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Sustained Effects of Attentional Re-training on Chocolate Consumption

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Abstract

Background and objectives: Accumulating evidence shows that cognitive bias modification produces immediate changes in attentional bias for, and consumption of, rewarding substances including food. This study examined the longevity of these attentional bias modification effects.

Methods: A modified dot probe paradigm was used to determine whether alterations in biased attentional processing of food cues, and subsequent effects on consumption, were maintained at 24-hour and one-week follow-up. One hundred and forty-nine undergraduate women were trained to direct their attention toward ('attend') or away from ('avoid') food cues (i.e., pictures of chocolate). Within each group, half received a single training session, the other half completed 5 weekly training sessions.

Results: Attentional bias for chocolate cues increased in the 'attend' group, and decreased in the 'avoid' group immediately post training. Participants in the 'avoid' group also ate disproportionately less of a chocolate food product in a so-called taste test than did those in the 'attend' group. Importantly, the observed re-training effects were maintained 24 hours later and also one week later, but only following multiple training sessions.

Limitations: There are a number of limitations that could be addressed in future research: (a) the inclusion of a no-training control group, (b) the inclusion of a suspicion probe to detect awareness of the purpose of the taste test, and (c) the use of different tasks to assess and re-train attentional bias.

Conclusions: The results showed sustained effects of attentional re-training on attentional bias and consumption. They further demonstrate the importance of administering multiple re-training sessions in attentional bias modification protocols.

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

1. Introduction

Contemporary Western environments are saturated with palatable food cues. People are continually exposed to images that are associated with food intake, such as advertisements on bill-boards and television, vending machines and fast food outlets. The mere presence of such food cues has been linked to increased food intake (Fedoroff, Polivy & Herman, 1997, 2003; Painter, Wansink & Hieggelke, 2002) and is an acknowledged contributor to the increased prevalence of overeating and obesity (Westerterp & Speakman, 2008).

One explanation for the link between food cue exposure and (over)consumption is that food cues "grab" attention. According to Berridge's (2009) Model of Food Reward, eating is a rewarding experience. Because of a continual association between food cues and the rewarding experience of eating, these cues become reinforcing. This classically conditioned association makes environmental food cues salient and attractive. As a result, they automatically capture (i.e., bias) attention, which then guides behaviour toward food acquisition and consumption.

Empirical evidence supports the link between food cue exposure and biased attentional processing. A number of studies have shown that pre-exposing participants to a selection of chocolate bars induces an attentional bias for chocolate cues (Kemps & Tiggemann, 2009; Smeets, Roefs & Jansen, 2009). There are also several strands of correlational evidence in support of the link between attentional bias for food cues and (over)consumption. A growing number of studies have reported an enhanced attentional bias for food cues in overweight and obese individuals (Braet & Crombez, 2003; Kemps, Tiggemann & Hollitt, in press; Long, Hinton & Gillespie, 1994). Biased attentional processing of food cues has also been associated with an increase in body mass index one year later (Calitri, Pothos, Tapper, Brunstrom & Rogers, 2010; Yokum, Ng & Stice, 2011).

More direct evidence would come from research that links attentional bias for food cues to actual consumption. In the only study to date, Nijs, Muris, Euser and Franken (2010) reported a positive correlation between attentional bias and intake of high-caloric snacks.

In addition to these correlational studies, more recent experimental evidence is consistent with a causal role for attentional bias in food intake. In particular, attentional re-training studies have shown that an experimental manipulation of attentional bias can produce a commensurate change in consumption. For example, using a modified dot probe task, Kemps, Tiggemann, Orr and Grear (2014) showed that participants who were trained to direct their attention *away* from chocolate pictures subsequently ate less of a chocolate food product than participants who were trained to direct their attention *toward* such pictures. Similarly, Werthmann, Field, Roefs, Nederkoorn and Jansen (2014) found that participants ate more chocolate when they had to attend to chocolate pictures in an anti-saccade task and ate less chocolate when they had to attend to non-chocolate pictures, but only if they displayed high accuracy rates on the task. In contrast, Hardman, Rogers, Etchells, Houstoun and Munafo (2013) failed to find any effect of attentional re-training of cake images on food intake.

Thus far, only immediate effects of attentional re-training effects on food intake have been investigated. However, if attentional bias modification is to have any practical application, it is important that its effects are maintained over time. Two recent attentional bias modification studies on alcohol have shown sustained effects of attentional re-training following multiple training sessions. In particular, Fadardi and Cox (2009) demonstrated sustained reductions in both attentional bias for alcohol cues and alcohol consumption in harmful drinkers three months after completing four weekly attentional re-training sessions. Likewise, Schoenmakers et al. (2010) administered five training sessions to alcohol-dependent patients and reported an increase in their ability to disengage from alcohol cues up

to three to four days post-training. These patients also showed a delay in relapse times at three-month follow-up compared to a control group. In contrast, a study conducted in tobacco smokers found that while attentional bias modification altered attentional bias for smoking cues immediately after training following a standard single training session, this effect was no longer present 24 hours later (Field, Duka, Tyler & Schoenmakers, 2009). Collectively, these findings suggest that multiple training sessions may be required to produce effects that go beyond the intervention.

The aim of the present study was to investigate sustained effects of attentional re-training in the food domain. Specifically, we sought to determine whether the changes in attentional bias for chocolate cues and chocolate consumption observed immediately post-training (Kemps et al., 2014; Werthmann et al., 2014) can be maintained 24 hours later and one week later. We used a modified dot probe paradigm to increase or decrease attentional bias for chocolate by directing attention either *toward* ('attend') or *away* ('avoid') from chocolate cues. Following Kemps et al., we examined whether this manipulation altered attentional bias for chocolate, relative to other popular, high-caloric food items that do not contain chocolate (e.g., cake, pizza). We specifically chose items for the comparison control category that were equally attractive (but that did not contain chocolate) rather than more neutral food items to ensure that any attentional bias modification effects could not be attributed to differences in overall appeal between the stimulus categories. The use of two equally desirable food categories thus provides a very clean test of any sustained effect of attentional re-training on consumption. Importantly, we compared the effects of a single versus multiple re-training sessions, because initial investigations into other domains (alcohol, tobacco) suggest that more than one training session may be required to produce sustained effects (Fadardi & Cox, 2009; Field et al., 2009; Schoenmakers et al., 2010).

2. Method

2.1. Participants

A sample of 160 undergraduate students were recruited from Flinders University, Adelaide, South Australia, via online and poster advertisements. To preclude possible gender effects on attentional bias and consumption (Havermans, Giesen, Houben & Jansen, 2011), participation was restricted to female students who liked chocolate. Participants received course credit or an honorarium in lieu of their time and commitment. Eleven participants withdrew from the study at varying time points. The final sample (N = 149) was between 18 and 37 years old (*M* = 20.22, *SD* = 2.56) and mostly of normal weight. Mean BMI was 23.44 (*SD* = 5.24). Participants consumed on average 1.89 (*SD* = 1.67) chocolate bars and 3.13 (*SD* = 2.95) chocolate-containing food items per week.

2.2. Design

The experiment used a 2 (group: attend, avoid) × 2 (sessions: single, multiple training) × 4 (time: pre-test, post-test, 24-hour follow-up, one-week follow-up) mixed factorial design. Participants were randomly assigned to the group × sessions conditions. Participant numbers for each of these conditions were: attend/single (N = 37), attend/multiple (N = 39), avoid/single (N = 38) and avoid/multiple (N = 35).

2.3. Materials

The stimuli for the modified dot probe task were 98 digital coloured photographs comprising 35 pictures of chocolate or chocolate-containing food items (e.g., chocolate bar, brownie) and 63 pictures of highly desired food items not containing chocolate (e.g., cake, pizza). All pictures were scaled to 120 mm 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), consisting of 35 and 14 pairs, respectively. Within each pair, pictures were matched according to ratings of perceptual characteristics,

pleasure, arousal, and category representativeness, obtained through pilot testing (Kemps et al., 2014). The 35 critical (chocolate – non-chocolate) pairs were divided into five subsets, each comprising seven pairs. Two of these subsets were used at pre-test and training. To increase generalizability, at each of the post-test and follow-up assessments, a combination of one previously seen and one new subset was used. Allocation of subsets to the pre-test and training phases versus the post-test and follow-up phases was counterbalanced across participants and conditions. Another 14 picture pairs, featuring non-food related content (e.g., car, beach ball), were created for practice and buffer trials.

2.4. Procedure

As an extension of standard attentional bias modification protocols (Field & Eastwood, 2005), the modified dot probe procedure consisted of five 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, (3) a post-training assessment of participants' attentional bias for chocolate similar to the pre-test (post-test), (4) a 24-hour follow-up assessment of participants' attentional bias for chocolate similar to the pre- and post-tests, and (5) a one-week follow-up of participants' attentional bias for chocolate.

Participants in the single-training condition received one training session. Following Schoenmakers et al. (2010), participants in the multiple-training condition were administered five training sessions. In line with Fadardi and Cox's (2009) protocol, these were scheduled over 5 weeks, once per week, always on the same day and at the same time. For both conditions, the initial testing session included the pre-test and one training session. For the single-training condition it also included the post-test. The multiple-training condition first completed another 4 training sessions, one week apart, followed by the post-test at the conclusion of the fifth training session. Both groups attended the first follow-up 24 hours

after the post-test; the second follow-up took place one week later. Table 1 provides a schematic representation of the timing of the training and testing sessions for the single and multiple training conditions.

Participants were tested in a quiet room in the Food Laboratory. As hunger has been associated with an increased attentional bias for food (Mogg, Bradley, Hyare & Lee, 1998), participants were instructed to eat something two hours before the testing (and training) sessions to ensure they were not hungry. All participants reported having complied with this instruction. Participants were seated at a desk, 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, followed by the modified dot probe task.

2.4.1. 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 80 mm between their inner edges. When the picture pair disappeared, a dot probe was presented in the location of one of the previously presented pictures. Participants were instructed to identify the location of the probe as quickly as possible, by pressing the corresponding keys labelled L ('z') and R ('/') on the computer keyboard. When a response was made the probe disappeared from the screen. The inter-trial interval was 500 ms.

The task commenced with 12 practice trials, followed by 2 buffer trials and 112 experimental trials. In the experimental trials, each of the 14 critical (chocolate – non-chocolate) and 14 control (non-chocolate – non-chocolate) picture pairs was presented four times, once for each of the picture location (left, right) × probe location (left, right) combinations. Thus probes replaced each of the pictures in each pair with equal frequency (50/50). All pairs were presented in a new randomly chosen order for each participant.

2.4.2. Training

In the attentional re-training phase, participants completed a modified dot probe task. Only the 14 critical (chocolate – non-chocolate) picture pairs were used. These were each presented 16 times, for a total of 224 trials, with each picture appearing 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. Conversely, for participants in the avoid condition, 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, as opposed to a 100-0 distribution, was used to reduce the obviousness of the contingency (Schoenmakers, Wiers, Jones, Bruce & Jansen, 2007). Participants in the single-training condition completed this training protocol once. Participants in the multiple-training condition completed it five times on a weekly basis.

2.4.3. Post-test

Upon completion of (the final instalment of) training, participants again completed a standard dot probe task. This post-test was similar to the pre-test, except that there were no practice trials. Next, participants were given a so-called taste test to assess chocolate consumption. Following Kemps et al. (2014), 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.

2.4.4. Follow-up

The 24-hour and 1-week follow-up assessments were the same as the post-test. At

each follow-up, participants also partook in another taste test under the guise of examining

changes in food perceptions over time.

3. Results

3.1. Statistical considerations

An alpha level of .05 was used to determine significance. Partial η^2 was used as the

effect size measure for ANOVAs; Cohen's *d* was used for t-tests. Benchmarks for partial η^2

are .01, small; .06, medium; .14, large; and for Cohen's *d* .20, small; .50, medium; .80, large.

3.2. Attentional bias

To assess the effect of re-training on attentional bias, we compared response times on

critical trials at pre-test with those at post-test, 24-hour follow-up and 1-week follow-up. For

each of these phases, an attentional bias score was calculated by subtracting the mean

response times to probes that replaced chocolate pictures from the mean response times to

probes that replaced non-chocolate pictures, such that a positive score indicates an attentional

bias toward chocolate and negative score a bias away from chocolate. As is standard practice,

data from incorrect trials (3.03%) were discarded. Additionally, response times greater than

2.5 *SD*s above or below the mean were eliminated as outliers (1.81%).

Attentional bias scores were analysed by a 2 (group: attend, avoid) $\times$ 2 (sessions:

single, multiple training) $\times$ 4 (time: pre-test, post-test, 24-hour follow-up, one-week follow-

up) mixed model ANOVA. There was a significant group $\times$ time interaction, $F(3, 435) =$

18.44, $p < .001$, partial $\eta^2 = .11$. However, more importantly, there was also a significant

group $\times$ sessions $\times$ time interaction, $F(3, 435) = 4.26$, $p < .01$, partial $\eta^2 = .03$. As can be seen

in Figure 1(a), following a single-training session, participants in the attend group demonstrated a significantly greater attentional bias for chocolate at post-test, $t(36) = 5.04$, $p < .001$, $d = 1.13$, 24-hour follow-up, $t(36) = 2.55$, $p < .05$, $d = .63$, and 1-week follow-up, $t(36) = 2.51$, $p < .05$, $d = .58$. In contrast, participants in the avoid group did not show a significant decrease in attentional bias scores at post-test, $t(37) = .40$, $p > .05$. Furthermore, scores reverted to show a bias toward chocolate at 24-hour follow-up, $t(36) = 2.84$, $p < .01$, $d = 0.65$, and 1-week follow-up, $t(37) = 2.06$, $p < .05$, $d = .43$. On the other hand, after multiple training sessions (see Figure 1(b)), participants in the attend condition also showed significant increases in attentional bias scores at post-test, $t(38) = 3.49$, $p < .001$, $d = 0.67$, 24-hour follow-up, $t(38) = 4.31$, $p < .001$, $d = 0.83$, and 1-week follow-up, $t(38) = 2.88$, $p < .001$, $d = 0.62$, relative to pre-test. Now, however, participants in the avoid condition showed significant reductions in bias scores at all three time points: post-test, $t(34) = 3.53$, $p < .001$, $d = 0.72$, 24-hour follow-up, $t(34) = 2.37$, $p < .05$, $d = .52$, and 1-week follow-up, $t(34) = 2.94$, $p < .01$, $d = 0.61$.

Visual inspection of the pre-test bias scores in Figure 1 indicates that, particularly in the single-training session condition, the training strengthened the existing bias rather than changed its direction. To ensure that the differences between the single and multiple training sessions reported above do not stem from differences in attentional bias at pre-test, the previous ANOVA was re-run without the pre-test scores. Importantly, the pattern of results remained the same. That is, there was still a significant group $\times$ time interaction, $F(2, 290) = 11.32$, $p < .001$, partial $\eta^2 = .07$, and a significant group $\times$ sessions $\times$ time interaction, $F(2, 290) = 3.54$, $p < .05$, partial $\eta^2 = .02$.

3.3. Chocolate consumption

For each of the post-test and two follow-up phases, 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. Mean consumption data for all conditions are shown in Figure 2. An overall 2 (group: attend, avoid) × 2 (sessions: single, multiple training) × 2 (muffin: chocolate, blueberry) × 3 (time: post-test, 24-hour follow-up, one-week follow-up) mixed model ANOVA showed significant main effects of time, $F(2, 290) = 3.60$, $p < .05$, partial $\eta^2 = .02$ (whereby consumption increased over time), and muffin, $F(1, 145) = 8.60$, $p < .01$, partial $\eta^2 = .06$ (whereby participants ate more chocolate than blueberry muffin), and a significant group × muffin × time interaction, $F(2, 290) = 3.08$, $p < .05$, partial $\eta^2 = .02$, but no other significant main or interaction effects.

To best examine the effect of attentional bias modification on consumption, we analysed the group × muffin interaction for the single and multiple training session conditions at each assessment point. At post-test, this interaction was not significant for either the single, $F(1, 73) = .02$, $p > .05$, or the multiple training condition, $F(1, 72) = .02$, $p > .05$. At 24-hour follow-up, the interaction was also not significant in either training session condition (single: $F(1, 73) = 1.26$, $p > .05$; multiple: $F(1, 72) = 1.37$, $p > .05$). However, as can be seen in Figure 2, simple effects analysis showed that participants in the avoid group ate significantly less of the chocolate muffin than those in the attend group in the multiple-training session condition, $t(72) = 2.31$, $p < .05$, $d = .54$. Finally, at 1-week follow-up, the group × muffin interaction was not significant for the single training condition, $F(1, 73) = 2.07$, $p > .05$, but it was statistically significant in the multiple-training condition, $F(1, 72) = 4.87$, $p < .05$, partial $\eta^2 = .06$. Simple effects analysis showed that the avoid group ate significantly less of the chocolate muffin than the attend group, $t(72) = 3.01$, $p < .01$, $d = .71$; however, there was no group difference in blueberry muffin consumption, $t(72) = .70$, $p > .05$. Furthermore, at this time point, visual comparison of the multiple with single training session condition suggests that the attend group ate relatively more, and the avoid group relatively less, of the chocolate muffin.

4. Discussion

The present study was the first to examine sustained effects of attentional re-training in the food domain. Consistent with recent attentional bias modification studies (Kemps et al., 2014; Werthmann et al., 2014), attentional re-training produced the predicted changes in attentional bias immediately after training, that is, attentional bias for chocolate cues increased in the attend condition and decreased in the avoid condition. Importantly, these effects were maintained at 24-hour and 1-week follow-up, but only for participants who received multiple training sessions. This finding is consistent with previous reports of sustained changes in attentional bias for alcohol cues following repeated training sessions (Fadardi & Cox, 2009; Schoenmakers et al., 2010). It further confirms the Field et al. (2009) observation for smoking cues that a single training session is insufficient to produce changes in attentional bias that extend beyond the re-training protocol.

Attentional bias modification is argued to change attentional processing via systematic practice in diverting attention away from one stimulus category (e.g., chocolate), and directing attention instead towards another stimulus category (e.g., non-chocolate). In support, attentional re-training has been shown to modify eye tracking gaze patterns (Wadlinger & Isaacowitz, 2008) and to alter the function of brain regions involved in attentional allocation, as determined by fMRI (Browning, Holmes, Murphy, Goodwin & Harmer, 2010). Because participants are instructed to focus on an ostensibly unrelated task (e.g., responding to probe location), attentional processes are altered through an implicit learning process (Bar-Haim, 2010; Beard, 2011). Although not explicitly tested here, other attentional bias modification studies have shown that participants not aware of the experimental manipulation still show the intended learning (Field & Eastwood, 2005; Field et al., 2009; Kemps et al., 2014; Kemps et al., in press; Schoenmakers et al., 2007). The current data do suggest that the additional practice gained from multiple training sessions serves to

reinforce this learning, thereby enabling its effects to persist over time. In support, a recent meta-analysis of attentional bias modification studies on threatening and appetitive (specifically, alcohol and tobacco) cues points to a dose-response relationship, such that more training sessions yield stronger (immediate) effects (Beard, Sawyer & Hofmann, 2012).

Importantly, attentional re-training also had an effect on chocolate consumption, but only for participants who received multiple training sessions. After 5 weekly training sessions, participants in the avoid group ate disproportionately less of the chocolate muffin during the taste test than those in the attend group at 24-hour and 1-week follow-up. In contrast, following a single training session, none of the training group differences were statistically significant at any assessment point. Werthmann et al. (2014) also found no significant difference in chocolate intake between their attend and avoid groups immediately after a single training session. In the absence of a no-training control group, it is not clear whether the observed group difference in chocolate muffin consumption following multiple training sessions was driven by a decrease in chocolate consumption in the avoid group, or an increase in the attend group, or both. Visual inspection of the graphs suggested that multiple trials of attentional re-training may have worked to produce effects in both directions. In addition, as the pre-test bias scores generally indicated a pre-existing attentional bias toward chocolate cues, it is likely that participants may have preferred the chocolate muffin, and that without any form of training they would have eaten much more of the chocolate than the blueberry muffin. Together, these observations suggest that training people to direct their attention away from chocolate cues may have some promise in reducing chocolate consumption. Nevertheless, the inclusion of a control condition in which attention is not manipulated in future studies will allow us to draw more definitive conclusions.

The observed longevity (up to one week later) of the attentional bias modification effect on chocolate consumption with repeated training is in line with that reported for

alcohol consumption (Fadardi & Cox, 2009) and, more broadly, with delayed time to relapse among alcohol-dependent patients at three-month follow-up (Schoenmakers, et al. 2010). It is also consistent with recent reports of sustained reductions in anxiety symptoms in patients with generalised social phobia four months after completing a multi-session attentional re-training intervention (Amir et al., 2009; Schmidt, Richey, Buckner & Timpano, 2009). The finding here that attentional re-training effects on chocolate consumption were observed only after multiple training sessions suggests that extended practice may be required to bring about reliable changes in food intake.

As in some previous attentional bias modification studies on food (Kemps et al., 2014) and other rewarding substances (Attwood et al., 2007; Field et al., 2007, 2009; Field & Eastwood, 2005), the observed re-training effects were stronger and more consistent for the attend group than the avoid group. Specifically, the increases in attentional bias in the attend group were statistically significant at each of the three assessments points and of medium to large effect size following both single and multiple training sessions; by contrast, any statistically significant decreases in attentional bias in the avoid group were limited to the three assessment times following multiple training sessions and were of medium effect size. Although the attend and avoid conditions were designed to be symmetrical (i.e., dot replaces chocolate picture versus dot replaces non-chocolate picture), the latter contingency may have been more difficult to learn due to the greater heterogeneity in the selection of non-chocolate pictures. Future research might usefully endeavour to more closely match the chocolate and non-chocolate picture pairs to be identical except in chocolate content (e.g., pair pictures of chocolate vs vanilla ice-cream).

An alternative explanation for the observed stronger and more consistent increases rather than decreases in attentional bias across attentional re-training studies could be inherent to the dot probe task, as well as to other attentional bias modification tasks.

Regardless of whether participants are trained to attend to, or to avoid a stimulus, they are inevitably exposed to it. This exposure may itself inadvertently induce or re-induce a bias toward the stimulus. Attentional bias modification protocols may thus be more successful if they focus on training people toward a desirable stimulus (e.g., fruit), instead of training them to avoid an undesirable one (e.g., chocolate). In support, Kakoschke, Kemps and Tiggemann (2014) recently demonstrated initial success in a novel adaptation of the attentional bias modification paradigm in which they trained participants to attend to healthy food cues, and thereby induced an attentional bias for such cues. Participants also ate more healthy snack foods in a subsequent taste test. Of course, it remains to be determined whether training people to attend to healthy food (e.g., fruit) also results in them eating less unhealthy food (e.g., chocolate).

The current findings have implications for the clinical utility of attentional bias modification. In particular, they demonstrate the need for multiple re-training sessions to yield sustained changes in attentional bias. These were paralleled, although less robustly, for consumption. Future research could usefully examine whether further additional training would bring about more consistent effects on consumption. Indeed, some attentional bias modification studies in the anxiety domain have delivered as many as eight training sessions (Beard et al., 2012). Nevertheless, the five sessions used here did affect group differences in chocolate consumption after one week. From a practical perspective, as the dot probe task is administered on computer and does not require therapist contact, individuals need not attend multiple appointments to receive training. Instead, the re-training protocol could be readily incorporated into existing technologies (e.g., smart phones, tablets), making it an accessible home-based clinical tool. Home-based delivery of attentional bias modification via the internet has already been trialled in the field of anxiety (See, MacLeod & Bridle, 2009). In

this way, attentional bias modification could provide a useful add-on to existing treatment regimes.

There are a number of limitations that need to be acknowledged. First, as noted above, the study included two manipulations: one designed to train participants' attention toward chocolate cues (attend), and the other designed to train attention away from such cues (avoid). In the absence of a no-training control group, it is not clear whether the observed effects on attentional bias and chocolate consumption are driven by the attend or avoid manipulation, or both. Second, the study did not include a suspicion probe to determine whether or not participants guessed the true purpose of the taste test, and so some level of demand effects cannot be ruled out. Third, consistent with most attentional bias modification protocols, we used the dot probe task to both assess and re-train an attentional bias for chocolate. Thus it is possible that the observed changes in attentional bias reflect the acquisition of a specific task strategy rather than the extent to which chocolate cues capture attention. Countering this, however, studies in other domains (e.g., anxiety) have used different tasks to re-train and test biased attentional processing and have similarly found changes in attentional bias (Amir et al., 2009; Amir, Weber, Beard, Bomyea, & Taylor, 2008; Dandeneau & Baldwin, 2004; Dandeneau, Baldwin, Baccus, Sakellaropoulo & Preussner, 2007).

In conclusion, the present study has clearly shown that effects of attentional re-training on attentional bias for food cues can be maintained over some time (at least for a week). There was also some evidence of attentional re-training effects on consumption. In so doing, the findings add to emerging research showing sustained effects of such re-training on alcohol consumption and anxiety. Future research could examine the longevity of attentional re-training effects on other consumption behaviours, such as smoking and drug use, as well as

other behaviours in which attentional biases play a role, such as gambling (Brevers et al.,

2011) and insomnia (Jones, McPhee, Broomfield, Jones & Espie, 2005).

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Declaration of interest

All authors declare that they have no conflicts of interest.

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Table 1

Timing of the training and testing sessions for the single and multiple training conditions

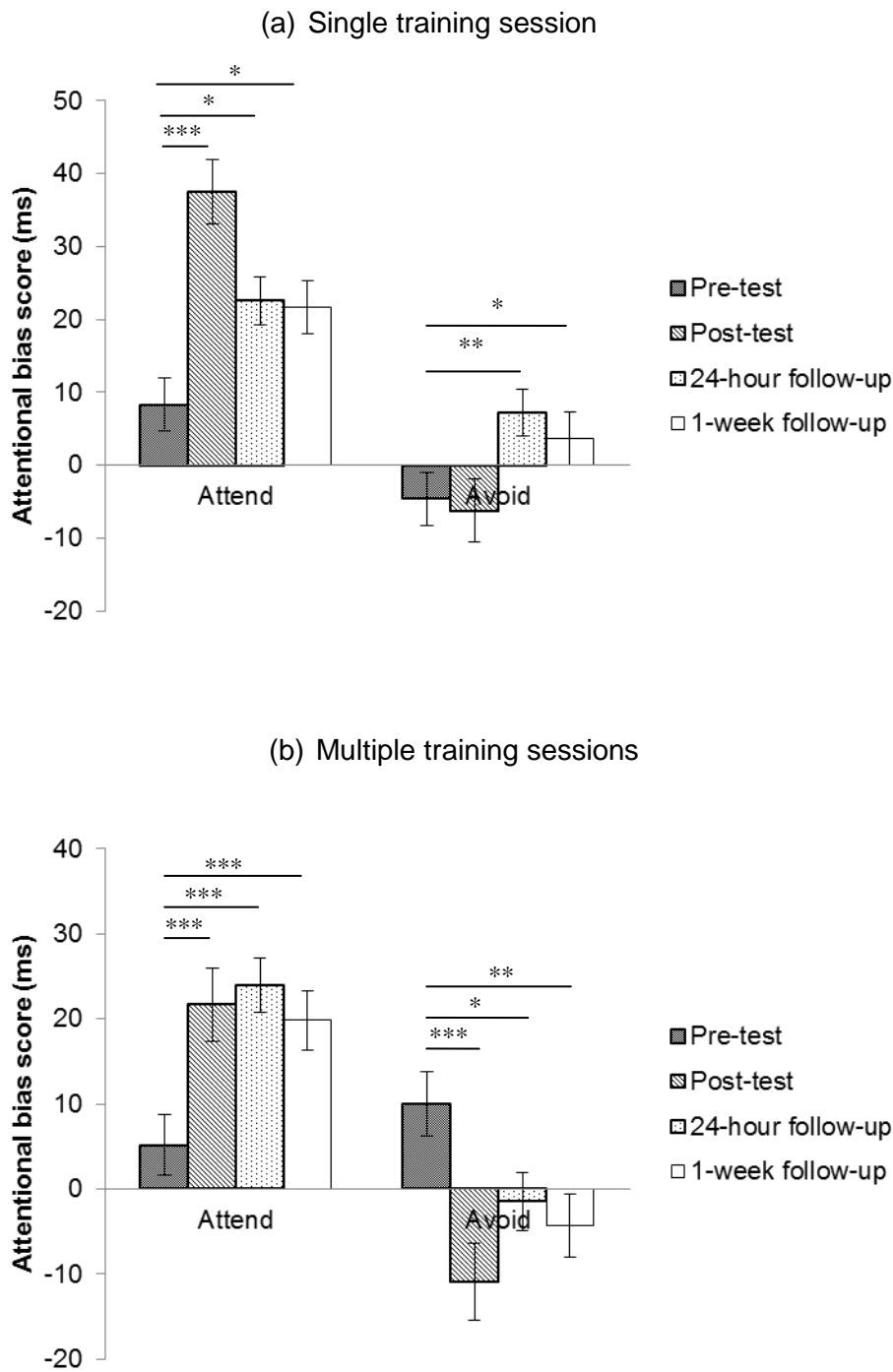| Day	Single training condition	Multiple-training condition
1	Pre-test Training session Post-test	Pre-test Training session 1
2	24-hour follow-up	
8	1-week follow-up	Training session 2
15		Training session 3
22		Training session 4
27		Training session 5 Post-test
28		24-hour follow-up
35		1-week follow-up

Figure 1. Mean attentional bias scores (with standard errors) for the attend and avoid groups

at each assessment time, following (a) a single training session or (b) multiple training

sessions; * $p < .05$, ** $p < .01$, *** $p < .001$.