



Archived at the Flinders Academic Commons:

<http://dspace.flinders.edu.au/dspace/>

This is the authors' version of an article published in *Journal of Experimental Psychology: Applied*. The original publication is available by subscription at:

<http://www.apa.org/pubs/journals/xap/index.aspx>

doi:10.1037/xap0000005

Please cite this article as:

Kemps, E., Tiggemann, M., Orr, J., & Grear, J. (2014).  
Attentional re-training can reduce chocolate consumption.  
*Journal of Experimental Psychology: Applied*, 20, 94-102.

Copyright (2014) American Psychological Association. All rights reserved.

This article may not exactly replicate the final version published in the APA journal. It is not the copy of record.

In press: Journal of Experimental Psychology: Applied

## Attentional Re-Training Can Reduce Chocolate Consumption

Eva Kemps, Marika Tiggemann, Jenna Orr and Justine Gear

School of Psychology, Flinders University, Adelaide, Australia

### Author Note

Eva Kemps, Marika Tiggemann, Jenna Orr and Justine Gear, School of Psychology, Flinders University, Adelaide, Australia.

This research was supported under the Australian Research Council's Discovery Project funding scheme (project number DP130103092).

We are grateful to Paul Douglas for developing the software for the computerised administration of the modified dot probe task.

Correspondence concerning this article should be addressed to Eva Kemps, School of Psychology, Flinders University, GPO Box 2100, Adelaide, SA 5001, Australia. Electronic mail may be sent to [Eva.Kemps@flinders.edu.au](mailto:Eva.Kemps@flinders.edu.au)

### Abstract

There is emerging evidence that attentional biases are related to the consumption of substances such as alcohol and tobacco, and that attentional bias modification can reduce unwanted consumption of these substances. We present evidence for the first time that the same logical argument applies in the food and eating domain. We conducted two experiments which used a modified dot probe paradigm to train undergraduate women to direct their attention toward ('attend') or away from ('avoid') food cues (i.e., pictures of chocolate). In Experiment 1, attentional bias for chocolate cues increased in the 'attend' group, and decreased in the 'avoid' group. Experiment 2 showed that these training effects generalised to novel, previously unseen, chocolate pictures. Importantly, attentional re-training affected chocolate consumption and craving. In both experiments, participants in the 'avoid' group ate less chocolate in a so-called taste test than did those in the 'attend' group. Additionally, in Experiment 2, but not in Experiment 1, the 'attend' group reported stronger chocolate cravings following training, whereas the 'avoid' group reported less intense cravings. The results support predictions of cognitive-motivational models of craving and consumption that attentional biases play a causal role in consumption behaviour. Furthermore, they present a promising avenue for tackling unwanted food cravings and (over)eating.

*Keywords:* food cues; attentional bias modification; dot probe task; consumption; craving

### Attentional Re-Training Can Reduce Chocolate Consumption

One particularly salient feature of contemporary Western environments is an abundance of food cues. We are continually bombarded with images of food and eating – in shops, fast food outlets, magazines, on bill-boards, public transport, and television. Further, it has been clearly established that the mere presence of such food cues can stimulate people's desire to eat and increase their food intake. For example, Fedoroff, Polivy and Herman (1997, 2003) showed that seeing and smelling freshly baked chocolate-chip cookies increased cravings for, and subsequent consumption, of these cookies. Similarly, Painter, Wansink and Hieggelke (2002) found that office workers ate more chocolates if these were in plain view on the desk than if they were in a drawer. Thus the omnipresence of densely calorific food and associated food images has been accepted as a contributing factor to widespread overeating and the increasing rates of obesity (Westerterp & Speakman, 2008).

One influential general theory that provides a coherent account for the observed link between cue exposure and consumption behaviour is Robinson and Berridge's (1993) incentive sensitisation model of craving and addiction. In this model, reward-related cues in the environment, such as drug-associated stimuli, acquire motivational properties, or incentive salience, through classical conditioning (i.e., repeated association between the cue and intake of the rewarding substance). Consequently, these cues come to be perceived as attractive and 'wanted'. As a result, reward-related cues automatically capture (i.e., bias) attention, stimulate craving, and guide behaviour toward substance acquisition and consumption. These processes are regulated by the dopaminergic system, and occur outside of conscious awareness.

Attentional biases have now been shown for a wide range of rewarding substances, including alcohol (Townshend & Duka, 2001), tobacco (Waters,

Shiffmann, Bradley & Mogg, 2003), drugs (Franken, Kroon, Wiers & Jansen, 2000) and caffeine (Yeomans, Javaherian, Tovey & Stafford, 2005). In addition, several studies have reported a positive correlation between attentional bias and subjective craving (Mogg & Bradley, 2002; Field, Mogg & Bradley, 2004; Field, Mogg & Bradley, 2005), although others have found no relationship (Ehrman et al., 2002; Field, Eastwood, Bradley & Mogg, 2006; Lubman, Peters, Mogg, Bradley & Deakin, 2000; Wertz & Sayette, 2001). Perhaps not surprisingly, a recent meta-analysis concluded that attentional bias indices across a range of rewarding substance cues (tobacco, alcohol and drugs) were positively correlated with subjective craving, but that the overall effect size was small ( $r = .19$ ) (Field, Munafo & Franken, 2009). The relationship with consumption has been less studied, although Fadardi and Cox (2008) showed that attentional bias for alcohol-related words predicted alcohol consumption in university students, in support of the model.

Although Robinson and Berridge's (1993) framework was originally developed for substances of abuse, we argue that it can be applied equally to food. Indeed, attentional biases for food cues have been well documented (Brignell, Griffiths, Bradley & Mogg, 2009; Green & Rogers, 1993). Such biases have, however, only recently been linked to craving and consumption. Specifically, Kemps and Tiggemann (2009) reported a positive correlation between attentional bias and craving for chocolate, while Nijs, Muris, Euser and Franken (2010) reported a positive correlation between attentional bias and consumption of high-caloric snack foods.

If the logic of the Incentive Sensitization model is correct and applies to food and eating, then one potential way to curb unwanted (over)consumption of food or other substances might be to modify the underlying attentional processes proposed to

cause substance seeking behaviour and consumption. Emerging evidence from alcohol research supports this possibility. For example, using a modified dot probe task, Field and Eastwood (2005) showed that an experimental manipulation of attentional bias for alcohol cues affected beer consumption in heavy social drinkers. Specifically, participants who were trained to direct their attention *toward* alcohol-related pictures ('attend alcohol') showed an increased attentional bias for such pictures; in contrast, participants who were trained to direct their attention *away* from these pictures ('avoid alcohol') showed a reduced bias. Importantly, participants in the avoid group drank less beer in a subsequent taste test than those in the attend group. In addition, attentional re-training also affected cravings, such that participants in the attend group reported an increased urge to drink alcohol. Similarly, using a modified Stroop task, Fadardi and Cox (2009) found that training hazardous and harmful drinkers to ignore alcoholic stimuli reduced both their attentional bias for, and consumption of, alcohol. Some other attentional bias modification studies in heavy drinkers (Schoenmakers, Wiers, Jones, Bruce & Jansen, 2007) and alcoholic patients (Schoenmakers et al., 2010) have also reported reductions in attentional bias for alcohol cues. In the latter study, although there was no resulting effect on craving or preference for an alcoholic beverage, attentional re-training also delayed time to relapse among the alcoholic patients (Schoenmakers et al., 2010).

Studies on attentional bias modification in relation to smoking have similarly found effects of attentional re-training on attentional bias for smoking-related cues; however, increasing or decreasing attentional bias for smoking-related cues did not affect tobacco seeking behaviour (Field, Duka, Tyler & Schoenmakers, 2009) or smoking topography (e.g., number of puffs taken, puff volume) (Attwood, O'Sullivan, Leonards, Mackintosh & Munafò, 2008). The latter study did, however,

find an effect of attentional bias modification on cigarette craving, with male smokers in the ‘attend smoking’ group reporting an increased urge to smoke. More generally, attentional bias modification has been shown to reduce symptoms of anxiety (Amir, Beard, Burns & Bomyea, 2009; Hazen, Vasey & Schmidt, 2009; Schmidt, Richey, Buckner & Timpano, 2009) and attenuate emotional responses to a subsequent stressor (MacLeod, Rutherford, Campbell, Ebsworthy & Holker, 2002; See, MacLeod & Bridle, 2009).

To date there have been no studies that have investigated attentional bias modification in the food and eating domain. Although the results from studies on alcohol and tobacco use are mixed, they do suggest that attentional bias modification might affect craving and consumption. The aim of the present experiments was to investigate the effect of attentional re-training on chocolate craving and consumption. Chocolate was chosen because it is a popular food that is generally well-liked. It is also the most commonly craved food in Western cultures (Hetherington & Macdiarmid, 1993), which makes it particularly suitable to test for any effect of attentional bias modification.

We used a well-established cognitive experimental procedure, the modified dot probe task, developed by MacLeod et al. (2002), to increase or decrease attentional bias for chocolate by directing attention either *toward* (‘attend’) or *away* (‘avoid’) from chocolate cues. We collected ratings of chocolate craving before and after attentional re-training. Following Field and Eastwood (2005), we used a taste test procedure to assess chocolate consumption. Participants were presented with a chocolate and a comparable non-chocolate food product, and asked to taste and rate these on a number of dimensions. Finally, we also measured participants’ awareness of the experimental contingencies used during the training to examine its potential

role on training effects. Findings from previous attentional bias modification studies on alcohol and cigarette cravings have been mixed. While some have found that training effects were restricted to participants who were aware of the experimental contingencies (Attwood, O'Sullivan, Leonards, Mackintosh & Munafò, 2008; Field et al., 2007), others found that contingency awareness did not influence training effects (Field et al., 2005; Field, Duka, Tyler & Schoenmakers, 2009). Experiment 1 used the same stimuli throughout. Experiment 2 examined whether the effects of attentional re-training would generalise to novel (i.e., not previously seen) chocolate stimuli.

## Experiment 1

### Method

**Participants.** Participants were 110 female undergraduate students at Flinders University who took part for course requirements and credit. They were aged between 18 and 26 years ( $M = 20.43$ ,  $SD = 2.24$ ). We specifically recruited a sample of young women, because food cravings are more prevalent in women than in men (Weingarten & Elston, 1991), and decrease in frequency and intensity with age (Pelchat, 1997). As hunger has been linked to attentional biases for food (Mogg, Bradley, Hyare & Lee, 1998), participants were instructed to eat something two hours before their testing session to ensure they were not hungry. All participants reported having complied with this instruction. Additionally, participants rated their level of hunger on a 100-mm visual analogue scale, ranging from “not hungry at all” to “extremely hungry”. Hunger ratings were relatively low ( $M = 28.75$ ,  $SD = 17.84$ ), and importantly, did not correlate with attentional bias scores at pre-test,  $r = .00$ ,  $p > .05$ , or post-test,  $r = -.01$ ,  $p > .05$ . Furthermore, all participants reported that they liked chocolate, in response to



the yes/no question “Do you like chocolate?”, and consumed on average 1.54 ( $SD = 1.23$ ) chocolate bars and 2.81 ( $SD = 2.07$ ) chocolate-containing food items per week.

**Design.** The experiment used a 2 (training condition: attend, avoid)  $\times$  2 (time: pre-test, post-test) between-within subjects design. Participants were randomly assigned to the training conditions, subject to equal numbers per condition.

**Materials.** The stimuli for the modified dot probe task were 48 digital coloured photographs comprising 16 pictures of chocolate or chocolate-containing food items and 32 pictures of highly desired food items not containing chocolate. Appendix A lists the chocolate and non-chocolate food categories shown in these pictures. All pictures were scaled to 120mm in width, whilst maintaining the pictures’ original aspect ratio. Two sets of stimulus pairs were constructed: critical (chocolate – non-chocolate) and control (non-chocolate – non-chocolate), with 16 picture pairs per set. Within each pair, pictures were matched as closely as possible for perceptual characteristics (i.e., height, brightness, complexity), as well as 9-point Likert scale ratings of valence, arousal and category representativeness, which were obtained from a pilot study conducted with an undergraduate student sample of 20 women aged 18 to 30 years ( $M = 22.65$ ,  $SD = 2.78$ ). Another 14 picture pairs, with no food related content (e.g., car, beach ball), were created for practice and buffer trials.

**Procedure.** Participants were tested individually in a quiet room in the Applied Cognitive Psychology Laboratory in a single session of 45 min. duration. All participants were tested in the afternoon, because food cravings occur more frequently after midday (Hill, Weaver & Blundell, 1991). Participants were seated approximately 50 cm in front of an IBM compatible computer with a 22-inch monitor. After giving informed consent, participants completed a brief demographics questionnaire, which included the hunger measure, followed by the modified dot probe task.

Following standard attentional bias modification protocols (Field & Eastwood, 2005), the modified dot probe procedure consisted of three phases: (1) a pre-training baseline assessment of participants' attentional bias for chocolate (pre-test), (2) a training phase in which half the participants were trained to attend to chocolate, and the other half were trained to avoid chocolate, and (3) a post-training assessment of participants' attentional bias for chocolate similar to the pre-test (post-test).

**Pre-test.** At pre-test, participants completed a standard dot probe task. On each trial, a fixation cross was displayed in the centre of the screen for 500 ms, followed by the presentation of a picture pair for 500 ms. The pictures were displayed on either side of the central position, with a distance of 40 mm between their inner edges. A dot probe was then displayed in the location of one of the previously presented pictures. Participants were asked to indicate as quickly as possible whether the dot probe appeared in the location previously occupied by the left or the right picture, by pressing the corresponding keys labelled L ('z') and R ('/') on the computer keyboard. The dot probe remained displayed until a response was made. The inter-trial interval was 500 ms.

The task commenced with 12 practice trials, followed by 2 buffer trials and 128 experimental trials. In the experimental trials, each of the 16 critical (chocolate – non-chocolate) picture pairs and each of the 16 control (non-chocolate – non-chocolate) picture pairs was presented four times, once for each of the picture location (left or right) × dot probe location (left or right) combinations. Thus probes replaced each of the pictures in each pair with equal frequency (50/50). Trials were presented in a new randomly chosen order for each participant.

Following this task, participants rated their current level of chocolate craving by placing a vertical mark on a 100-mm visual analogue scale, ranging from “no

desire or urge to eat chocolate” to “extremely strong desire or urge to eat chocolate”. Such self-report is argued to provide the most appropriate measure of chocolate craving (Pelchat, 2002).

**Training.** In the attentional re-training phase, participants completed a modified dot probe task. Only the 16 critical (chocolate – non-chocolate) picture pairs were used. These were each presented 16 times, for a total of 256 trials, with each picture presented 8 times on each side of the screen. Attentional bias was manipulated by varying the location of the dot probes for the two training conditions. Specifically, for participants in the attend condition, dot probes replaced chocolate pictures on 90% of trials and non-chocolate pictures on 10% of trials, designed to direct attention toward chocolate cues. For participants in the avoid condition, these contingencies were reversed, that is dot probes replaced chocolate pictures on 10% of trials and non-chocolate pictures on 90% of trials, designed to direct attention away from chocolate cues. A 90-10 distribution was used, as opposed to a 100-0 one, to reduce the obviousness of the contingency (Schoenmakers et al., 2007).

**Post-test.** The post-test was similar to the pre-test, except that there were no practice trials. Subsequently, participants again rated their current level of chocolate craving, followed by a so-called taste test to assess chocolate consumption (Field & Eastwood, 2005). Participants were presented with two equal size muffins of the same brand: one chocolate and one blueberry. These were presented together, with order of muffin (left versus right) counterbalanced across participants and conditions. Participants were instructed to taste each muffin and rate it on several dimensions (e.g., sweetness, texture, likeability). Participants were told that they could sample as much of each muffin as they wished, and were given 10 min. to make their ratings.

Muffins were weighed out of participants' sight before, and again after, the taste test to determine how much of each muffin had been consumed.

Finally, participants' awareness of the relationship between the content of the picture and the location of the dot probe during the training phase was assessed. Following Field and Eastwood (2005), contingency awareness was first assessed by an open-ended recall question and then by a multiple-choice recognition question. The open-ended question asked participants to describe the relationship between the type of pictures and the location of the probes. The multiple-choice question asked participants to choose the correct statement from five different statements that described relationships between picture type and the probe location (e.g., "dots mainly appeared on the same side of the screen as chocolate-related pictures").

## Results

**Statistical considerations.** An alpha level of .05 was used to determine significance. Partial  $\eta^2$  was used as the effect size measure for ANOVAs; Cohen's  $d$  was used for t-tests. Benchmarks for partial  $\eta^2$  are .01, small; .06, medium; and .14, large; and for Cohen's  $d$  .20, small; .50, medium; and .80, large.

**Attentional bias.** To assess the effect of the attentional training, we compared response times on critical trials at post-test with those at pre-test. As is standard practice, response times of incorrect trials (2.47% of data) were discarded. Following previous protocols (e.g., Townshend & Duka, 2001), response times of less than 150 ms or more than 1500 ms were considered anticipatory and delayed respectively, and eliminated as outliers. Response times more than 3 *SDs* above or below the individual mean were also excluded. Such outliers accounted for only 0.17% of the data. For each test phase, an attentional bias score was calculated by subtracting the mean response times to probes that replaced chocolate-related pictures from the mean

response times to probes that replaced pictures of other highly desired foods, such that a positive score indicates an attentional bias for chocolate.

These attentional bias scores were analysed by a 2 (training condition: attend, avoid)  $\times$  2 (time: pre-test, post-test) mixed model ANOVA. There was a significant main effect of training condition,  $F(1, 108) = 21.31, p < .001$ , partial  $\eta^2 = .17$ , whereby the attend group showed a bias toward chocolate ( $M = 20.58$ ) and the avoid group a bias away from chocolate ( $M = -2.43$ ). There was no main effect of time,  $F(1, 108) = 2.68, p > .05$ . Importantly, as can be seen in Figure 1, the predicted training condition  $\times$  time interaction was significant,  $F(1, 108) = 27.48, p < .001$ , partial  $\eta^2 = .20$ . Paired samples  $t$  tests showed a significant increase in attentional bias scores from pre- to post-test in the attend group,  $t(54) = 4.10, p < .001, d = .69$ , 95% CI [.15, 1.23], and a significant decrease in the avoid group,  $t(54) = 3.31, p < .01, d = .64$ , 95% CI [.10, 1.18].

**Chocolate craving.** To examine the effect of attentional training on craving, chocolate craving ratings were similarly analysed by a 2 (training condition: attend, avoid)  $\times$  2 (time: pre-test, post-test) mixed model ANOVA. There were no significant main effects of training condition,  $F(1, 108) = 3.68, p > .05$ , or time,  $F(1, 108) = .06, p > .05$ . Although, as can be seen in Table 1, craving ratings for the attend and avoid groups changed in the predicted direction from pre- to post-test, the interaction between training condition and time was not statistically significant,  $F(1, 108) = .63, p > .05$ .

**Chocolate consumption.** Total amounts of chocolate and blueberry muffin eaten were calculated separately by subtracting the weight of the muffin (in grams) after the taste test from the weight of the muffin before the taste test. These consumption data were analysed by a 2 (training condition: attend, avoid)  $\times$  2 (muffin:

chocolate, blueberry) mixed model ANOVA. There were no significant main effects of training condition,  $F(1, 108) = 3.48, p > .05$ , or muffin,  $F(1, 108) = 1.25, p > .05$ , but importantly, there was a significant training condition  $\times$  muffin interaction,  $F(1, 108) = 8.58, p < .01$ , partial  $\eta^2 = .07$ . As can be seen in Figure 2, independent samples  $t$  tests showed that participants in the avoid group ate significantly less of the chocolate muffin than those in the attend group,  $t(108) = 3.51, p < .01, d = .67, 95\%$  CI [.28, 1.05]. By contrast, blueberry muffin consumption did not differ between the two training conditions,  $t(108) = .15, p > .05$ .

**Awareness of experimental contingencies.** Sixty-five participants (59%) correctly recalled or recognised the relationship between the type of pictures and the location of the probes during the training phase; the other 45 participants (41%) were not aware of (or at least did not report) the experimental contingencies. To examine the effect of contingency awareness on attentional bias scores, chocolate craving ratings and percentage of chocolate muffin consumption, the previous analyses were repeated with awareness (aware, unaware) as an additional between-subjects factor. Across analyses, there was no main effect of awareness, nor, most importantly, any interactions involving awareness (all  $ps > .05$ ). Indeed, as can be seen in Table 2, separate analyses conducted for participants who noticed the relationship between picture type and probe location, and those who did not, showed exactly the same pattern as the overall results above.

### **Discussion of Experiment 1**

In line with predictions, results showed that attentional biases for rewarding food cues can indeed be modified. Participants demonstrated changed biases for chocolate cues in accordance with their training condition; the attend group showed an increase in attentional bias following attentional re-training, whereas the avoid

group showed a decrease. These findings are consistent with reports of attentional bias modification for other reward-related cues, such as alcohol (Fadardi & Cox, 2009; Field & Eastwood, 2005; Field et al., 2007; Schoenmakers et al., 2007, 2010) and tobacco (Atwood et al., 2008; Field et al., 2009), as well as emotionally threatening cues (Amir et al., 2009; Hazen et al., 2009; MacLeod et al., 2002; Schmidt et al., 2009; See et al., 2009).

Attentional re-training, however, did not affect chocolate craving. Although the attend group reported a slight increase in chocolate craving after training and the avoid group a slight decrease, these changes were not statistically significant. This finding fits with several other studies that have found no effect of attentional bias modification on craving for alcohol (Schoenmakers et al., 2007, 2010) or cigarettes (Field et al., 2009).

Importantly, the attentional training manipulation did affect chocolate consumption. As predicted, participants in the avoid group ate less of the chocolate muffin during the taste test than did those in the attend group. This observation is in line with the few previous findings of attentional bias modification effects on alcohol consumption (Fadardi & Cox, 2009; Field & Eastwood, 2005).

Finally, the training effects on attentional bias and chocolate consumption were observed across the board, regardless of whether participants were aware of the experimental contingencies. This suggests that participants need not be consciously aware of the re-training to show its intended effects.

## **Experiment 2**

Experiment 1 showed that attentional bias for rewarding food cues (i.e., chocolate) can be altered, and that this alteration in attentional processing can affect subsequent consumption, but not craving. Experiment 2 replicated the procedure of

Experiment 1, except that the post-training assessment used novel (i.e., not previously seen) chocolate stimuli. Previous attentional bias modification studies have produced mixed results, with some reporting that training effects do generalise to novel stimuli (Field et al., 2007; Schoenmakers et al., 2010), but others finding no support for such generalisation (Field et al., 2009; McHugh, Murray, Hearon, Calkins, & Otto, 2010; Schoenmakers et al., 2007).

## **Method**

**Participants.** Participants were 88 female undergraduate students at Flinders University aged 17 to 25 years ( $M = 19.82$ ,  $SD = 2.29$ ). None had taken part in Experiment 1. As in Experiment 1, participants ate something two hours prior to testing. Hunger ratings were again relatively low ( $M = 29.48$ ,  $SD = 13.70$ ) and did not correlate with attentional bias scores at pre-test,  $r = -.10$ ,  $p > .05$ , or post-test  $r = .03$ ,  $p > .05$ . Additionally, all participants reported that they liked chocolate, and consumed on average 2.40 ( $SD = 2.11$ ) chocolate bars and 2.97 ( $SD = 2.32$ ) chocolate-containing food items per week.

**Design, Materials and Procedure.** Design, materials and procedure were the same as in Experiment 1, except that the critical pairs at post-test were novel (i.e., previously not seen). To this end, another 16 critical (chocolate – non-chocolate) picture pairs were created. These, together with the 16 critical pairs used in Experiment 1, were divided into two subsets. One subset was used at pre-test and training; the other one was used at post-test. Allocation of subsets to the pre-test and training phases versus the post-test phase was counterbalanced across participants and conditions.

## **Results**



**Attentional bias.** Data from trials with errors (3.69%) and outlying response times (1.70%) were eliminated from analyses. A 2 (training condition: attend, avoid)  $\times$  2 (time: pre-test, post-test) mixed model ANOVA showed a significant main effect of training condition,  $F(1, 86) = 22.13, p < .001, \text{partial } \eta^2 = .21$ , with the attend group ( $M = 22.94$ ) showing a greater attentional bias for chocolate than the avoid group ( $M = -2.35$ ), but no main effect of time,  $F(1, 86) = .00, p > .05$ . There was also a significant interaction between training condition and time,  $F(1, 86) = 23.56, p < .001, \text{partial } \eta^2 = .22$ . As can be seen in Figure 3, paired samples  $t$  tests showed a significant increase in attentional bias scores from pre- to post-test in the attend group,  $t(43) = 4.03, p < .001, d = .87, 95\% \text{ CI } [.25, 1.48]$ , and a significant decrease in the avoid group,  $t(43) = 3.04, p < .01, d = .69, 95\% \text{ CI } [.08, 1.29]$ .

**Chocolate craving.** A 2 (training condition: attend, avoid)  $\times$  2 (time: pre-test, post-test) mixed model ANOVA conducted on chocolate craving ratings showed a significant main effect of time,  $F(1, 86) = 7.18, p < .01, \text{partial } \eta^2 = .08$ , whereby cravings increased from pre- ( $M = 52.72$ ) to post-test ( $M = 55.65$ ), but no main effect of training condition,  $F(1, 86) = .71, p > .05$ . However, the training condition  $\times$  time interaction was now statistically significant,  $F(1, 86) = 53.15, p < .001, \text{partial } \eta^2 = .38$ . As shown in Table 3, chocolate cravings significantly increased from pre- to post-test in the attend group,  $t(43) = 7.08, p < .001, d = .44, 95\% \text{ CI } [-.15, 1.03]$  and decreased in the avoid group,  $t(43) = 3.25, p < .01, d = .24, 95\% \text{ CI } [-.35, .83]$ .

**Chocolate consumption.** A 2 (training condition: attend, avoid)  $\times$  2 (muffin: chocolate, blueberry) mixed model ANOVA performed on the amounts of chocolate and blueberry muffin eaten showed no main effects of training condition,  $F(1, 86) = .57, p > .05$ , or muffin,  $F(1, 86) = .81, p > .05$ , but, as shown in Figure 4, there was again a significant interaction between these two factors,  $F(1, 86) = 29.48, p < .001,$

partial  $\eta^2 = .26$ . Independent samples  $t$  tests showed that participants in the avoid group again ate significantly less of the chocolate muffin than those in the attend group,  $t(86) = 3.32, p < .01, d = .72, 95\% \text{ CI } [.29, 1.15]$ , and somewhat more of the blueberry muffin,  $t(86) = 2.16, p < .05, d = .46, 95\% \text{ CI } [.04, .88]$ .

**Awareness of experimental contingencies.** Forty-five participants (51%) were aware of the experimental contingencies between picture type and probe location during training; the remaining 43 participants (49%) were not. The previous analyses were repeated with awareness (aware, unaware) as an additional between-subjects factor, but there were no main effects of awareness, nor any interactions involving awareness (all  $ps > .05$ ). As shown in Table 4, separate analyses for participants who were aware of the experimental manipulation, and those who were not, again showed the same pattern of results.

## Discussion of Experiment 2

As in Experiment 1, the attentional training manipulation produced the predicted changes in attentional bias scores; attentional bias for chocolate cues increased in the attend group and decreased in the avoid group. The use of novel pictures at post-test demonstrates that these training effects clearly generalised to previously unseen chocolate cues. This is consistent with reports of generalisation to novel alcohol cues in other attentional bias modification studies (Field et al., 2007; Schoenmakers et al., 2010). In line with Experiment 1, attentional re-training also affected chocolate consumption. The avoid group again ate less of the chocolate muffin compared to the attend group.

Interestingly, in contrast to Experiment 1, the attentional training manipulation now also affected chocolate craving. Participants in the attend group reported stronger chocolate cravings after the training; in contrast, participants in the avoid group

reported less intense cravings. These training effects on chocolate craving are consistent with those found by some researchers for alcohol and tobacco (Field & Eastwood, 2005; Attwood et al., 2008).

Finally, as in Experiment 1, awareness of the experimental contingencies between picture type and probe location during training did not influence the observed training effects on attentional bias, chocolate craving or consumption.

### **General Discussion**

The present study was the first to show beneficial effects of attentional bias modification in the food and eating domain. Our two experiments clearly showed that attentional re-training can successfully alter attentional biases for rewarding food cues. Participants trained to direct their attention toward chocolate cues showed an increased attentional bias for such cues, whereas participants trained to direct their attention away from these cues showed a reduced bias. Experiment 2 further showed that these training effects generalised to novel chocolate cues. Thus the observed changes in attentional bias for chocolate here extended beyond the specific chocolate stimuli that were used during training. Such generalisation is important if attentional bias modification is to have any real-world application. Individuals need to learn to not attend to all unwanted food cues, not just the particular ones used in training. Indeed, because of the abundance of rewarding food cues in our environment, people are likely to encounter a multitude of novel food cues on a daily basis.

But our most important finding was that attentional re-training also clearly affected chocolate consumption. In each experiment, participants trained to avoid chocolate cues consumed less of a chocolate food product than those trained to attend to these cues. This supports the widely accepted view that attentional bias for

rewarding cues can influence consumption behaviour (Franken, 2003; Kavanagh et al., 2005; Robinson & Berridge, 1993; Ryan, 2002; Tiffany, 1990).

In contrast, the findings for craving were less clear. Experiment 2 showed a significant effect of attentional retraining on chocolate craving, such that participants trained to attend to chocolate cues reported stronger chocolate cravings and those trained to avoid these cues reported less intense cravings. Although Experiment 1 showed this same general pattern, the effect was not statistically significant. These inconsistent findings add to the previous mixed reports of attentional bias modification effects on craving for alcohol and tobacco, and the conclusion that the association between attentional bias for rewarding cues and subjective craving is relatively weak (Field et al., 2009). In the present experiments, it is possible that the novel images presented in the test phase of Experiment 2 served to heighten or maintain participants' craving.

Theoretically, the results are broadly consistent with recent cognitive-motivational models of craving and consumption (Franken, 2003; Kavanagh et al., 2005; Ryan, 2002). These maintain that attentional bias plays a causal role in consumption behaviour (although empirical evidence supports a reciprocal causal relationship between attentional bias and craving, for a review, see Field & Cox, 2008). Thus any change in the attentional bias toward reward-related cues will result in a commensurate change in subsequent craving and consumption. The current data show that attentional biases for food cues can indeed be altered, and that this alteration may lead to a change in self-reported craving (Experiment 2) and food intake (Experiments 1 and 2). While this temporary reduction in chocolate craving and consumption is promising, future research needs to address the longevity of these attentional re-training effects.

A methodological strength of the present experiments is that the non-chocolate pictures, like the chocolate pictures, showed highly desired food items, in an attempt to equalise the desirability of the two food categories. In addition, the food products for the consumption measure (i.e., chocolate and blueberry muffins) were chosen to be equal in all regards except for (not) containing chocolate. In so doing, the current design provides a very clean first test of attentional re-training effects on craving and consumption in the food and eating domain. It may also have some practical use in understanding the experience of chocolate ‘addicts’ (so-called ‘chocoholics’). However, its broader practical application is limited in that the desirable food items shown in the control pictures were also high-calorie. Future research needs to test whether it is equally possible to train people to direct their attention toward healthier food options.

Another limitation is that the sample consisted of university students of mostly normal weight. Future research needs to test whether the results generalise to overweight and obese people. These individuals exhibit a greater attentional bias for food (e.g., Nijs et al., 2010), and thus re-training of this bias may prove more difficult. Attentional bias modification protocols also need to be mindful of other sample characteristics. For example, chronic dieters have been shown to overeat when their attentional resources are restricted, unless they are exposed to diet-salient cues (Mann & Ward, 2007). Thus protocols may need to be tailored to accommodate such sample-specific patterns of attentional allocation.

To the extent that experimental manipulation of attentional bias for food cues can reduce unwanted food intake in these groups, this would have important clinical implications for combating pathological (over)eating. Attentional bias modification focuses on altering people’s implicit attentional processes, rather than tackling their

explicit attitudes or behaviours. In this way, it might make a particularly suitable and attractive intervention for individuals who have difficulty curbing their consumption behaviour, i.e., for most individuals who are trying to, or need to, lose weight. Thus attentional bias modification may prove a useful addition to existing weight-loss treatments.

In conclusion, the current study has demonstrated that an experimental manipulation of attentional bias for food cues can influence a behavioural measure of food intake. In so doing, it has extended the attentional bias modification paradigm from rewarding substances such as alcohol and tobacco to food. The results provide clear empirical evidence for the causal effect of attentional re-training on consumption. Furthermore, they offer potential scope for curbing unwanted food cravings and (over)eating.

## References

- Amir, N., Beard, C., Burns, M., & Bomyea, J. (2009). Attention modification program in individuals with generalized anxiety disorder. *Journal of Abnormal Psychology, 118*, 28-33.
- Attwood, A.S., O'Sullivan, H., Leonards, U., Mackintosh, B., & Munafò, M.R. (2008). Attentional bias training and cue reactivity in cigarette smokers. *Addiction, 103*, 1875-1882.
- Brignell, C., Griffiths, T., Bradley, B.P., & Mogg, K. (2009). Attentional and approach biases for pictorial food cues. Influence of external eating. *Appetite, 52*, 299-306.
- Ehrman, R.N., Robbins, S.J., Bromwell, M.A., Lankford, M.E., Monterosso, J.R., & O'Brien, C.P. (2002). Comparing attentional bias to smoking cues in current smokers, former smokers, and non-smokers using a dot-probe task. *Drug and Alcohol Dependence, 67*, 185-191.
- Fadardi, J. S., & Cox, W. M. (2008). Alcohol-attentional bias and motivational structure as independent predictors of social drinkers' alcohol consumption. *Drug and Alcohol Dependence, 97*, 247-256.
- Fadardi, J. S., & Cox, W. M. (2009). Reversing the sequence: Reducing alcohol consumption by overcoming alcohol attentional bias. *Drug and Alcohol Dependence, 101*, 137-145.
- Fedoroff, I.C., Polivy, J., & Herman, C.P. (1997). The effect of pre-exposure to food cues on the eating behavior of restrained and unrestrained eaters. *Appetite, 28*, 33-47.

- Fedoroff, I.C., Polivy, J., & Herman, C.P. (2003). The specificity of restrained versus unrestrained eaters' responses to food cues: General desire to eat, or craving for the cued food? *Appetite*, *41*, 7-13.
- Field, M., & Cox, W. M. (2008). Attentional bias in addictive behaviors: A review of its development, causes, and consequences. *Drug and Alcohol Dependence*, *97*, 1–20.
- Field, M., Duka, T., Eastwood, B., Child, R., Santarcangelo, M., & Gayton, M. (2007). Experimental manipulation of attentional biases in heavy drinkers: Do the effects generalise? *Psychopharmacology*, *192*, 593-608.
- Field, M., Duka, T., Tyler, E., & Schoenmakers, T. (2009). Attentional bias modification in tobacco smokers. *Nicotine & Tobacco Research*, *11*, 812–822.
- Field, M., & Eastwood, B. (2005). Experimental manipulation of attentional bias increases the motivation to drink. *Psychopharmacology*, *183*, 350-357.
- Field, M., Eastwood, B., Mogg, K., & Bradley, B.P. (2006). Selective processing of cannabis cues in regular cannabis users. *Drug and Alcohol Dependence*, *85*, 75-82.
- Field, M., Mogg, K., & Bradley, B.P. (2004). Cognitive bias and drug craving in recreational cannabis users. *Drug and Alcohol Dependence*, *74*, 105-111.
- Field, M., Mogg, K., & Bradley, B.P. (2005). Craving and cognitive biases for alcohol cues in social drinkers. *Alcohol & Alcoholism*, *40*, 504-510.
- Field, M., Munafo, M.R., & Franken, I.H.A. (2009). A meta-analytic investigation of the relationship between attentional bias and subjective craving in substance abuse. *Psychological Bulletin*, *135*, 589-607.



- Franken, I.H.A. (2003). Drug craving and addiction: Integrating psychological and neuropsychopharmacological approaches. *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, 27, 563-579.
- Franken, I.H.A., Kroon, L.Y., Wiers, R.W., & Jansen, A. (2000). Selective cognitive processing of drug cues in heroin dependence. *Journal of Psychopharmacology*, 14, 395-400.
- Green, M.W., & Rogers, P.J. (1993). Selective attention to food and body shape words in dieters and restrained nondieters. *International Journal of Eating Disorders*, 14, 515-517.
- Hazen, R. A., Vasey, M. W., & Schmidt, N. B. (2009). Attentional retraining: A randomized clinical trial for pathological worry. *Journal of Psychiatric Research*, 43, 627–633.
- Hetherington, M. M., & Macdiarmid, J.I. (1993). “Chocolate addiction”: A preliminary study of its description and its relationship to problem eating. *Appetite*, 21, 233-246.
- Hill, A.J., Weaver, C.F., & Blundell, J.E. (1991). Food craving, dietary restraint and mood. *Appetite*, 17, 187-197.
- Kavanagh, D., Andrade, A., & May, J. (2005). Imaginary relish and exquisite torture: The elaborated intrusion theory of desire. *Psychological Review*, 112, 446-467.
- Kemps, E., & Tiggemann, M. (2009). Attentional bias for craving-related (chocolate) food cues. *Experimental and Clinical Psychopharmacology*, 17, 425-433.
- Lubman, D.I., Peters, L.A., Mogg, K., Bradley, B.P. & Deakin, J.F.W. (2000). Attentional bias for drug cues in opiate dependence. *Psychological Medicine*, 30, 169-175.

MacLeod, C., Rutherford, E., Campbell, L., Ebsworthy, G., & Holker, L. (2002).

Selective attention and emotional vulnerability: Assessing the causal basis of their association through experimental manipulation of attentional bias.

*Journal of Abnormal Psychology, 111*, 107-123.

Mann, T., & Ward, A. (2007). Attention, self-control, and health behaviours. *Current Directions in Psychological Science, 16*, 280-283.

McHugh, R. K., Murray, H. W., Hearon, B. A., Calkins, A. W., & Otto, M. W.

(2010). Attentional bias and craving in smokers: The impact of a single attentional training session. *Nicotine & Tobacco Research, 12*, 1261-1264.

Mogg, K., & Bradley, B.P. (2002). Selective processing of smoking-related cues in smokers: Manipulation of deprivation level and comparison of three measures of processing bias. *Journal of Psychopharmacology, 16*, 385-392.

Mogg, K., Bradley, B.P., Hyare, H., & Lee, S. (1998). Selective attention to food-related stimuli in hunger: Are attentional biases specific to emotional and psychopathological states, or are they also found in normal drive states? *Behaviour Research and Therapy, 36*, 227-237.

Nijs, I.M.T., Muris, P., Euser, A.S., & Franken, I.H.A. (2010). Differences in attention to food and food intake between overweight/obese and normal-weight females under conditions of hunger and satiety. *Appetite, 54*, 243-254.

Painter, J.E., Wansink, B., & Hieggelke, J.B. (2002). How visibility and convenience influence candy consumption. *Appetite, 38*, 237-238.

Pelchat, M. L. (1997). Food cravings in young and elderly adults. *Appetite, 28*, 103-113.

Pelchat, M.L. (2002). Of human bondage: Food craving, obsession, compulsion, and addiction. *Physiology & Behavior, 76*, 347-352.

- Robinson, T.E., & Berridge, K.C. (1993). The neural basis of craving: An incentive-sensitization theory of addiction. *Brain Research Review*, *18*, 247-291.
- Ryan, F. (2002). Detected, selected, and sometimes neglected: Cognitive processing of cues in addiction. *Experimental and Clinical Psychopharmacology*, *10*, 67-76.
- Schmidt, N. B., Richey, J. A., Buckner, J. D., & Timpano, K. R. (2009). Attention training for generalized social anxiety disorder. *Journal of Abnormal Psychology*, *118*, 5–14.
- Schoenmakers, T. M., de Bruin, M., Lux, I. F. M., Goertz, A. G., Van Kerkhof, D. H. A. T., & Wiers, R. W. (2010). Clinical effectiveness of attentional bias modification training in abstinent alcoholic patients. *Drug and Alcohol Dependence*, Advance online publication.
- Schoenmakers, T., Wiers, R. W., Jones, B. T., Bruce, G., & Jansen, A. T. M. (2007). Attentional re-training decreases attentional bias in heavy drinkers without generalization. *Addiction*, *102*, 399–405.
- See, J., MacLeod, C., & Bridle, R. (2009). The reduction of anxiety vulnerability through the modification of attentional bias: A real-world study using a home-based cognitive bias modification procedure. *Journal of Abnormal Psychology*, *118*, 65-75.
- Tiffany, S.T. (1990). A cognitive model of drug urges and drug-use behavior: Role of automatic and nonautomatic processes. *Psychological Review*, *97*, 147-168.
- Townshend, J.M., & Duka, T. (2001). Attentional bias associated with alcohol cues: Differences between heavy and occasional social drinkers. *Psychopharmacology*, *157*, 67-74.

- Waters, A.J., Shiffman, S., Bradley, B.P., & Mogg, K. (2003). Attentional shifts to smoking cues in smokers. *Addiction*, *98*, 1409-1417.
- Weingarten, H., & Elston, D. (1991). Food cravings in a college population. *Appetite*, *17*, 167-175.
- Wertz, J.M., & Sayette, M.A. (2001). A review of the effects of perceived drug use opportunity on self-reported urge. *Experimental and Clinical Psychopharmacology*, *9*, 3-13.
- Westerterp, K.R. & Speakman, J.R. (2008). Physical activity energy expenditure has not declined since the 1980s and matches energy expenditure of wild mammals. *International Journal of Obesity*, *32*, 1256-1263.
- Yeomans, M.R., Javaherian, S., Rovey, H.M., & Stafford, L.D. (2005). Attentional bias for caffeine-related stimuli in high but not moderate of non-caffeine consumers. *Psychopharmacology*, *181*, 477-485.

Table 1

*Mean chocolate craving ratings (with 95% confidence intervals) for the attend and avoid conditions at pre- and post-test in Experiment 1*

	<i>Attend</i>	<i>Avoid</i>
Pre-test	54.24 [46.69, 61.78]	45.84 [38.29, 53.38]
Post-test	56.11 [48.44, 63.78]	44.86 [37.19, 52.53]

Table 2

*Means (with 95% confidence intervals) for participants aware and unaware of the experimental contingencies in Experiment 1*

	Aware				
	Attend		Avoid		
	Pre-test	Post-test	Pre-test	Post-test	
	Attentional bias score	5.35 [-3.97, 14.67]	33.64 [20.38, 46.90]	6.38 [-4.33, 17.10]	
Chocolate craving	61.03 [52.48, 69.58]	61.51 [52.97, 70.05]	46.61 [36.78, 56.44]	42.79 [32.97, 52.60]	ns
Chocolate consumption	N/A	44.64 [37.21, 52.06]	N/A	31.45 [22.92, 39.99]	*
	Unaware				
	Attend		Avoid		
	Pre-test	Post-test	Pre-test	Post-test	
	Attentional bias score	7.22 [-6.87, 21.32]	38.42 [20.24, 56.61]	4.04 [-7.47, 15.54]	
Chocolate craving	40.28 [26.12, 54.44]	45.00 [30.01, 59.99]	45.04 [33.47, 56.60]	47.01 [34.77, 59.25]	ns
Chocolate consumption	N/A	45.80 [35.04, 56.55]	N/A	28.54 [19.76, 37.32]	*

\*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$

Table 3

*Mean chocolate craving ratings (with 95% confidence intervals) for the attend and avoid conditions at pre- and post-test in Experiment 2*

	<i>Attend</i>	<i>Avoid</i>
Pre-test	50.73 [43.97, 57.49]	54.70 [47.94, 61.47]
Post-test	61.64 [54.67, 68.61]	49.66 [42.69, 56.63]

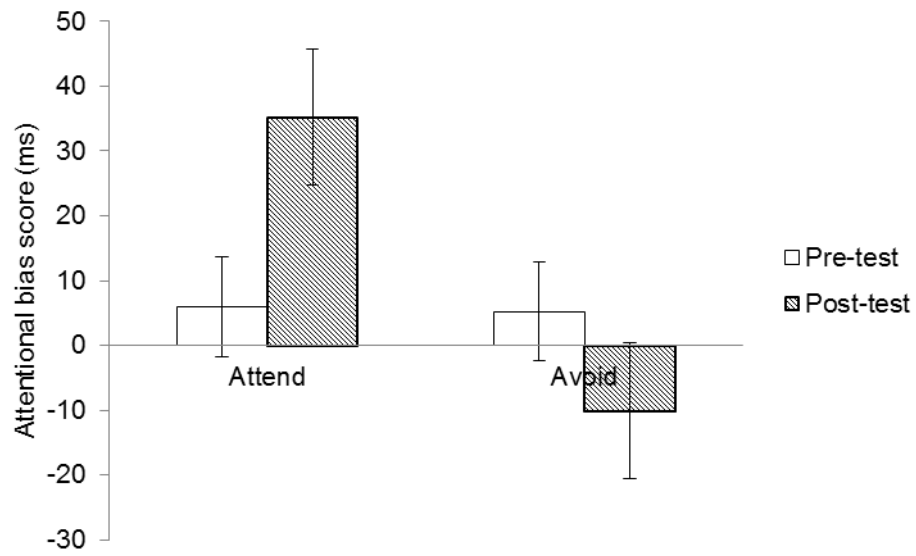
Table 4

*Means (with 95% confidence intervals) for participants aware and unaware of the experimental contingencies in Experiment 2*

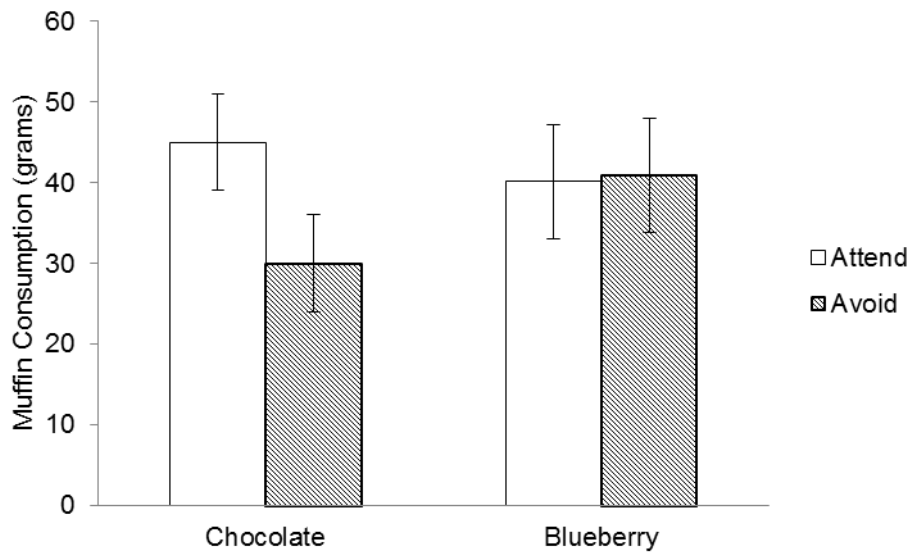
	Aware				
	Attend		Avoid		
	Pre-test	Post-test	Pre-test	Post-test	
Attentional bias score	7.29 [-.28, 14.85]	34.01 [16.19, 51.83]	12.08 [2.81, 21.34]	-17.97 [-39.79, 3.86]	***
Chocolate craving	48.48 [39.04, 57.93]	58.74 [49.10, 68.36]	55.17 [43.60, 66.73]	48.50 [36.69, 30.31]	***
Chocolate consumption	N/A	60.99 [49.87, 72.10]	N/A	41.61 [28.00, 55.22]	*
	Unaware				
	Attend		Avoid		
	Pre-test	Post-test	Pre-test	Post-test	
Attentional bias score	11.04 [-4.41, 26.50]	42.13 [19.20, 65.06]	11.61 [-.89, 24.11]	-15.49 [-34.03, 3.05]	**
Chocolate craving	54.29 [44.04, 64.55]	66.24 [55.60, 76.88]	54.38 [46.09, 62.68]	50.46 [41.86, 59.07]	***
Chocolate consumption	N/A	53.94 [37.25, 70.62]	N/A	32.27 [18.79, 45.76]	*

\*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$

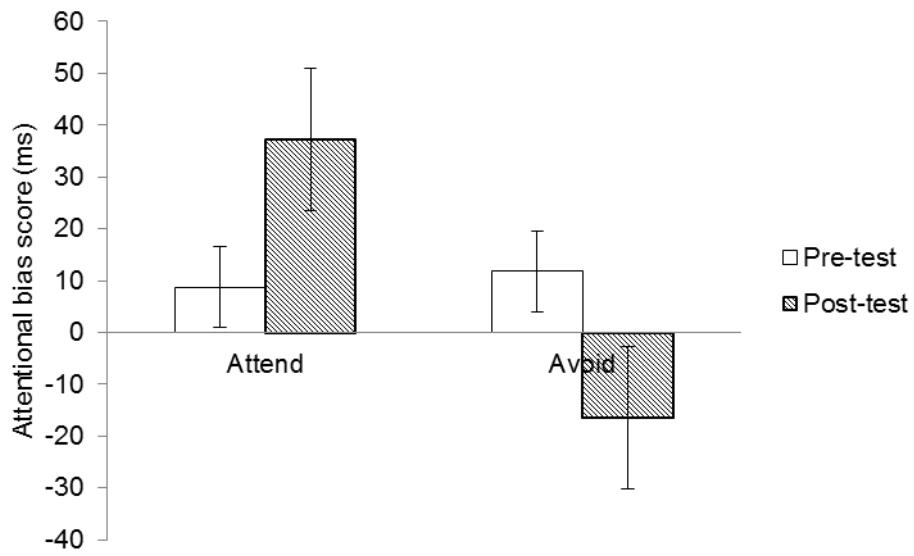




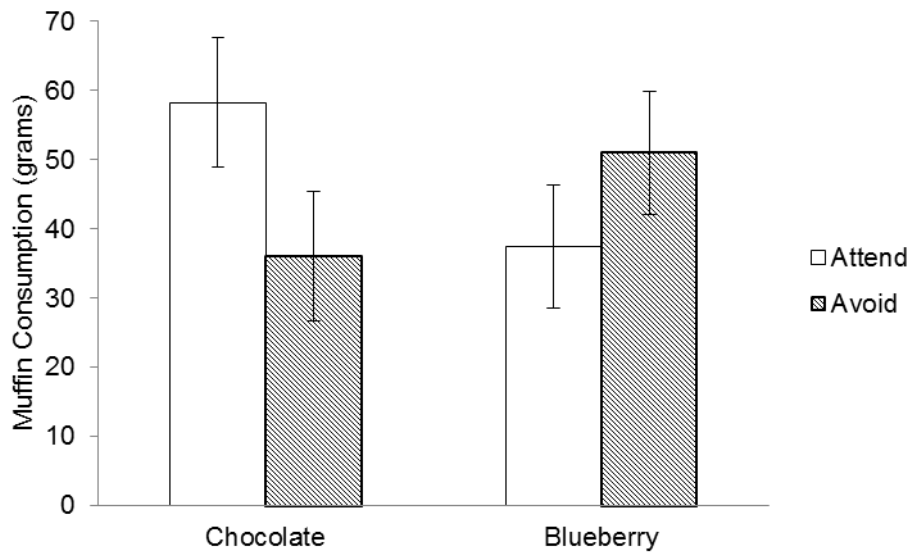
*Figure 1.* Mean attentional bias scores (with 95% confidence intervals) for the attend and avoid conditions at pre- and post-test in Experiment 1.



*Figure 2.* Mean chocolate and blueberry muffin consumption (with 95% confidence intervals) for the attend and avoid conditions in Experiment 1.



*Figure 3.* Mean attentional bias scores (with 95% confidence intervals) for the attend and avoid conditions at pre- and post-test in Experiment 2.



*Figure 4.* Mean chocolate and blueberry muffin consumption (with 95% confidence intervals) for the attend and avoid conditions in Experiment 1.

## Appendix A

### Categories of chocolate and non-chocolate food pictures

**Chocolate:** biscuit, brownie, chocolate bar, chocolate block, chocolate mousse, cake (whole), cake (piece), donut, ice cream (bowl), ice cream (cone), muffin, pastry, pudding

**Non-chocolate:** biscuit, cake (whole), cake (piece), donut, fries, hamburger, ice cream (bowl), ice cream (cone), muffin, pasta, pastry, pizza (whole), pizza (slice), potato crisps