Implicit Approach-Avoidance Associations for Craved Food Cues

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Abstract

Implicit approach associations are well documented for substances such as alcohol, tobacco and illicit drugs. This paper reports two experiments designed to establish and modify such associations specifically in the food craving domain. Experiment 1 used a pictorial implicit association task to examine approach-avoidance associations with chocolate cues in a sample of 48 undergraduate women. Participants were faster to respond to trials that paired chocolate pictures and approach words, and trials that paired pictures of highly desired food items not containing chocolate and avoid words, than the converse pairings. The magnitude of this approach bias was positively correlated with participants’ reported chocolate craving. Experiment 2 examined whether chocolate-related approach associations can be modified. Using a modified implicit association task, 96 undergraduate women were trained to associate chocolate pictures either with approach or with avoid words. As predicted, chocolate-approach associations increased in the approach group and decreased in the avoid group. Additionally, the approach group reported stronger chocolate cravings following training; in contrast, cravings tended to decrease in the avoid group. These results are consistent with incentive- and cognitive-motivational accounts of craving, and support and extend reports of approach biases (and the re-training of those biases) for other substances, including alcohol and cigarettes, to the food domain. They also offer potential scope for curbing unwanted food cravings in the context of problem eating behaviour.

Keywords: food craving, approach-avoidance association, approach bias, implicit association task, cognitive bias modification
Implicit Approach-Avoidance Associations for Craved Food Cues

The term ‘craving’ refers to a motivational state in which an individual feels compelled to seek and ingest a particular substance (Baker, Morse & Sherman, 1986). Although it usually refers to alcohol, tobacco and drugs, the term has become increasingly applied to food. Cravings are one of the main reasons why people fail to abstain from smoking, alcohol consumption and drug use (Carter et al., 2008). Even in people who have quit substance use, they can often trigger a relapse (Shiffman et al., 1997). Food cravings, in contrast, are generally not pathological (Lafay et al., 2001). However, they can be maladaptive for some people, and even pose health risks (Kemps & Tiggemann, 2010). Specifically, food cravings can trigger binge-eating episodes (Gendall, Joyce, Sullivan & Bulik, 1998; McManus & Waller, 1995), which can, in turn, give rise to obesity (Schlundt, Virts, Sbrocco & Pope-Cordle, 1993) and bulimia nervosa (Mitchell, Hatsukami, Eckert & Pyle, 1985; Waters, Hill & Waller, 2001). Food cravings have also been linked to impaired cognition (Kemps, Tiggemann & Grigg, 2008), and have the potential to thwart motivations to diet in people who are trying to lose weight (Sitton, 1991), leading to feelings of guilt and shame (Macdiarmid & Hetherington, 1995).

One contemporary theory of craving that emphasises appetitive motivational processes is Robinson and Berridge’s (1993) incentive-sensitisation account of addiction. According to this theory, craving-related cues, such as a beer or a cigarette, acquire motivational properties, or incentive salience, through a classically conditioned association between the cue and its subsequent consumption. Consequently, craving-related cues come to be perceived as attractive and ‘wanted’. As a result of this attribution process, craving-related stimuli automatically capture attention and trigger an appetitive response that guides behaviour toward target
acquisition and consumption. This has come to be known as an approach bias. The activation of this incentive motivational process is regulated by the dopaminergic reward system and occurs implicitly, outside of conscious awareness. Approach biases are thought to be at the heart of (unwanted) cravings and (over) consumption.

Although Robinson and Berridge’s (1993) model predicts a link between implicit approach associations and craving, it does not predict that these associations could be cognitively re-trained or that such a change would be reflected in craving or consumption behaviour. The latter prediction is, however, consistent with recent cognitive-motivational models of craving (Franken, 2003; Kavanagh, Andrade & May, 2005; Ryan, 2002). According to these models, an experimental manipulation of approach bias should produce a change in craving and consumption behaviour.

Over recent years, a growing number of studies have demonstrated an approach bias for commonly craved substances such as alcohol, tobacco and illicit drugs. For example, using a modified implicit association task, Palfai and Ostafin (2003) showed that heavy drinkers were faster to respond to trials that paired alcohol words (e.g., liquor) and approach words (e.g., advance) versus trials that paired control words (e.g., juice) and avoid words (e.g., withdraw) than the converse pairings. Cigarette smokers have similarly been found to show a stronger approach than avoid association with smoking cues (De Houwer, Custers & De Clercq, 2006). Using a different paradigm, the stimulus response compatibility task, several studies have shown that smokers are faster to move a manikin toward smoking-related pictures (e.g., a packet of cigarettes) and away from non-smoking control pictures (e.g., a bowl of cereal) than the other way round (Bradley, Field, Mogg & De Houwer, 2004; Bradley, Field, Healy & Mogg, 2008; Mogg, Bradley, Field & De Houwer, 2003; Mogg, Field & Bradley, 2005). Likewise, Field, Eastwood, Mogg and Bradley
(2006) reported an approach bias for drug cues in regular cannabis users on this task. Cousijn, Goudriaan and Wiers (2011) recently extended this finding to heavy cannabis users, using an approach avoidance task. Specifically, they found that heavy users were faster to pull (i.e., approach) than to push (i.e., avoid) a joystick in response to the angular orientation of drug-related pictures.

In addition to investigating an approach bias, many of these studies also examined its association with craving. Although a substantial number found no relationship between approach-avoidance associations and subjective craving (Bradley et al., 2008; Cousijn et al., 2011; Field et al., 2006; Mogg et al., 2003, 2005), several others did. In particular, Palfai and Ostafin (2003), and also Field and colleagues (Field, Mogg & Bradley, 2005; Field, Kiernan, Eastwood & Child, 2008), reported a positive correlation between heavy drinkers’ approach bias for alcohol cues and their urge to drink alcohol.

Although not focusing on craved foods, a number of studies have investigated approach-avoidance associations in relation to food in general (Brignell, Griffiths, Bradley & Mogg, 2009; Havermans, Giesen, Houben & Jansen, 2011; Veenstra & de Jong, 2010). These have shown that overweight and obese individuals, as well as restrained (individuals who intentionally restrict their food intake for the purpose of weight control) and external (individuals who eat in response to external cues (e.g., the sight or smell of food) rather than internal feelings of hunger) eaters, show a heightened food approach bias. In the only study to date to investigate an approach bias specifically in the context of food craving, Van Gucht, Vansteenwegen, Van den Bergh and Beckers (2008) showed that participants were faster to move a manikin toward a picture of a serving tray that had previously been associated with eating chocolate, and away from a picture of another serving tray that had previously been
associated with not eating chocolate, than vice versa. They interpreted this finding as evidence of an approach bias for a cue-induced food craving. However, as their design did not include a comparison food as a control, this result could be a function of an appetitive response for food in general, rather than chocolate. Further, it does not speak to the distinction between an actual craving and a more general appetitive response (Pelchat, 2002). A food craving refers to an intense desire or urge to eat a specific food (Weingarten & Elston, 1990), for which there is no substitute (Weingarten & Elston, 1991).

Thus the present experiments were designed to examine implicit approach-avoidance associations in the food craving domain. Experiment 1 aimed to investigate an approach bias for a specific craved food, as distinct from an appetitive response more generally. To this end, we used an implicit association task to examine approach-avoidance associations with regard to one particular highly craved food, namely chocolate, relative to that of comparison control foods. Chocolate was chosen because it is the most commonly craved food in Western cultures (Hetherington & Macdiarmid, 1993). Importantly, the control foods were also highly craved foods (e.g., French fries), as opposed to foods that are not typically craved (e.g., broccoli). If stronger implicit chocolate-approach (relative to chocolate-avoid) associations are successfully demonstrated under these circumstances, this would provide a very strong test of the specificity of food cravings.

Given the potentially adverse effects of food cravings, Experiment 2 examined whether chocolate-related approach-avoidance associations can be modified. Emerging evidence shows that it is possible to influence approach biases. In fact, using an approach-avoidance re-training paradigm, Wiers and colleagues (Wiers, Rinck, Kordts, Houben & Strack, 2010; Wiers, Eberl, Rinck, Becker & Lindenmeyer,
2011) showed that training hazardous drinkers and alcoholics to avoid alcohol cues attenuated their approach bias for alcohol. Experiment 2 investigated whether approach-avoidance associations in the food craving domain can similarly be modified.

These aims gave rise to a number of specific hypotheses. In Experiment 1, we predicted that (a) performance on the implicit association task would show a stronger chocolate-approach than chocolate-avoid association, and (b) the magnitude of this association would correlate positively with chocolate craving. In Experiment 2, we predicted that (a) experimental manipulation of chocolate-related approach-avoidance associations would produce group differences in approach bias scores, such that participants trained to associate chocolate with the concept of approach would show a heightened chocolate-approach association, and participants trained to associate chocolate with the concept of avoid would show a chocolate-avoidance association. We further predicted that (b) this re-training would produce changes in chocolate craving, such that cravings would increase in the approach group and decrease in the avoid group.

**Experiment 1**

Experiment 1 investigated approach-avoidance associations in relation to chocolate-related stimuli relative to other highly desired food stimuli. Following Palfai and Ostafin (2003), we used an implicit association task. Participants were asked to categorise stimuli that belonged to one of two concept categories (chocolate and non-chocolate) or one of two attribute categories (approach and avoid). An approach bias for chocolate would be demonstrated by faster categorisation times in the congruent (pairing chocolate and approach versus non-chocolate and avoid) than in the incongruent (pairing chocolate and avoid versus non-chocolate and approach).
approach phase of the task. We further examined whether this approach bias for chocolate cues correlated positively with participants’ self-reported craving for chocolate.

Method

Participants. Participants were 48 female undergraduate students at Flinders University who took part for course requirements and credit. They were aged between 18 and 25 years ($M = 19.58, SD = 1.91$). 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 cognitive 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, all participants reported that they liked chocolate, in response to the yes/no question “Do you like chocolate?”, and consumed on average 2.03 ($SD = 1.75$) chocolate bars and 3.49 ($SD = 3.46$) chocolate-containing food items per week.

Materials.

Implicit association task. There were four sets of stimuli, one for each of the two concept and two attribute categories, comprising 10 items each. Thus there were 10 pictures of chocolate or chocolate-containing food items (e.g., chocolate bar, brownie), 10 pictures of highly desired food items not containing chocolate (e.g., cake, pizza), 10 approach-related words (e.g., forward, advance) and 10 avoid-related words (e.g., escape, withdraw).

The chocolate and non-chocolate pictures were digital coloured photographs and measured $100 \times 100$ mm. These were obtained on the basis of a pilot study in which 18 women aged 20 to 23 years ($M = 21.39, SD = .85$) rated 74 pictures of
chocolate and other highly desired foods on 9-point valence and arousal scales. Importantly, the selected chocolate and non-chocolate picture sets were carefully matched on both valence (chocolate $M = 5.99$, $SD = .50$, non-chocolate $M = 5.82$, $SD = .89$, $t(18) = .54$, $p > .05$) and arousal (chocolate $M = 5.72$, $SD = .47$, non-chocolate $M = 5.51$, $SD = .88$, $t(18) = .67$, $p > .05$). The approach- and avoid-related words were adapted from Palfai and Ostafin (2003). These were constructed to clearly reflect the two semantically contrasting categories of approach and avoidance.

Following standard implicit association task procedures (Greenwald, McGhee & Schwartz, 1998), the task consisted of 5 blocks. In Block 1, participants were instructed to categorise stimuli according to concept only (e.g., left = chocolate, right = non-chocolate). In Block 2, participants categorised stimuli according to attribute only (e.g., left = approach, right = avoid). In Block 3, participants categorised stimuli according to both concept and attribute (e.g., left = chocolate + approach, right = non-chocolate + avoid). In Block 4, participants were again instructed to categorise stimuli according to concept only, but with the location of category labels reversed (e.g., left = non-chocolate, right = chocolate). Finally, in Block 5, participants again categorised stimuli according to both concept and attribute, but with the pairing of concept category labels reversed (e.g., left = non-chocolate + approach, right = chocolate + avoid).

During each block, the appropriate category labels were displayed in the top left and right hand corners of the computer screen. On each trial, a single stimulus (picture or word) was presented in the centre of the screen. Participants were asked to categorise the stimulus according to the designated concept and/or attribute category, by pressing the corresponding left (‘z’) or right (‘/’) key on the computer keyboard. They were instructed to respond as quickly and as accurately as possible. The
stimulus remained on screen until a response was made. The inter-trial interval was 250 ms.

Blocks 1, 2 and 4 consisted of 40 trials (each concept or attribute stimulus presented twice), and Blocks 3 and 5 consisted of 80 trials (each concept and attribute stimulus presented twice). Within each block, stimuli were presented in a new randomly chosen order for each participant, with the constraints that (a) the same stimulus was not repeated on consecutive trials, and (b) the same response (left or right) occurred on no more than 3 consecutive trials. Prior to commencing the critical mixed categorisation phases (i.e., Blocks 3 and 5), participants were given 8 practice trials using words and pictures that did not feature in the actual task. The assignment of response keys to concept stimuli (left or right) and the order of congruent (i.e., chocolate + approach versus non-chocolate + avoid) and incongruent (i.e., non-chocolate + approach versus chocolate + avoid) mixed categorisation phases was counterbalanced, resulting in four task versions, each administered to one quarter of the participants.

Chocolate craving. Chocolate craving was assessed using a 100-mm visual analogue scale. Participants indicated their current level of chocolate craving by placing a vertical mark on the 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).

Procedure. Participants were tested individually in a quiet room in the Applied Cognitive Psychology laboratory at Flinders University (South Australia) in a session of 30 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 17-inch monitor. After giving informed consent, participants completed a brief demographics questionnaire. They then performed the implicit association task, and rated their level of chocolate craving.

**Results**

**Implicit association task.** Only response times of correct trials in the critical mixed categorisation phases (i.e., congruent (chocolate + approach vs non-chocolate + avoid) and incongruent (non-chocolate + approach vs chocolate + avoid) trials of Blocks 3 and 5) were included in the analysis. The proportion of correctly categorised stimuli in these blocks was high (95.45%). Following previous protocols (e.g., Palfai and Ostafin, 2003), response times of less than 300 ms or more than 3000 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. Outliers accounted for 3.27% of the data.

Mean reaction times of the mixed categorisation phases were analysed by a 2 (phase: congruent, incongruent) × 2 (block order: congruent phase first, incongruent phase first) mixed model ANOVA. There was a significant main effect of phase, $F(1, 46) = 51.56, p < .001$, partial $\eta^2 = .53$. As predicted, reaction times were faster in the congruent ($M = 698$ ms, $SD = 100$ ms) than the incongruent ($M = 808$ ms, $SD = 153$ ms) phase, indicative of a stronger chocolate-approach than chocolate-avoid association. As can be seen in Table 1, both faster chocolate-approach pairings and faster non-chocolate avoid pairings contributed to this effect. There was also a significant main effect of block order, $F(1, 46) = 5.52, p < .05$, partial $\eta^2 = .11$, whereby reaction times were faster in the second ($M = 715$ ms, $SD = 110$ ms) than in the first ($M = 790$ ms, $SD = 110$ ms) mixed categorisation block. Furthermore, as is often found (e.g., Greenwald et al., 1998), there was a significant phase × block order
interaction, $F(1, 46) = 13.40, p < .001$, partial $\eta^2 = .23$. As can be seen in Table 2, the approach-avoidance associations were stronger when the congruent phase came first. In addition, paired samples $t$ tests comparing the categorisation of approach and avoid attributes for chocolate and non-chocolate cues separately, showed an approach association for chocolate (chocolate avoid – chocolate approach = 108 ms), $t(47) = 5.48, p < .001, d = .82$, and an avoidance association for non-chocolate (non-chocolate avoid – non-chocolate approach = -112 ms), $t(47) = 5.91, p < .001, d = .87$.

**Relationship between approach bias and chocolate craving.** Mean chocolate craving scores were moderate, around the mid-point of the scale ($M = 52.20, SD = 29.72$). A correlational analysis was performed to investigate whether the stronger chocolate-approach than chocolate-avoid association was a function of chocolate craving. An approach bias score was calculated by subtracting the mean reaction times in the congruent phase from those in the incongruent phase. As predicted, there was a significant positive correlation between participants’ approach bias scores and their chocolate craving ratings, $r = .30, p < .05$. Additionally, analyses conducted for chocolate (chocolate avoid – chocolate approach) and non-chocolate (non-chocolate avoid – non-chocolate approach) bias scores separately, showed a positive correlation between chocolate craving ratings and chocolate bias scores, $r = .29, p < .05$, but no such correlation for non-chocolate bias scores, $r = -.19, p > .05$.

**Discussion**

As predicted, performance on the implicit association task indicated an approach bias for chocolate (i.e., a stronger approach than avoid association with chocolate). Participants were faster to categorise stimuli in the congruent (i.e., chocolate + approach versus non-chocolate + avoid) than in the incongruent (i.e., non-chocolate + approach versus chocolate + avoid) phase of the task. This finding is
consistent with reports of approach biases for other craved substances, in particular those for alcohol (Field et al., 2005, 2008; Palfai & Ostafin, 2003), cigarettes (Bradley et al., 2004, 2008; De Houwer et al., 2006; Mogg et al., 2003, 2005) and cannabis (Cousijn et al., 2011; Field et al., 2006).

Importantly, the approach bias for chocolate was obtained in comparison with other highly desired food. Thus, unlike Van Gucht et al. (2008), the approach bias for craving-related chocolate cues observed here cannot be construed as a general appetitive response. This provides a clear test of the specificity of chocolate cravings. Moreover, the observed approach bias for chocolate could not be attributed to differences in valence or arousal between the two concept categories, as the chocolate and non-chocolate pictures were carefully matched on these appetitive qualities. As in the original paper on the implicit association task (Greenwald et al., 1998), the approach-avoidance associations were stronger when the congruent phase came first.

Interestingly, the stronger approach than avoid association with chocolate reflected both an approach association with chocolate and an avoidance association with non-chocolate. The latter is perhaps somewhat surprising as the non-chocolate pictures also portrayed highly desired foods and were matched to the chocolate pictures. One possible explanation could be the unique position chocolate occupies in the Western diet. Because of its hedonic appeal and its ambivalent status as both naughty and nice (Rogers & Smit, 2000), it is by far the most commonly and intensely craved food in Western cultures (Hetherington & Macdiarmid, 1993). Consequently, compared to chocolate, all other foods, including other highly craved foods, would be perceived to be less attractive. Another related explanation could be the inherent nature of the implicit association task. This task looks at relative comparisons between pairings of concept and attribute categories, in this case chocolate + approach versus
non-chocolate + avoid, and non-chocolate + approach versus chocolate + avoid. Thus, relative to chocolate, it would appear that participants formed an avoidance association with the non-chocolate pictures; however, this would have been unlikely if the comparison category had been other foods that are not typically craved or non-food items.

Finally, in line with previous studies on approach biases for alcohol cues (Field et al., 2005, 2008; Palfai & Ostafin, 2003), participants’ bias to approach chocolate cues was associated with subjective chocolate craving. Specifically, participants who reported stronger chocolate cravings showed a stronger approach bias for chocolate. Separate correlational analyses for chocolate and non-chocolate bias scores showed that this relationship was due to an association between chocolate craving and chocolate bias scores. In fact, non-chocolate bias scores did not correlate with chocolate craving. This speaks to the specificity of chocolate cravings, that is, there is no substitute for chocolate when it is craved. The correlation between approach bias scores and chocolate craving ratings was, however, rather small. This fits with previous reports of low correlations between approach bias and craving (Field et al., 2005, 2008; Palfai & Ostafin, 2003), and likely accounts for the mixed findings across the literature (Bradley et al., 2008; Cousijn et al., 2011; Field et al., 2006; Mogg et al., 2003, 2005).

**Experiment 2**

Experiment 1 demonstrated a stronger approach than avoid association specifically with regard to a craved food, namely chocolate. Experiment 2 investigated whether this association can be modified. To this end, we used a modified implicit association task to train participants to associate chocolate either with approach or with avoidance. We further examined the effect of this manipulation
on participants’ level of chocolate craving, and thus tested the causal role of the bias in craving (MacLeod, Rutherford, Campbell, Ebsworthy & Holker, 2002). In the only two studies to date to examine effects of approach bias re-training on craving, specifically alcohol craving, one found an effect (Wiers et al., 2011), but the other did not (Wiers et al., 2010).

Finally, we also measured participants’ awareness of the experimental contingencies used during the training (i.e., the pairing of chocolate pictures and approach/avoid words to response keys) to examine its potential role on training effects. Findings from previous cognitive 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, Mackinstosh & Munafo, 2008; Field et al., 2007), others found that contingency awareness did not influence training effects (Field et al., 2005; Field, Duka, Tyler & Schoenmakers, 2009).

**Method**

**Participants.** Participants were 96 female undergraduate students at Flinders University, aged 18 to 25 years (M = 20.51, SD = 1.84). None had taken part in Experiment 1. As in Experiment 1, participants ate something two hours prior to testing. Again, all participants reported that they liked chocolate. They consumed on average 1.62 (SD = 1.52) chocolate bars and 2.95 (SD = 2.64) chocolate-containing food items per week.

**Design.** The experiment used a 2 (training condition: approach, avoid) × 2 (time: pre-training assessment, post-training assessment) between-subjects pre-test post-test design. Participants were randomly assigned to the training conditions, subject to equal numbers per condition.
Materials.

Modified implicit association task. The same four sets of stimulus materials (chocolate and non-chocolate pictures, approach- and avoid-related words) were used as in Experiment 1. Following standard cognitive bias modification protocols (Field & Eastwood, 2005), the modified implicit association task consisted of three phases: (1) a pre-training baseline assessment of participants’ approach-avoidance associations with regard to chocolate, (2) a training stage in which half the participants were trained to associate chocolate with approach, and the other half were trained to associate chocolate with avoidance, and (3) a post-training assessment of participants’ approach-avoidance associations akin to the pre-training assessment.

Pre-training assessment. In the pre-training assessment stage, participants completed a recoding-free version of the implicit association task (Houben, Rothermund & Wiers, 2009; Rothermund, Teige-Mocigemba, Gast & Wentura, 2009). This not only shortened the task (from the standard 5 blocks to 3 blocks), but also made the critical phase (Block 3) more similar to the training stage. In Block 1, participants categorised stimuli according to attribute only (i.e., approach and avoid). As in Experiment 1, the response assignment of the attribute categories (left or right) remained constant, and was counterbalanced. In Block 2, participants categorised stimuli according to concept only (i.e., chocolate and non-chocolate). Here the response assignment of the concept categories (left or right) switched randomly between trials. In Block 3, participants categorised stimuli according to both attribute and concept, with response assignment of the concept categories switching between trials. In so doing, the critical congruent (i.e., chocolate + approach versus non-chocolate + avoid) and incongruent (i.e., non-chocolate + approach versus chocolate + avoid) categorisation phases were randomly intermixed in this combined block.
On each trial, the appropriate category labels were displayed in the top left and right hand corners of the computer screen 1500 ms before stimulus onset. This ensured that participants were aware of the correct response key assignment. As in Experiment 1, a single stimulus (picture or word) was then presented in the centre of the screen. Participants categorised the stimulus according to the designated attribute and/or concept category, by pressing the corresponding left (‘z’) or right (‘/’) key on the computer keyboard. They were instructed to respond as quickly and as accurately as possible. The stimulus remained on screen until a response was made. The inter-trial interval was 250 ms.

As in Experiment 1, Blocks 1 and 2 consisted of 40 trials (each attribute or concept stimulus presented twice), and Block 3 consisted of 80 trials (each attribute and concept stimulus presented twice). Within each block, stimuli were presented in a new randomly chosen order for each participant, with the constraints that (a) the same stimulus was not repeated on consecutive trials, and (b) the same response (left or right) occurred on no more than 3 consecutive trials. An additional constraint in Blocks 2 and 3 was that each concept was presented once for each response assignment. Furthermore, in Block 3 half the trials were congruent (i.e., chocolate + approach versus non-chocolate + avoid) whereas the other half were incongruent (i.e., non-chocolate + approach versus chocolate + avoid).

**Training.** In the training stage, participants were trained to associate chocolate either with approach or with avoidance. The task essentially involved a modification of Block 3 of the pre-training assessment. Specifically, for participants in the approach condition, 90% of trials were congruent (i.e., chocolate + approach versus non-chocolate + avoid) and 10% were incongruent (i.e., non-chocolate + approach versus chocolate + avoid). For participants in the avoid condition, these contingencies
were reversed, that is 10% congruent trials and 90% incongruent trials. Following Wiers et al. (2010), a 90-10 distribution was used, as opposed to a 100-0 one, to make responses less predictable, and thus reduce the obviousness of the contingency. The training phase consisted of 240 trials, with each attribute and concept stimulus presented 6 times.

Post-training assessment. The post-training assessment was identical to Block 3 of the pre-training assessment.

Chocolate craving. As in Experiment 1, participants rated their current level of chocolate craving 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”.

Awareness of experimental contingencies. Following Field and Eastwood (2005), awareness of experimental contingencies 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 pairings of the chocolate pictures and the approach/avoid words to the response keys during the training phase. The multiple-choice question asked participants to choose the correct statement from five different statements that described relationships between the pairings of the chocolate pictures and the approach/avoid words to the response keys (e.g., “chocolate pictures and approach words were paired to the same response key most of the time”).

Procedure. As in Experiment 1, participants were tested individually in a quiet room in the Applied Cognitive Psychology laboratory at Flinders University. All participants were tested in the afternoon in a session of 45 min. duration. Participants performed the modified implicit association task on an IBM compatible computer with a 17-inch monitor. Chocolate craving was assessed at two time points, just before
as well as immediately after the training phase. The contingency awareness measures were administered at the end of the testing session.

**Results**

**Modified implicit association task.** To assess the effect of the training, we compared approach-avoid associations from the post-training assessment with the Block 3 data of the pre-training assessment. Response times of incorrect trials were discarded. Additionally, response times of less than 300 ms or more than 3000 ms were excluded as outliers, as were response times more than 3 SDs above or below the individual mean. Errors and outliers accounted for 5.63% and 4.39% of the data, respectively. Descriptive statistics for the concept and attribute stimuli at pre- and post-training assessment for each training condition are shown in Table 3. For each assessment phase, an approach bias score was calculated by subtracting the mean reaction time of the congruent (chocolate + approach vs non-chocolate + avoid) trials, from the mean reaction time of the incongruent (non-chocolate + approach vs chocolate + avoid) trials.

Approach bias scores were analysed by a 2 (training condition: approach, avoid) × 2 (time: pre-training assessment, post-training assessment) mixed model ANOVA. There were no significant main effects of training condition, $F(1, 94) = 1.26, p > .05$, or time, $F(1, 94) = .07, p > .05$. However, as predicted, there was a significant training condition × time interaction, $F(1, 94) = 8.32, p < .01$, partial $\eta^2 = .08$. Independent samples $t$ tests showed that the two training conditions did not differ at pre-training assessment, $t(94) = 1.42, p > .05$. However, at post-training assessment, there was a significant group difference, $t(94) = 2.84, p < .01$, $d = .58$, with the approach group showing a chocolate-approach association and the avoid group showing a chocolate-avoid association. In addition, as can be seen in Figure 1,
paired samples $t$ tests, conducted for each training condition separately, showed a significant increase in approach bias scores from pre- to post-training assessment in the approach group, $t(47) = 2.08, p < .05, d = .43$, and a significant decrease in the avoid group, $t(47) = 2.03, p < .05, d = .45$. Furthermore, as can be seen in Figure 2, analyses of variance conducted for chocolate (chocolate avoid – chocolate approach) and non-chocolate (non-chocolate avoid – non-chocolate approach) bias scores separately, showed that training specifically affected the approach-avoidance associations for chocolate, $F(1, 94) = 10.42, p < .01$, partial $\eta^2 = .10$ (training condition × time interaction), but not for non-chocolate cues, $F(1, 94) = .23, p > .05$.

**Chocolate craving.** Chocolate craving ratings were also analysed by a 2 (training condition: approach, avoid) × 2 (time: pre-training assessment, post-training assessment) mixed model ANOVA. The pattern of results was the same as for the approach bias scores. There were no significant main effects of training condition, $F(1, 94) = .00, p > .05$, or time, $F(1, 94) = .30, p > .05$, but there was a significant interaction between training condition and time, $F(1, 94) = 4.41, p < .05$, partial $\eta^2 = .05$. As can be seen in Figure 3, paired samples $t$ tests, conducted for each training condition separately, showed that chocolate cravings increased significantly from pre- to post-training assessment in the approach condition, $t(47) = 2.08, p < .05, d = .16$. Although cravings decreased from pre- to post-training assessment in the avoid condition as expected, this change was not statistically significant, $t(47) = 1.01, p > .05$.

**Awareness of experimental contingencies.** Thirty-nine participants (41%) correctly recalled or recognised the relationship between the pairings of the chocolate pictures and the approach/avoid words to the response keys during the training phase; the other 57 participants (59%) were not aware of (or at least did not report) the
experimental contingencies. To examine the effect of contingency awareness on approach bias scores and chocolate craving ratings, the previous ANOVAs 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 $F$s < 1, $p$s > .05). It needs to be noted, however, that the reduced sample size is small and thus lacking in power.

Discussion

Experiment 2 showed that approach-avoidance associations for craving-related food cues can be modified. Specifically, participants demonstrated changed chocolate-related associations in accordance with their training condition, such that the approach group showed an increased chocolate-approach association from pre- to post-training assessment, whereas the avoid group showed an increased chocolate-avoidance association. These changes were entirely attributable to alterations in approach-avoidance associations for the chocolate cues. The altered approach-avoidance associations found here are consistent with recent studies that have found similar changes in approach bias for alcohol cues following a re-training protocol in hazardous drinking students (Wiers et al., 2010) and alcoholic inpatients (Wiers et al., 2011).

The training manipulation produced a similar pattern of effects on craving ratings. Participants in the approach group reported significantly stronger chocolate cravings after the training; in contrast, participants in the avoid group reported less intense cravings, although not significantly so. The training effects on chocolate craving observed here are in line with those of Wiers et al. (2011) on alcohol craving. However, Wiers et al. (2010) found no effect of approach bias re-training on alcohol craving. Other cognitive bias modification paradigms likewise have produced mixed
approach-avoidance associations and food craving, with some showing effects of attentional re-training on craving (Atwood et al., 2008; Field et al., 2005, 2007), and others not (Field et al., 2009; Schoenmakers, Wiers, Jones, Bruce & Jansen, 2007; Schoenmakers et al., 2010). Nevertheless, the finding here that the manipulation of chocolate-related approach-avoidance associations did produce a corresponding change in chocolate craving supports a causal relationship between approach bias and craving.

Finally, the training effects on approach-avoidance associations and craving 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.

**General Discussion**

The present experiments investigated implicit approach-avoidance associations in the food craving domain. Experiment 1 established the existence of an approach bias specifically for one particular craved food, namely chocolate. Experiment 2 demonstrated for the first time that this bias can be modified.

Our results are broadly consistent with reports of approach biases for other craved substances, such as alcohol (Field et al., 2005, 2008; Palfai & Ostafin, 2003), cigarettes (Bradley et al., 2004, 2008; De Houwer et al., 2006; Mogg et al., 2003, 2005) and drugs (Cousijn et al., 2011; Field et al., 2006). They also support recent findings of approach bias re-training to avoid alcohol (Wiers et al., 2010, 2011), and thus extend the application of approach bias modification to food cravings.

Theoretically, the current findings fit well into aspects of incentive- and cognitive-motivational accounts of craving. The findings of Experiment 1 are consistent with Robinson and Berridge’s (1993) predicted link between implicit approach associations and craving. The chocolate-related pictures used in the implicit
association task would have had high incentive salience for our sample of young Western women who regularly consume chocolate. These stimuli were therefore perceived as attractive and ‘wanted’, and could not be ignored. This in turn elicited the stronger chocolate-approach than avoid association, and accounts for the observed correlation with self-reported chocolate craving. Experiment 2 took the further step of testing predictions of more recent cognitive-motivational models of craving (Franken, 2003; Kavanagh et al., 2005; Ryan, 2002). These posit a causal effect of cognitive bias on subjective craving. Specifically, they predict that approach biases can be cognitively re-trained, and that such a change can influence subsequent craving. In support, Experiment 2 showed that chocolate-related approach-avoidance associations can indeed be modified, and that this modification produced a change in self-reported chocolate craving.

The results of Experiment 2 also have clinical implications. The finding that approach associations, and accompanying cravings, for food can be modified offers potential scope for curbing unwanted food cravings in vulnerable populations. In particular, future research should aim to extend the present findings obtained in an undergraduate sample with moderate chocolate cravings to individuals for whom such cravings are problematic, i.e., “chocoholics”, as well as binge eaters, overweight or obese individuals who are trying to lose weight, and individuals affected by eating disorders (Gendall, Joyce, Sullivan & Bulik, 1998; McManus & Waller, 1995; Sitton, 1991). Manipulating approach-avoidance associations might thus ameliorate some of the potentially adverse consequences of food craving.

Another avenue for further research would be to include a measure of consumption. It is widely accepted that craving drives consumption (Robinson & Berridge, 1993), although see Tiffany and Carter (1998) for an alternative view. Thus
the effects of approach-avoidance re-training should extend to consumption behaviour. In support, Wiers et al. (2010) found an effect of such re-training on alcohol consumption in heavy drinkers. In particular, heavy drinkers trained to avoid alcohol consumed less beer on a subsequent taste test than those trained to approach alcohol.

In conclusion, the present study adds to a growing body of research on craving-related approach-avoidance associations. We have clearly demonstrated an approach bias specifically for craving-related food cues, and have also shown that this bias can be modified.
References


Wiers, R.W., Eberl, C., Rinck, M., Beckers, S., & Lindenmeyer, J. (2011). Retraining automatic action tendencies changes alcoholic patients’ approach bias for alcohol and improves treatment outcome. *Psychological Science, 22,* 490-497.

**Table 1**

*Mean Reaction Times (and Standard Deviations) for the Concept and Attribute Stimuli in the Mixed Categorisation Phases in Experiment 1*

<table>
<thead>
<tr>
<th>Concept stimulus</th>
<th>Approach</th>
<th>Avoid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chocolate</td>
<td>695 (114)</td>
<td>803 (148)</td>
</tr>
<tr>
<td>Non-chocolate</td>
<td>814 (169)</td>
<td>702 (103)</td>
</tr>
</tbody>
</table>
Table 2

*Mean Reaction Times (and Standard Deviations) for the Congruent and Incongruent Phases as a Function of Block Order in Experiment 1*

<table>
<thead>
<tr>
<th>Block order</th>
<th>Congruent</th>
<th>Incongruent</th>
<th>Approach-avoidance association</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congruent first</td>
<td>707 (95)</td>
<td>873 (149)</td>
<td>166</td>
</tr>
<tr>
<td>Incongruent first</td>
<td>689 (106)</td>
<td>742 (130)</td>
<td>53</td>
</tr>
</tbody>
</table>
Table 3

*Mean Reaction Times (and Standard Deviations) for the Concept and Attribute Stimuli in the Approach and Avoid Conditions at Pre- and Post-training Assessment in Experiment 2*

<table>
<thead>
<tr>
<th>Training condition</th>
<th>Approach</th>
<th>Avoid</th>
<th>Approach</th>
<th>Avoid</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-training</td>
<td>Chocolate</td>
<td>1059 (198)</td>
<td>1085 (213)</td>
<td>1067 (277)</td>
</tr>
<tr>
<td>assessment</td>
<td>Non-chocolate</td>
<td>1123 (193)</td>
<td>1187 (243)</td>
<td>1182 (299)</td>
</tr>
<tr>
<td>Post-training</td>
<td>Chocolate</td>
<td>809 (160)</td>
<td>905 (159)</td>
<td>925 (248)</td>
</tr>
<tr>
<td>assessment</td>
<td>Non-chocolate</td>
<td>906 (184)</td>
<td>949 (208)</td>
<td>945 (264)</td>
</tr>
</tbody>
</table>
Figure 1. Mean approach bias scores (with standard errors) for the approach and avoid conditions at pre- and post-training assessment in Experiment 2; * $p < .05$. 

*approach avoidance associations and food craving*
Figure 2. Mean approach bias scores (with standard errors) for the approach and avoid conditions at pre- and post-training assessment for chocolate (top panel) and non-chocolate (bottom panel) cues in Experiment 2; * $p < .05$. 
Figure 3. Mean chocolate craving ratings (with standard errors) for the approach and avoid conditions at pre- and post-training assessment in Experiment 2; * $p < .05$. 

* - Indicates statistical significance with $p < .05$. The bars represent mean chocolate craving ratings with standard errors for the approach and avoid conditions at pre- and post-training assessment in Experiment 2.