-food matched controls 20 filler pairs non-food 12 food-control for practise and buffer trials.	Fixation cross 500ms Pic pair 500ms or 2000ms ITI 500ms or 1500ms 12 x practise 2 buffer 2 blocks x 120 trials (160 critical, 80 filler), 2 buffer between.	High external eaters showed greater AB for food cues than low external eaters at 2000ms, and a non-significant trend at 500ms.	YES
Calitri, Pothos, Tapper, Brunstrom, and Rogers (2010) UK	HN	151 at baseline 102 at 1-yr follow up	19 (1.0) 19 (1.0)	88/151 female 58/102 female	23.32 (3.52) 23.64 (3.50)	Dot probe DEBQ DASS Physical activity scale Height/weight Stroop (food and neutral words)	Words: 20 food (10 healthy, 10 unhealthy), 20 office	Fixation cross 500ms Word pair 500 or 1250ms ITI 1000ms 8 x prac. 4 x buffer 2 blocks x 80 trials, 4 buffer between	No AB or DEBQ indices predicted BMI change.	NO
Castellanos et al. (2009) USA	Obese (OB; fed or fasted) Normal weight (NW; fed or fasted)	18 18	29.5 (4.48) 27.61 (3.45)	18/18 female 18/18 female	38.69 (6.87) 21.73 (1.85)	Dot probe BMI Visual acuity TPQ BIS/BAS scales TFEQ DEBQ Hunger scale Eye Tracking Height/weight	Pictures: 20 high calorie food, 20 low calorie food, 20 nature scenery	Fixation cross 1000ms Pic pair 2000ms ITI n.r. Trials n.r.	No differences between conditions for dot probe. However, eye-tracking revealed NW more likely to shift gaze toward food rather than non-food when hungry rather than fed. In contrast OB focussed greater visual attention on food compared with non-food regardless of whether hungry or fed.	NO for dot probe

Reference and country	Groups	*N*	Age *M (SD)*	Gender	BMI *M (SD)*	Measures	Dot probe stimuli	Parameters	Relevant results	AB found?
di Pellegrino, Magarelli, and Mengarelli (2011) Italy	HN pre-satiety HN post-satiety	26 26 (same group, later session).	25.1 (n.r) across both groups	26/26 female 26/26 female	n.r.	Dot probe Hunger EAT-26	Pictures: 1 savoury food, 1 sweet food, 1 neutral food, 1 telephone token.	Fixation cross 800ms Pic pair 200 or 700ms Probe 100ms ITI 1000ms or 1500ms 24 practise 144 trials	The food-specific devaluation induced a reduction in AB for devalued (eaten) foods, and a decrease in perceived pleasantness of those foods. AB toward valued (uneaten) foods did not change significantly.	YES
Hepworth, Mogg, Brignell, and Bradley (2010) UK	HN Neutral mood HN Negative mood	37 43	20.4 (2.8) 21.0 (5.6)	37/37 female 43/43 female	22.8 (3.8) 22.3 (2.8)	Dot probe DEBQ BDI-II Mood VAS Appetite VAS MHQ POMS-A POMS-D PSS BIS/BAS scales SDS Height/weight	Pictures: 20 food (mixture of high calorie and low calorie) paired with non-food matched controls 20 filler pairs non-food 12 food-control for prac. and buffer trials.	Fixation cross 500ms Pic pair 500ms or 2000ms ITI 500ms or 1500ms 12 x practise 2 buffer 2 blocks x 120 trials (160 critical, 80 filler), 2 buffer between.	Induced negative mood increased attentional bias to food cues. Correlational analyses showed that AB was also positively associated with measures of trait eating style (emotional, external and restrained eating), perceived stress, and dysphoria.	YES
Hou et al. (2011) UK	HN	42	22.0 (4.7)	29/42 female	21.75 (3.36)	Dot probe DEBQ-Ex BIS BAS SPSRQ Grand Hunger Height/weight	Pictures: 20 food (mixture of high calorie and low calorie), 20 home objects. Extra 10 non-food fillers, extra 10 food-control for buffer and practice trials.	Fixation cross 500ms Pic pair 2000ms 10 practise 2 buffer 120 trials (80 food-nonfood critical, 40 filler)	AB for food cues correlated positively with external eating and trait impulsivity.	YES

Reference and country	Groups	*N*	Age *M (SD)*	Gender	BMI *M (SD)*	Measures	Dot probe stimuli	Parameters	Relevant results	AB found?
Johansson, Ghaderi, and Andersson (2004) UK	HEX LEX	22 21	22.23 (2.11) 22.24 (2.21)	22/22 female 21/21 female	21.76 (1.16) 22.19 (1.12)	Dot probe DEBQ Rosenberg Self-Esteem Scale BSQ EAT-26 Stroop (voice response; food, body shape)	Words: 10 high calorie food, 10 body/shape, 20 neutral words. Extra 10 neutral word pairs for filler material.	Fixation cross n.r. Word pair 500 ms ITI 500ms 10 practise 80 trials	High external eaters directed attention away from food words, whereas low external eaters directed attention toward food words on the dot probe task. No differences found for Stroop task.	YES
Kemps and Tiggemann (2009): Study 1 Australia	HN choc cravers (CC) HN non-cravers (NC)	40 40	19.70 (2.08) across both groups	40/40 female 40/40 female	21.60 (3.30) 22.60 (3.70)	Dot probe General attention Response speed Trait chocolate craving Grand Hunger DEBQ-R EAT-26	Pictures: 8 chocolate-containing, 8 non-choc palatable, 16 transport. Stimulus pairs: Critical choc-food, Control food-food, Filler transport-transport.	Fixation cross 1000ms Pic pair 500ms ITI 500ms 12 practise 2 buffer 96 trials	Chocolate cravers showed an AB for chocolate cues. No differences between groups in hunger, restraint, ED symptomatology, general attention, or response speed. The AB stemmed from difficulty in disengaging attention from chocolate cues rather than hypervigilence toward chocolate cues.	YES
Kemps and Tiggemann (2009): Study 2 Australia	HN craving manipulation (CM) HN control	53 53	21.14 (2.42) across both groups	106/106 female	23.10 (5.70) 23.40 (8.00)	Dot probe General attention Response speed Trait chocolate craving Grand Hunger DEBQ-R EAT-26 Chocolate rating VAS Chocolate craving VAS	Pictures: 8 chocolate-containing, 8 non-choc palatable, 16 transport. Stimulus pairs: Critical choc-food, Control food-food, Filler transport-transport.	Fixation cross 1000ms Pic pair 500ms ITI 500ms 12 practise 2 buffer 96 trials	Individuals in whom a craving for chocolate was induced showed an AB for chocolate cues. The AB stemmed from difficulty in disengaging attention from chocolate cues rather than hypervigilence toward chocolate cues.	YES

Reference and country	Groups	*N*	Age *M (SD)*	Gender	BMI *M (SD)*	Measures	Dot probe stimuli	Parameters	Relevant results	AB found?
Lee and Shafran (2008) UK	ED patients Hi anxiety controls (ANX) HN low shape concern (HNL) HN mod. shape concern (HNM) HN high shape concern (HNH)	23 19 31 21 23	22.17 (3.58) 26.26 (7.52) 23.39 (6.69) 27.90 (8.26) 24.26 (5.63)	23/23 female 19/19 female 31/31 female 21/21 female 23/23 female	21.79 (4.98) 22.33 (3.35) 22.21 (2.34) 25.04 (5.62) 25.21 (3.29)	Dot probe EDEQ BDI-II BAI Height/weight	Pictures: positive, negative, neutral eating/shape; neutral weight; animal controls.	Fixation digit 1000ms Pic pair 1000ms ISI 500ms or 2000ms 84 trials	ED patients had an AB toward positive and negative eating stimuli, negative and neutral shape stimuli and weight stimuli when using an ISI of 500 ms. However, with an ISI of 2000 ms patients attended only to weight stimuli.	YES but only at 500ms ISI
Lee, Shafran, and Fairburn (2004) UK Conference abstract.	ED (self-reported) HN	n.r. n.r.	n.r.	All female	n.r. n.r.	Dot probe EDEQ	Pictures: positive, negative, or neutral eating, shape/weight; animal controls.	Fixation cross n.r. Pic pair 1000ms ITI n.r. Trials n.r.	Participants with eating disorders showed AB toward negative eating stimuli and away from positive eating stimuli as compared to other groups. AB correlated with restraint and eating concerns.	YES
Loeber et al. (2011) Germany	OB HN	20 20	47.90 (12.50) 44.90 (11.70)	20/20 female 20/20 female	38.80 (6.30) 22.60 (1.10)	Dot probe TFEQ BIS Grand Hunger Go/no-Go D2 Test of attention Auditive verbal learning Trail-making test WCS	Pictures: 20 food (mixture of high calorie and low calorie), 20 objects. Extra 40 neutral objects for filler.	Fixation cross 500ms Pic pair 50ms ITI n.r. 160 trials	No AB toward food cues for OB or HN. Salience of the food cues seems too low for such an early modulation of attention.	NO
Loeber, Grosshans, Herpertz, Kiefer, and Herpertz (2013) Germany	Hungry Sated	18 30	24.28 (4.50) 24.68 (4.81)	27/28 female and 21/48 male across both groups	21.63 (1.84) 21.60 (2.35)	Dot probe TFEQ Grand Hunger Go/no-Go Blood glucose level (BGL)	Pictures: 20 food (mixture of high calorie and low calorie), 20 objects. Extra 40 neutral objects for filler.	Fixation cross 500ms Pic pair 50ms or 500ms ITI 1000ms 160 trials	No difference in AB between hungry and sated groups, although hungry participants had longer reaction times in general. Participants with a lower BGL had a bias toward food cues and those with a higher BGL showed an avoidance of food cues.	NO for hunger. YES for BGL at 50ms

Reference and country	Groups	*N*	Age *M (SD)*	Gender	BMI *M (SD)*	Measures	Dot probe stimuli	Parameters	Relevant results	AB found?
Mogg, Bradley, Hyare, and Lee (1998) UK	Low hunger (LH) High hunger (HH)	15 16	20.90 (2.00) 20.60 (0.90)	7/15 female 9/16 female	n.r. n.r.	Dot probe Lexical decision task Grand Hunger EAT-26	Words: 64 food-related (mixture of high calorie and low calorie), 64 transport. Extra 64 neutral filler word pairs	Fixation cross 500ms Word pair 14ms or 500ms. ITI 500ms or 1500ms 12 practise 128 trials	Participants with high hunger showed a greater AB for food words presented for 500ms compared with those with low hunger No hunger-related bias found in pre-attentive processes (14ms and masked presentation).	YES
Newman, O'Connor, and Conner (2005) UK Conference abstract.	HEX LEX	32 stress or control 37 stress or control	n.r. n.r.	n.r. n.r.	n.r. n.r.	Dot probe Stroop (food words)	Words: food, control.	n.r.	Null effects for dot probe. For Stroop, high external eaters showed an increased bias when stressed, and low external eaters demonstrated the opposite pattern.	NO for dot probe
Nijs, Muris, Euser, and Franken (2010) The Netherlands	OV/OB sated OV/OB hungry NW sated NW hungry	13 13 20 20	22.08 (3.01) 20.92 (3.71) 20.60 (1.60) 22.15 (1.46)	13/13 female 13/13 female 20/20 female 20/20 female	29.85 (2.98) 30.14 (5.96) 20.76 (1.05) 20.50 (1.24)	Dot probe DEBQ Eye tracking EEG/ERP Bogus taste test Hunger VAS Height/weight	Pictures: 15 high calorie snacks paired with 15 office items. Extra 10 pairs of tool pictures for filler.	Fixation cross 1000ms Pic pair 100ms or 500ms ITI 500ms 10 practise 4 blocks x 100 trials	At 100ms, there was an AB towards food pictures in hungry vs. satiated participants, and in OV/OB (especially hungry OV/OB) vs. NW. The latter finding only approached significance. No between-condition differences for 500ms trials. Results suggest all participants demonstrated maintained attention to food, irrespective of weight group or condition.	YES for hungry at 100ms. NO for 500ms
Papies, Stroebe, and Aarts (2008) Study 1 The Netherlands	HR food pre-exposure HR non-exposure LR food pre-exposure LR non-exposure	104 across all groups	n.r.	79/104 female	n.r.	Dot probe Lexical decision task Revised restraint scale Hedonic ratings	Words: 10 palatable food-office pairs and 10 control food-office pairs. Extra 20 filler word pairs.	Fixation cross 500ms Word pair 200ms ITI n.r. 20 practise 2 blocks x 80 trials.	After exposure to food cues, restrained eaters allocated attention towards hedonically rated food.	YES

Reference and country	Groups	*N*	Age *M (SD)*	Gender	BMI *M (SD)*	Measures	Dot probe stimuli	Parameters	Relevant results	AB found?
Papies et al. (2008) Study 2 The Netherlands	HR food pre-exposure HR non-food pre-exposure HR food pre-exposure plus prime LR food pre-exposure LR non-food pre-exposure LR food pre-exposure plus prime	138	n.r.	98/138 female	n.r.	Dot probe Lexical decision task Revised restraint scale Hedonic ratings	Words: 10 palatable food-office pairs and 10 control food-office pairs. Extra 20 filler word pairs. 5 restraint-related words for diet priming.	Fixation letter strings 250ms Prime 30ms Postmask letter string 350ms Word pair 200ms ITI n.r. 20 practise 2 blocks x 80 trials.	After exposure to food cues, restrained eaters allocated attention towards hedonically rated food. Restrained eaters' AB did not occur when they were primed with the concept of dieting.	YES
Placanica, Faunce, and Soames Job (2002) Australia	High EDI fasted High EDI nonfasted Low EDI fasted Low EDI nonfasted	19 19 19 19	18.10 (n.r.) across all groups	56/56 female	n.r.	Dot probe EDI-2 Grand Hunger Scale Word rating scales	Words: 14 high calorie and 14 low calorie food paired with household items; 14 negative and 14 positive weight/shape paired with transport.	Word pair 500ms ISI 50ms ITI 1000ms 224 trials	Fasting increased AB toward high calorie foods across all participants. High EDI-2 scorers showed an AB toward low calorie food words, but only when nonfasted.	YES
Pothos, Tapper, and Calitri (2009) UK	HN	128	18.70 (0.78)	69/128 female	22.74 (2.94)	Dot probe Food Stroop EAST Recognition task DEBQ DASS BPAS Height/weight	Words: 10 unhealthy food and 10 healthy food, paired with 20 office. 12 number words for prac. and buffer.	Fixation cross 500ms Word pair 500ms or 1250ms ITI 1000ms 8 practise 4 buffer 2 blocks x 80 trials	BMI did not predict any indices of AB. In females, dietary restraint was positively correlated with AB toward healthy foods. No significant correlations between AB and emotional or external eating.	YES for restraint in females

Reference and country	Groups	*N*	Age *M (SD)*	Gender	BMI *M (SD)*	Measures	Dot probe stimuli	Parameters	Relevant results	AB found?
Shafran, Lee, Cooper, Palmer, and Fairburn (2007) Study 1 UK	ED patients	23	22.17 (3.58)	23/23 female	21.79 (4.98)	Dot probe BAI EDE Height/weight Emotional valence ratings BDI-II	Pictures: 6 positive eating, 6 negative eating, 6 neutral eating, 24 body-related, paired with animals.	Fixation stimulus 1000ms Pic pair 1000ms ITI n.r. 2 practise 84 trials	ED patients had an AB toward negative eating stimuli and an avoidance of positive eating stimuli.	YES
	ANX	19	26.26 (7.52)	19/19 female	22.33 (3.35)					
	HNL	31	23.39 (6.69)	31/31 female	22.21 (2.34)					
	HNM	21	27.90 (8.26)	21/21 female	25.04 (5.62)					
	HNH	23	24.26 (5.63)	23/23 female	25.21 (3.29)					
Shafran et al. (2007) Study 2 UK	ED patients	82	25.87 (6.92)	82/82 female	21.59 (4.12)	Dot probe EDE-Q	Pictures: 6 positive eating, 6 negative eating, 6 neutral eating, 24 body-related, paired with animals.	Fixation stimulus 1000ms Pic pair 1000ms ITI n.r. 2 practise 84 trials	ED patients had an AB toward negative eating stimuli and a bias away from positive eating stimuli.	YES
	HN	44	26.41 (6.50)	44/44 female	23.09 (3.92)					
Shafran, Lee, Cooper, Palmer, and Fairburn (2008) Study 2[a] UK	ED patients	31	26.03 (6.94)	31/31 female	22.72 (4.24)	Dot probe EDE-Q	Pictures: 6 positive eating, 6 negative eating, 6 neutral eating, 24 body-related, paired with animals.	Fixation stimulus 1000ms Pic pair 1000ms ITI n.r. 2 practise 84 trials	AB toward positive and negative eating stimuli reduced with cognitive-behavioural treatment.	YES

Reference and country	Groups	*N*	Age *M (SD)*	Gender	BMI *M (SD)*	Measures	Dot probe stimuli	Parameters	Relevant results	AB found?
Tapper, Pothos, and Lawrence (2010) UK	HN	105	22.70 (4.69)	69/105 female	22.90 (3.14)	Dot probe Hunger VAS BAS	Pictures: 10 appetizing foods, 10 bland foods, 50 household items.	Fixation cross 500ms Pic pair 100ms, 500ms, or 2000ms ITI 500ms 10 practise 4 buffer 3 blocks x 120 trials	There was an AB for appetizing foods at 100ms, 500ms, and 2000ms. Bias at 100ms and 500ms likely due to delayed disengagement rather than enhanced orienting. However, at 2000ms there was evidence for both. Hunger predicted AB to all food cues at 100ms, but not 500 or 2000ms. Trait reward-drive predicted delayed disengagement from appetizing foods at 100ms.	YES
Werthmann (2011) The Netherlands	Overweight/ Obese (OW/OB) NW	22 29	19.86 (1.28) 19.31 (1.95)	22/22 female 29/29 female	28.03 (3.74) 21.16 (2.03)	Dot probe Eye Tracking Restraint Scale DEBQ-Ex PFS PANAS Craving VAS Satiety VAS Height/weight (self-reported)	Pictures: Palatable foods paired with musical instruments, filler office-traffic picture pairs.	Fixation cross n.r. Pic pair 2000ms ITI n.r. 120 trials (80 critical, 40 filler).	Dot probe RT bias score did not differ between groups. However, eye tracking data showed OW/OB directed first gaze more often toward high-fat food images than NW, but subsequently showed reduced maintenance of attention on these pictures. OW/OB consumed more snack food than NW.	NO for dot probe
Werthmann (2013) The Netherlands	HR LR	24 21	21.50 (1.34) 21.87 (2.66)	24/24 female 21/21 female	21.77 (1.59) 21.11 (1.60)	Dot probe Eye Tracking Restraint Scale Hunger VAS BMI (self-reported)	Pictures: High calorie foods paired with musical instruments, filler office-traffic picture pairs.	Fixation cross n.r. Pic pair 2000ms ITI n.r. 120 trials (80 critical, 40 filler).	For both dot probe and eye tracking, all participants showed an AB toward food cues, irrespective of restraint status.	NO

Note: ITI = inter-trial interval; ISI = inter-stimulus interval; DEBQ-R = Dutch Eating Behaviour Questionnaire–Restraint; SRC = Stimulus Response Compatibility; FRT = Food Reinforcement Task; THT = Taste Habituation Task; POFS = Power of Food Scale; SPSRQ = Sensitivity to Punishment Sensitivity to Reward Questionnaire; EDDS = Eating Disorders Diagnostic Scale; IAT = Implicit Association Test; EDE = Eating Disorder Examination; EDE-Q = Eating Disorder Examination Questionnaire; HRSD = Hamilton Rating Scale for Depression; BDI-II = Beck

Depression Inventory; DEBQ-Ex = Dutch Eating Behaviour Questionnaire–External Eating; EAT-26 = Eating Attitudes Test; DASS = Depression, Anxiety, and Stress Scale; TPQ = Tridimensional Personality Questionnaire; BIS/BAS = Behavioural Inhibition System/Behavioural Activation System; TFEQ = Three-Factor Eating Questionnaire; VAS = visual analogue scale; MHQ = Modified Hunger Questionnaire; POMS-A = Shortened Profile of Mood States: Tension/Anxiety; POMS-D = Shortened Profile of Mood States: Depression; SDS = Social Desirability Scale; BSQ = Body Shape Questionnaire; BAI = Beck Anxiety Inventory; WCS = Wisconsin Card Sorting Test; EEG/ERP = Electroencephalography/Event-related Potentials; EDI-2 = Eating Disorder Inventory–2; EAST = Extrinsic Affective Simon Task ; BPAS = Brief Physical Assessment Tool; PANAS = Positive and Negative Affect Scale.

[a] Shafran et al. (2008) Study 1 omitted from table as it is a duplicate of Shafran et al. (2007) Study 2

Table S2. ***Word and pictorial stimuli pairs***

Category		Image	Word	WL	WF	Image	Word	WL	WF
High-calorie food–Neutral (household items)	*Pair 1*		SUGAR	5	3237		CLOCK	5	2785
	Pair 2		BUTTER	6	1977		PLATES	6	1776
	Pair 3		BACON	5	881		TOWEL	5	871
	Pair 4		DOUGHNUTS	9	55		DETERGENT	9	76
	Pair 5		LOLLIES	7	23		BATHTUB	7	25
Low-calorie food–Neutral (household items)	*Pair 1*		APPLE	5	2020		BOXES	5	2471
	Pair 2		POTATO	6	871		BUCKET	6	997
	Pair 3		PLUM	4	280		HOSE	4	248
	Pair 4		CHERRIES	8	210		DOORBELL	8	216
	Pair 5		STRAWBERRIES	12	271		REFRIGERATOR	12	297

Category		Image	Word	WL	WF	Image	Word	WL	WF
Fillers: High-calorie food–Low-calorie food	*Pair 1*		CHIPS	5	1723		BEANS	5	1322
	Pair 2		SAUSAGE	7	513		CARROTS	7	474
	Pair 3		HAMBURGER	9	99		ASPARAGUS	9	100
	Pair 4		COOKIES	7	63		PEACHES	7	94
	Pair 5		ICE CREAM	8	32		BEETROOT	8	30
Fillers: Neutral (music-related)–Neutral (travel-related)	*Pair 1*		GUITAR	6	2705		CAMERA	6	2588
	Pair 2		BELL	4	1714		TAXI	4	1879
	Pair 3		HEADPHONES	10	203		TOOTHBRUSH	10	124
	Pair 4		VIOLINS	7	131		PADLOCK	7	117
	Pair 5		CYMBALS	7	51		SNOWMAN	7	58

Category		Image	Word	WL	WF	Image	Word	WL	WF
Practice trial stimuli: Neutral (animals)–Neutral (clothing)	*Pair 1*		SEAL	4	872		HATS	4	845
	Pair 2		MONKEY	6	542		SHORTS	6	584
	Pair 3		FROGS	5	449		SCARF	5	467
	Pair 4		SWAN	4	250		SOCK	4	194
	Pair 5		GOLDFISH	8	221		RAINCOAT	8	255

Note: WL = Word length in characters; WF = Word frequency per million words according to the British National Corpus (http://ucrel.lancs.ac.uk/bncfreq/). Images sourced from copyright-free stock image websites (http://www.dreamstime.com and http://www.istockphoto.com)