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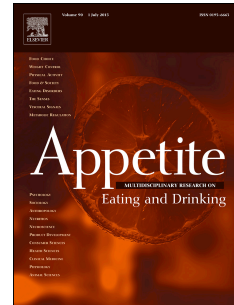
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Impulsivity Moderates the Effect of Approach Bias Modification on Healthy
Food Consumption

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Abstract

The study aimed to modify approach bias for healthy and unhealthy food and to determine its effect on subsequent food consumption. In addition, we investigated the potential moderating role of impulsivity in the effect of approach bias re-training on food consumption. Participants were 200 undergraduate women (17-26 years) who were randomly allocated to one of five conditions of an approach-avoidance task varying in the training of an approach bias for healthy food, unhealthy food, and non-food cues in a single session of 10 minutes. Outcome variables were approach bias for healthy and unhealthy food and the proportion of healthy relative to unhealthy snack food consumed. As predicted, approach bias for healthy food significantly increased in the 'avoid unhealthy food/approach healthy food' condition. Importantly, the effect of training on snack consumption was moderated by trait impulsivity. Participants high in impulsivity consumed a greater proportion of healthy snack food following the 'avoid unhealthy food/approach healthy food' training. This finding supports the suggestion that automatic processing of appetitive cues has a greater influence on consumption behaviour in individuals with poor self-regulatory control.

Keywords: Approach bias modification; food; consumption; eating behaviour; impulsivity

Impulsivity moderates the effect of approach bias modification on healthy food consumption

The contemporary Western environment provides continual exposure to an abundance of unhealthy food cues through advertising on the internet, TV, billboards, and in magazines (Havermans, 2013). An ‘obesogenic’ environment has been linked to consuming too much food high in fat, salt, and sugar, and not enough fruit and vegetables (Hill & Peters, 1998). Unhealthy eating behaviour is a key contributor to the increasing rates of overweight and obesity, which have doubled during the last few decades (Cohen, 2008). It is estimated that 35% of adults can now be classified as overweight and 11% as obese (WHO, 2014a). Excess body weight can lead to negative health consequences such as cancer, cardiovascular disease and diabetes (WHO, 2014b). Therefore, it is important to identify the mechanisms by which exposure to appetitive food cues in the environment can affect unhealthy eating behaviour.

One such mechanism implicated in the development of unhealthy eating behaviour is biased automatic processing of appetitive cues (Marteau, Hollands, & Fletcher, 2012). Recent dual process models propose that two types of processing determine our behaviour: automatic and controlled processing (Strack & Deutsch, 2004). Automatic processing is fast, effortless, and implicit, while controlled processing is slow, effortful, and explicit. Moreover, automatic processing involves cognitive biases, such as an approach bias, which refers to an automatic tendency to reach out toward (approach) rather than move away from (avoid) appetitive cues in the environment (Wiers, Gladwin, Hofmann, Salemink, & Ridderinkoff, 2013).

Approach biases exist for appetitive substances such as alcohol (Wiers, Rinck, Kordts, Houben, & Strack, 2010) and unhealthy food (Brignell, Griffiths, Bradley, & Mogg, 2009; Kemps & Tiggemann, 2015; Kemps, Tiggemann, Martin, & Elliott, 2013), and importantly, have been linked to increased consumption of such substances (alcohol, Wiers et al., 2010; unhealthy food; Kakoschke, Kemps, & Tiggemann, 2015a). Dual process models posit that controlled processes regulate the impact of automatic processes on behaviour; however, the

ability to regulate such processes is influenced by individual differences in self-regulatory control. For example, impulsivity, which is ‘a general tendency to act without deliberation’ (Hofmann, Friese, & Wiers, 2008, p. 113) may allow automatic processes to exert a greater influence on behaviour. Indeed, impulsivity predicts intake of unhealthy food (Kakoschke, Kemps, & Tiggemann et al., 2015b; Nederkoorn, Braet, Van Eijs, Tanghe, & Jansen, 2006).

Recently, researchers have begun to investigate whether automatic approach biases for appetitive cues can be modified using a computerised cognitive re-training paradigm. In commonly used protocols such as the Approach-Avoidance Task (AAT), participants are instructed to respond to images by pushing or pulling a joystick. Responses are based on an irrelevant feature (e.g., portrait or landscape format), rather than the image content, to ensure that the task captures automatic processing (Wiers et al., 2013). An avoidance of appetitive substances can be trained using a modified AAT in which these response contingencies are manipulated. Specifically, in ‘avoidance training’ target (appetitive) images are consistently presented in a format that requires them to be pushed (avoided) and control images in a format that requires them to be pulled (approached). In contrast, ‘approach training’ involves the reverse contingencies, while what has been termed ‘sham-training’ (a neutral or control condition) involves equal approach and avoidance of target and control images, which is the same as the assessment version of the task.

Previous studies have shown that manipulating the contingencies of the AAT can be used to re-train approach bias for appetitive cues. Specifically, research shows that training can be used to successfully reduce approach bias for alcohol (e.g., Wiers et al., 2010; Wiers et al., 2011) and chocolate (Schumacher, Kemps, & Tiggemann, 2016; Dickson, Kavanagh, & Macleod, 2016). Furthermore, a single training session can reduce consumption of alcohol (Wiers et al., 2010) and chocolate (Schumacher et al., 2016) during a laboratory taste test. A recent literature review concluded that approach bias modification is an effective intervention

for reducing approach biases for unhealthy substances and for discouraging the consumption of alcohol, cigarettes, and unhealthy food (Kakoschke, Kemps, & Tiggemann, 2017).

It is clearly possible to avoid unhealthy substances such as alcohol and cigarettes as there is no biological requirement to consume them. Food is a substance that is essential for human survival, thus complete avoidance is not possible. Instead, a healthy diet is about developing the right balance between eating enough healthy food and not too much unhealthy food. An approach bias modification protocol that simultaneously encourages the avoidance of unhealthy food and approach of healthy food may lend itself best to promoting a healthy diet. Moreover, interventions that not only discourage unhealthy behaviour, but also promote healthy behaviour, are likely to be more attractive and acceptable, an important consideration for cognitive bias modification tasks (Wiers et al., 2013).

A few studies have examined approach bias re-training in the healthy eating domain. In an early study, Fishbach and Shah (2006, Study 5) trained participants to approach healthy and avoid unhealthy food or to approach unhealthy and avoid healthy food, the former of which subsequently made healthier snack choices. More recently, Dickson, Kavanagh and MacLeod (2016) compared 'approach healthy food/ avoid chocolate' training with 'approach chocolate/avoid healthy food' training. Although approach bias was re-trained as expected, no group difference in chocolate consumption was found. In another recent study, Maas, Keijers, Rinck, Tanis and Becker (2015) found that 'approach healthy/avoid unhealthy food' training successfully modified approach bias, but eating behaviour was not measured. Finally, Becker et al. (2015, Study 1) found no difference in healthy snack choice between approach healthy/avoid unhealthy food training and a control group (sham-training). Thus, evidence for the use of approach bias modification in the healthy eating domain is relatively inconsistent.

One potential methodological explanation for the mixed findings lies in the particular comparison condition used. Similar to studies on alcohol, Fishbach and Shah (2006, Study 5),

who found a positive result, compared two extreme training conditions i.e., approach healthy/avoid unhealthy food versus avoid healthy/approach unhealthy food. In contrast, Becker et al. (2015, Study 1), who did not obtain a significant group difference in snack choice (only for successfully trained participants), compared approach healthy/avoid unhealthy food training with a less extreme condition (i.e., sham-training). Thus, it appears that using a more extreme comparison may result in significant differences in eating behaviour. To date, no study has compared all three conditions (i.e., 'approach', 'avoidance', and 'sham' training).

In addition, the approach healthy/avoid unhealthy food training has two interwoven components: approach healthy food; avoid unhealthy food. To determine which component is most important for effective re-training, we included two further conditions. In one, approach of healthy food was paired with avoidance of a non-food category, whereas in the other one, avoidance of unhealthy food was paired with approach of a non-food category. Thus, in total, the present study included five training conditions: simultaneous approach of healthy and avoidance of unhealthy food; a reverse training condition (i.e., simultaneous approach of unhealthy and avoidance of healthy food); a control condition in which approach-avoidance of healthy and unhealthy food was equal (i.e., sham-training); an avoid unhealthy food (approach non-food) condition and an approach healthy food (avoid non-food) condition.

A different kind of factor that may contribute to the observed inconsistent effects of approach bias re-training on food consumption is individual differences, which might make re-training differentially effective for different people. In particular, individual differences in aspects of self-regulatory control, such as trait impulsivity, have been shown to moderate the influence of impulses in general (Hofmann & Friese, 2008; Thush et al., 2008). Thus, trait impulsivity may predict whether training promotes successful regulation of approach bias in determining eating behaviour. To date, no study has examined the potential moderating role of trait impulsivity in the effect of approach bias modification on subsequent consumption.

While it is possible that highly impulsive individuals may have more difficulties in adopting avoidance behaviour, and thus might benefit less from the training, we predicted that training effects would be greater for highly impulsive individuals. This prediction was based on the idea that automatic processes likely play a more important role in consumption for those who have poor self-regulatory control (Friese et al., 2008; Strack & Deutsch, 2004).

In sum, the main aim of the study was to investigate whether approach bias for both healthy food and unhealthy food can be modified using a single 10-minute training session, and to determine the effect of such training on subsequent food consumption. Specifically, it was predicted that participants trained to approach healthy food and avoid unhealthy food would show a greater increase in approach bias for healthy food and a decrease in approach bias for unhealthy food compared to those trained to approach unhealthy food and avoid healthy food, or those in the control condition (i.e., sham-training). It was further expected that participants trained to approach healthy food and avoid unhealthy food would consume the greatest proportion of healthy food relative to unhealthy food, and that trait impulsivity would moderate the effect of training on consumption.

Method

Participants

A total of 200 women were recruited from the undergraduate student population at Flinders University. Participants ranged in age from 17 to 26 years ($M = 20.16$, $SD = 2.24$). BMI of the sample ranged from 15.23 to 43.34 kg/m^2 , with a mean of 23.12 kg/m^2 ($SD = 4.83$). Of the sample, 13.6% of participants were underweight ($<18.5 \text{ kg/m}^2$), 58% were of normal weight (18.5-25 kg/m^2), 18.6% were overweight (25-30 kg/m^2), and 9.5% were obese ($>30 \text{ kg/m}^2$; WHO, 2014a). Only women were recruited because they have a greater tendency to overeat than men (Burton, Smit & Lightowler, 2007). Participants were recruited if they could speak English fluently, liked most foods, and did not have any food allergies,

intolerances, or special dietary requirements. Participants were instructed to eat something two hours before their scheduled testing session in the laboratory to ensure that they were not hungry as hunger has been shown to confound approach bias for food cues (Seibt, Hafner, & Deutsch, 2007). Most participants reported having complied with this instruction as the mean time period since participants had last eaten was 2.40 hours ($SD = .98$). Participants also rated their current hunger level on a 100 mm visual analogue scale ranging from 'not hungry at all' to 'extremely hungry' (Grand, 1968). Mean hunger ratings fell slightly below the mid-point of the scale ($M = 47.24$, $SD = 22.07$).

Design

The study used a 5 (AAT training condition) x 2 (picture: unhealthy food, healthy food) x 2 (time: pre-training, post-training) mixed experimental design. Participants were randomly allocated to one of the five training conditions: (1) avoid unhealthy food and approach healthy food; (2) avoid unhealthy food and approach non-food (i.e., animals); (3) approach healthy food and avoid non-food (i.e., animals); (4) approach unhealthy food and avoid healthy food; (5) approach and avoid healthy and unhealthy food equally (i.e., control).

Materials

Stimulus materials. Following Wiers et al. (2010), the Approach-Avoidance Task was adapted to measure and modify approach bias for healthy food and unhealthy food cues. The stimuli were 60 digital coloured photographs (presented in a resolution of 1024 x 768 pixels), comprising 20 images of healthy foods, 20 images of unhealthy foods and 20 images of non-food stimuli depicting animals not normally eaten in Western society. Healthy foods were defined as those containing a low level of fat, sugar and/or salt (e.g., grapes, sushi), while unhealthy foods contained a high level of fat, sugar and/or salt (e.g., crisps, chocolate cake). Both categories contained an equal number of sweet and savoury food items. Foods were presented against a white background without any visible plates (see Appendix A for

exemplary images). Animals were chosen for the non-food stimuli as they, like food, are overall appealing. A portrait (aspect ratio 3:4) and landscape (aspect ratio 4:3) format of each image was created.

The healthy food pictures were selected from a subset of those used in a previous study (Kakoschke, Kemps, & Tiggemann, 2014). The ratings were obtained from a pilot test with 20 women aged 18–25 years ($M = 21.60$, $SD = 1.50$) in which participants were asked to rate 36 pictures of healthy food on 9-point pleasure and arousal scales. The ratings for the unhealthy food and animal pictures were obtained from a pilot test in which 21 women aged 17–45 years ($M = 23.67$, $SD = 8.28$) rated 590 pictures of unhealthy food and animals on 9-point pleasure and arousal scales (Kemps, Tiggemann, & Hollitt, 2014). The pictures were selected on the basis that the healthy food, unhealthy food, and animal categories did not significantly differ on mean ratings of pleasure and arousal (all $ps > 0.40$). Another 12 images of common objects (e.g., ball, flower) were used for the practice trials preceding the task.

Approach-Avoidance Task. Based on standard procedures (e.g., Wiers et al., 2010), a computerized Approach-Avoidance Task was used. The protocol consisted of three phases: (1) a pre-training phase in which participants' approach bias for healthy and unhealthy food was measured; (2) a training phase in which participants were trained to approach or avoid healthy food, unhealthy food and/or animals; and (3) a post-training phase in which participants' approach bias for healthy and unhealthy food was again measured.

On each trial of the pre- and post-training phases, participants began by pressing the start button on the top of the joystick. A picture of a healthy food or an unhealthy food then appeared in the centre of the screen. Participants were instructed to push or pull the joystick according to whether the picture was presented in portrait versus landscape format. These instructions were counterbalanced (i.e., half of the participants pulled portrait pictures and pushed landscape, and vice versa). When participants pulled the joystick, the picture size

increased (simulating approach), while pushing the joystick decreased the picture size (simulating avoidance; Neumann & Strack, 2000). Participants were asked to respond as quickly and accurately as possible. Prior to the pre-training phase, 12 practice trials were used so that participants could learn to push and pull the joystick in response to the picture format. During the pre-training phase, each of the 40 images (20 healthy and 20 unhealthy food) were shown twice, once in the format participants were instructed to pull and once in the format they were instructed to push, resulting in 80 trials. Thus, participants pushed and pulled the healthy and unhealthy food pictures equally often.

In the training phase, participants completed a modified Approach-Avoidance Task. Specifically, the push-pull contingencies of healthy food, unhealthy food, and animal pictures were manipulated to create five training conditions (see Table 1). Participants in all five conditions pushed and pulled pictures from the two stimulus categories with equal frequency. Following previous studies (Schumacher et al., 2016), the 40 images used in each condition were presented six times resulting in 240 trials. Training lasted approximately 10 minutes.

In the post-training phase, participants again undertook the assessment version of the Approach-Avoidance Task, as they did in the pre-training phase.

For the trials from the pre- and post-training phases, median reaction times were calculated for the four combinations of pushing versus pulling healthy and unhealthy food pictures. Reaction times on pull (approach) trials were subtracted from reaction times on push (avoidance) trials, resulting in positive bias scores that indicate relative approach and negative bias scores that indicate relative avoidance for each of the two types of pictures.

Taste test. A so-called taste test was used to assess the effect of the training on healthy and unhealthy food consumption after the post-training phase of the Approach-Avoidance task. Participants were presented with a platter comprising two healthy (grapes and almonds) and two unhealthy snacks (chocolate M&Ms and potato crisps). The snacks

were presented in equally-filled separate bowls and were chosen as they are commonly consumed and are bite-sized to facilitate eating. The presentation order of the four bowls was counterbalanced across participants using a 4×4 Latin square. Participants were instructed to taste as much or as little of the food as they liked so that they could rate each snack on several characteristics (e.g., 'How sweet is this food?'). They were given 10 minutes to complete their ratings after which time the platter was taken away. The amount of each food consumed was calculated by subtracting the weight (in grams) of the food after the taste test from the weight of the food before the taste test. The weight in grams for each food was then converted into the number of calories consumed. A single measure of relative consumption of healthy and unhealthy food was calculated as the proportion of healthy food consumed out of total food consumption.

Barratt Impulsiveness Scale (BIS-11). Trait impulsivity was assessed by the widely used BIS-11 (Patton et al., 1995). The BIS-11 comprises 30 items designed to assess different aspects of impulsivity including attentional (e.g., 'I am restless at the theatre or lectures'), motor (e.g., 'I do things without thinking'), and non-planning (e.g., 'I am more interested in the present than the future'). Items are scored on a 4-point Likert-scale (1 = 'rarely/ never', 4 = 'almost always/always'). Scores are summed to provide a BIS-11 total score. According to Stanford et al. (2009, p. 387), a total score of 72 or above indicates high impulsivity, a widely recognised cut-off, including in the eating domain (e.g., Lattimore & Mead, 2015). According to this cut-off, participants in the current sample were classified into high ($n = 49$) and low ($n = 151$) impulsivity groups. The BIS-11 has good test-retest reliability and internal reliability (Patton et al., 1995; Stanford et al., 2009). In the present study, internal reliability for the total scale was also good ($\alpha = .85$).

Procedure

Participants were tested in the Food Laboratory in the School of Psychology at Flinders University during a single one-hour session. After providing informed consent, participants completed a brief demographics questionnaire, followed by the Approach-Avoidance Task. After completing the computer task, participants underwent the taste test, and finally, they completed the Barratt Impulsiveness Scale. All participants were debriefed via e-mail once data collection was completed.

Results

Statistical considerations

An alpha value of .05 was used to determine significant p values. Effect size measures were partial eta² (η^2) for ANOVA and Cohen's d for t-tests. For η^2 , a value of .01 represents a small effect, .06, a medium effect, and .14, a large effect, while for Cohen's d , .20 represents a small effect, .50, a medium effect, and .80, a large effect (Cohen, 1992).

Effect of training on approach bias

To assess the effect of the training on approach bias for each of the two picture types (i.e., healthy and unhealthy food), reaction times at pre-training were compared with those at post-training. Following earlier research using the AAT (Wiers et al., 2010), median reaction times of correct trials (94.64%) were used for data analysis.

Changes in approach bias scores were analysed using a 5 (AAT condition: avoid unhealthy/approach healthy food, avoid unhealthy food/approach animals, approach healthy/avoid animals, approach unhealthy/avoid healthy food, approach/avoid healthy/unhealthy food equally) x 2 (picture: healthy food, unhealthy food) x 2 (time: pre-training, post-training) mixed model ANOVA. Results revealed significant condition x picture, $F(1, 195) = 9.45, p < .001, \eta^2 = .162$, and picture x time interactions, $F(1, 195) = 5.68, p = .018, \eta^2 = .028$. Importantly, there was a significant condition x picture x time interaction, $F(1, 195) = 7.47, p < .001, \eta^2 = .133$.

The nature of the three-way interaction was further examined using separate pairwise comparisons for healthy food and unhealthy food (using a Bonferroni correction) to assess change in approach bias from pre- to post-training in each condition. For unhealthy food (Figure 1a), approach bias significantly decreased from pre- to post-training in the avoid unhealthy/approach healthy food condition, $F(1,195) = 8.38, p = .004, \eta^2 = .041$, and in the avoid unhealthy food/approach animals condition, $F(1, 195) = 9.47, p = .002, \eta^2 = .046$. In addition, approach bias for unhealthy food significantly increased in the approach unhealthy/avoid healthy food condition, $F(1, 195) = 6.26, p = .013, \eta^2 = .031$. These results showed that it is the ‘avoid unhealthy food’, rather than the ‘approach healthy food’, component that seems to be crucial for the training effect for unhealthy food.

For healthy food (Figure 1b), approach bias significantly increased from pre- to post-training in the avoid unhealthy/approach healthy food condition, $F(1,195) = 5.91, p = .016, \eta^2 = .029$. Approach bias for healthy food trended toward a decrease from pre- to post-training in the approach unhealthy/avoid healthy food condition, $F(1,195) = 2.96, p = 0.08, \eta^2 = .015$. There were no other significant changes in approach bias for healthy food cues. These results showed that both the ‘avoid unhealthy food’ and ‘approach healthy food’ components appear to be important for the training effect on healthy food. Overall, it seems that it was easier to train the avoidance of unhealthy food than the approach toward healthy food cues.

Effect of training on consumption

A one-way ANOVA was used to assess the effect of the training on the proportion of healthy food consumed (see Table 2 for descriptive statistics). Results revealed no significant differences in consumption between conditions, $F(4, 196) = .425, p = .791, \eta^2 = .009$. This result indicates that training did not have an overall effect on the relative amount of healthy food consumed. As can be seen from the means, participants in all of the training conditions consumed about 50% healthy food. The only condition in which participants ate more healthy

food than unhealthy food was the 'avoid unhealthy/approach healthy food' condition (53%), but pairwise analyses showed that this did not differ significantly from any other condition (all p 's $>.25$).

Moderation of training effect by impulsivity

Further analyses were performed to determine whether impulsivity group (high/low, based on the established cut-off score) moderated the effect of training on approach bias or consumption. For approach bias, results showed no significant main effect of impulsivity group, $F(1, 194) = .006, p = .939, \eta^2 = .001$, nor any interactions involving impulsivity (all p 's $>.09$). This indicates that the training had equivalent effects on approach biases for healthy food and unhealthy food regardless of participants' level of trait impulsivity.

For consumption, on the other hand, results showed likewise no main effect of impulsivity group, $F(1, 190) = .017, p = .998, \eta^2 = .001$, but a significant interaction between condition and impulsivity group, $F(4, 190) = 2.47, p = .046, \eta^2 = .049$ (see Figure 2). Separate analyses for the impulsivity groups revealed that there was no significant difference in the proportion of healthy food consumed across conditions for participants with low impulsivity, $F(4, 190) = .304, p = .875, \eta^2 = .006$. In contrast, for those with high impulsivity, there was a significant difference between conditions, $F(4, 190) = 2.596, p = .038, \eta^2 = .001$. Pairwise comparisons showed that the proportion of healthy food consumed was significantly greater in the avoid unhealthy/approach healthy food condition than in the approach unhealthy/avoid healthy food condition, $p = .005, d = 1.15$, and in the approach/avoid healthy/unhealthy food equally condition, $p = .010, d = 1.06$. This result indicates that the effect of the training on the relative amount of healthy food consumed was found only in participants with high impulsivity.

Discussion

The current study aimed to use approach bias modification to encourage healthier eating behaviour. As predicted, participants trained to avoid unhealthy and approach healthy food showed a bias away from unhealthy food and a bias toward healthy food following the training, whereas those trained to approach unhealthy and avoid healthy food showed a bias toward unhealthy food and a (non-significant) bias away from healthy food. In addition, for consumption, training interacted with trait impulsivity to predict relative healthy food intake in a subsequent taste test. Specifically, only among highly impulsive participants, did those trained to avoid unhealthy and approach healthy food eat a greater proportion of healthy food.

As expected, participants allocated to the avoid unhealthy and approach healthy food condition showed an increase in their approach bias for healthy food and a decrease in their approach bias for unhealthy food from pre- to post-training. These results are consistent with previous studies showing that an increased approach bias for healthy food cues can be trained while simultaneously training an avoidance of unhealthy food (Fishbach & Shah, 2006, Study 5; Maas et al., 2015; Dickson et al., 2015). Conversely, in the current study, participants in the approach unhealthy and avoid healthy food condition showed an increased approach bias for unhealthy food. Previous studies have similarly shown an increased bias for unhealthy food after training toward unhealthy food (Fishbach & Shah, 2006; Schumacher et al., 2016). As expected, there were no approach bias changes for healthy or unhealthy food in the condition in which healthy and unhealthy food were equally approached and avoided.

The design of our study was novel in that it included two further training conditions, which examined either avoidance of unhealthy food or approach of healthy food compared to animals (a non-food category). The finding that approach bias for unhealthy food reduced in participants trained to avoid unhealthy food and approach animals fits with one previous study in the food domain (Brockmeyer, Hahn, Reetz, Schmidt, & Friederich, 2015), but our results indicate that it is the 'avoid unhealthy food' component that is important. In contrast,

participants trained to approach healthy food and avoid animals showed no significant change in approach bias for healthy or unhealthy food. It appears that both the ‘approach healthy’ and the ‘avoid unhealthy’ components are needed to increase approach toward healthy food, while only the ‘avoid unhealthy’ component is needed to induce avoidance of unhealthy food.

More generally, it is evident from these findings that the control comparison condition chosen (i.e., ‘avoid healthy/approach unhealthy food’ or ‘sham’ training) is important for evaluating the effectiveness of approach training for healthy food. Nevertheless, it is important to note that while the extreme comparison between an ‘approach healthy food’ with an ‘approach unhealthy food’ condition is a useful step in demonstrating the basic effects of approach-avoidance training, as we did here, it would be unethical to train a sample of individuals with problematic eating behaviour to approach unhealthy food. Thus, future studies, particularly those using multiple or more intensive training sessions, should screen for clinical eating disorders.

Our finding that approach bias modification did not produce a main effect on healthy snack food consumption is at odds with some results for alcohol and chocolate (Wiers et al., 2010; Schumacher et al., 2016). It also does not support the finding of Fishbach and Shah (2006, Study 5), which showed that participants trained to approach healthy food were more likely to choose a healthy snack over an unhealthy one than those trained to avoid healthy food. However, our finding is consistent with some previous studies that likewise found no overall main effect of training on eating behaviour (Becker et al., 2015, Study 1; Dickson et al., 2016). One potential reason as to why no main effect of training condition on food consumption was observed is that a single training session of 10 minutes may not be sufficiently intensive to produce an immediate effect on consumption. Some previous studies in the alcohol domain that have found positive effects of training on consumption have used multiple training sessions (Eberl et al., 2013; Wiers, Eberl, Rinck, Becker, & Lindenmeyer,

2011). Future studies should aim to determine how many training sessions are required to obtain an immediate effect on consumption and explore the longevity of such training effects.

Our final aim was to examine the role of impulsivity on training effects for both approach bias and food consumption. We found that impulsivity did not moderate the effect of training on approach bias for healthy or unhealthy food. As expected, this indicates that the re-training was equivalent in its effectiveness at changing approach biases, regardless of participants' level of trait impulsivity. In contrast, it did moderate the effect of training on healthy food consumption. As predicted, highly impulsive participants who were trained to avoid unhealthy and approach healthy food consumed a greater proportion of healthy snacks than highly impulsive participants who were trained to approach unhealthy and avoid healthy food or those in the control (i.e., sham-training) condition. Together, these findings indicate that changes in automatic processing will affect behaviour, but only among highly impulsive individuals, consistent with the idea that automatic processes likely play a more important role in consumption for those with poor self-regulatory control (Friese et al., 2008; Strack & Deutsch, 2004). Thus, interventions that target approach bias for food may only be effective at changing subsequent food consumption for highly impulsive individuals. Future studies should examine the effect of training on food intake for specific sub-groups of individuals.

Theoretically, our findings support the underlying assumptions of contemporary dual process models of behaviour (Strack & Deutsch, 2004). In particular, our findings support the suggestion that both automatic processing and self-regulatory control determine eating behaviour. Specifically, the finding that the training was effective at encouraging a greater proportion of healthy food consumption, but only among the highly impulsive individuals, is consistent with the proposition that eating behaviour is guided by both automatic approach biases and self-regulatory control of impulsive responses (Hofmann et al., 2008).

The current results also have practical implications as they indicate that increasing approach bias for healthy food encourages a greater proportion of healthy food consumption, albeit only for highly impulsive individuals. This suggests that an approach bias modification protocol that trains the simultaneous approach of healthy food and avoidance of unhealthy food would be most beneficial for individuals with high levels of trait impulsivity, such as overweight and obese people, who tend to be more impulsive than normal-weight people (Nederkoorn et al., 2006; Nederkoorn, Smulders, Havermans, Roefs, & Jansen, 2006; Kakoschke et al., 2015b). This is important given that in modern Western society, overweight and obesity rates are increasing, which is partly influenced by consuming too much food high in fat, salt and sugar. Therefore, approach bias modification interventions may be one way to effectively encourage highly impulsive people, such as overweight and obese individuals, to eat more healthy food and less unhealthy food. Although the current research focused on trait impulsivity as an individual variable that potentially affected the findings, it is possible that other variables at the time of testing, such as mood, attempts to reduce caloric intake, intention to lose weight and dietary restraint may also have impacted the main outcomes.

Similar to most research, the current study is subject to a number of limitations. First, the sample was restricted to females due to their elevated prevalence of overeating. However, over a third of those with a binge eating disorder are male (Hudson, Hiripi, Pope, & Kessler, 2007). Relatedly, participants were an unselected sample. Thus, future researchers might use a screening questionnaire to determine overeating (or food craving or external eating) rather than gender as an inclusion criterion. Second, the study used a single brief training session. Future researchers could use multiple or more intensive training sessions that are liable to procure more reliable effects on food consumption. Third, moderator analyses in the current study used an established cut-off score on the BIS (Stanford et al., 2009) to define high and low impulsivity groups, resulting in a relatively smaller high impulsivity group. Thus, future

studies might target larger samples containing individuals with high impulsivity. Finally, although the food images were selected on ratings of pleasure and arousal, future studies may consider using a standard, validated picture set (e.g., FoodPics; Blechert, Meule, Busch, & Ohla, 2014) to increase comparability with other studies.

In conclusion, the present study demonstrated that approach bias modification can be used in the eating domain to modify approach bias for both healthy and unhealthy food and to encourage healthier eating behaviour. Additionally, our findings support the hypothesis that trait impulsivity moderates the effectiveness of approach bias re-training on consumption of healthy food. Specifically, highly impulsive women benefited the most from receiving the avoid unhealthy and approach healthy food training as they subsequently consumed a greater proportion of healthy snack food. These findings suggest that future research needs to take into account the role of individual differences in impulsivity and could usefully examine the benefits of approach bias modification protocols for increasing healthy food consumption among individuals with problematic eating behaviour driven by impulsivity.

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ACCEPTED MANUSCRIPT

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Table 1

Push/pull contingencies for each training condition on the Approach-Avoidance Task.

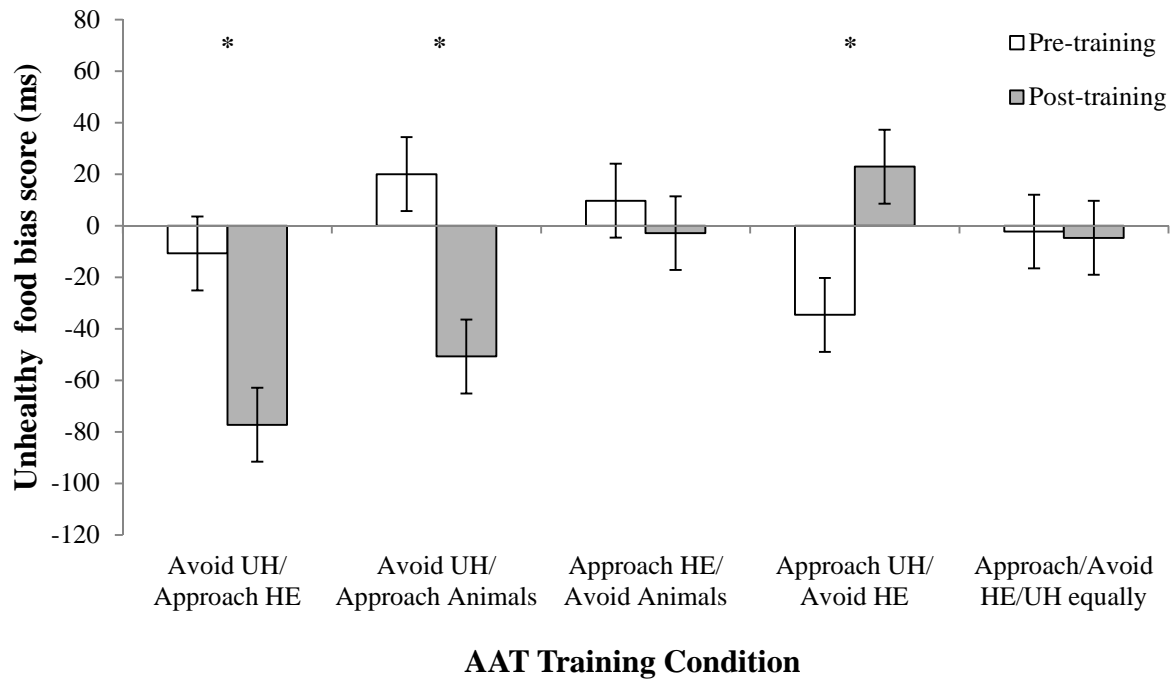
Approach-Avoidance Training Condition	Contingencies	
	Push (avoid)	Pull (approach)
Avoid unhealthy food /Approach healthy food	90% = unhealthy	10% = unhealthy
	10% = healthy	90% = healthy
Avoid unhealthy food/Approach animals	90% = unhealthy	10% = unhealthy
	10% = animals	90% = animals
Approach healthy food/Avoid animals	10% = healthy	90% = healthy
	90% = animals	10% = animals
Approach unhealthy food/Avoid healthy food	10% = unhealthy	90% = unhealthy
	90% = healthy	10% = healthy
Approach/avoid healthy/unhealthy food equally	50% = healthy	50% = healthy
	50% = unhealthy	50% = unhealthy

Table 2

Means and standard deviations for the proportion of healthy food consumed for each training condition on the Approach-Avoidance Task.

Approach-Avoidance Training Condition	Proportion of Healthy Food Consumed	
	Mean	Standard Deviation
Avoid unhealthy food /Approach healthy food	.53	.23
Avoid unhealthy food/Approach animals	.48	.16
Approach healthy food/Avoid animals	.48	.23
Approach unhealthy food/Avoid healthy food	.50	.19
Approach/avoid healthy/unhealthy food equally	.47	.18

(a) Unhealthy Food



(b) Healthy Food

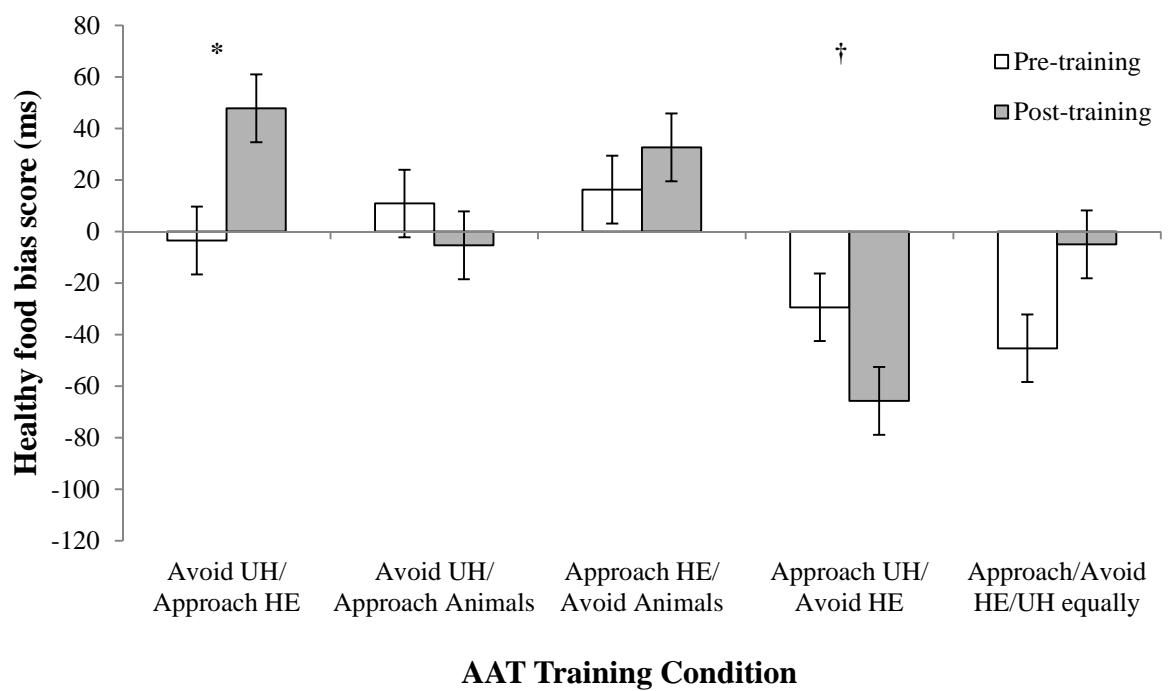


Fig 1. Mean approach bias scores (with 95% confidence intervals [CI]) for AAT training condition at pre- and post-training for (a) unhealthy and (b) healthy food. Within-subjects 95% CIs were calculated using formulae from Masson and Loftus (2003). * $p < .05$, † $p = .08$.

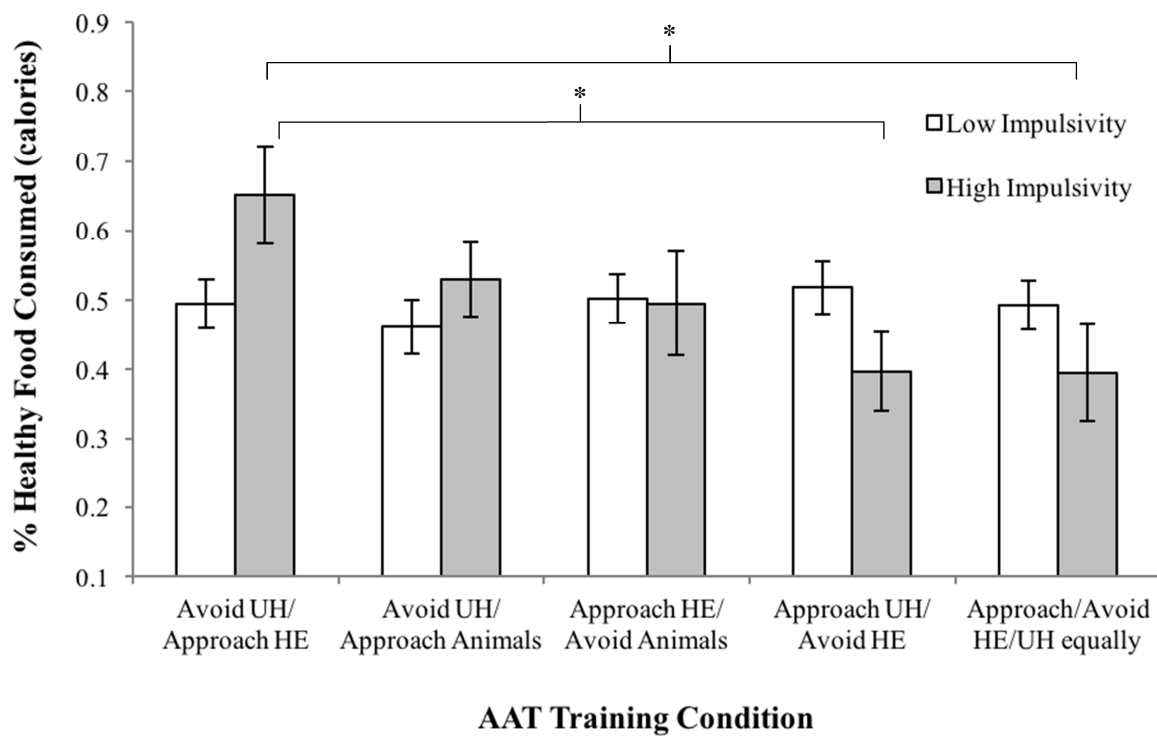


Fig. 2. Proportion of healthy food consumption in calories (with standard error bars) as a function of AAT training condition and trait impulsivity. $*p < .05$

Appendix A

Exemplary images of (a) healthy and (b) unhealthy foods used in the Approach-Avoidance task.

(a) Healthy food



(b) Unhealthy food

