The Role of Automatic Processing of Food Cues in Unhealthy Eating Behaviour

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Summary

Recent empirical research and theoretical models have acknowledged that automatic processing of appetitive food cues is an important contributor to unhealthy eating behaviour. However, relatively little research has examined when, and for whom, automatic processing of food cues influences such behaviour. Therefore, the first aim of the thesis was to investigate automatic processing in conjunction with self-regulatory control or trait eating styles to gain a better understanding of unhealthy eating behaviour. The second aim was to determine whether interventions designed to modify automatic processes and/or self-regulatory control are effective for reducing unhealthy eating and/or promoting healthier eating. These two aims were addressed in a series of correlational and experimental studies.

The thesis consists of six papers (two published, one under revision, and three under review). Study 1 examined the combined effects of cognitive bias (attentional and approach) and inhibitory control on unhealthy eating behaviour. It was found that a stronger approach bias for unhealthy food combined with lower inhibitory control predicted increased consumption of unhealthy food. Study 2 tested the effects of the affective aspect of automatic processing (implicit evaluation) and an emotional eating style on unhealthy eating behaviour. The findings showed that a positive implicit food evaluation (increased liking) predicted increased choice for unhealthy snack food in participants with lower emotional eating.

Study 3 investigated the combined effects of approach bias for food and eating style on unhealthy food consumption in normal weight and overweight individuals using a pooled sample. Among overweight participants, an external and emotional eating style individually moderated the relationship between approach bias for unhealthy food and snack intake, such that approach bias was positively related to consumption in high external or emotional eaters, but negatively related in low external or emotional eaters. These interactions were not observed among normal weight participants.

Studies 4 and 5 experimentally manipulated automatic processing and/or inhibitory control. These studies were preceded by a literature review on the effectiveness of approach bias modification as an intervention for reducing the consumption of appetitive substances in general. All of the reviewed studies (with one exception) that reported a positive outcome for consumption also showed a successful reduction of approach bias for appetitive cues. Study 4 demonstrated that the combined re-training of approach bias for unhealthy food together with inhibitory control was more effective than either task alone for reducing implicit liking of unhealthy food; however, no significant effects were found for food consumption. Approach bias re-training on its own did reduce unhealthy snack food choice. Study 5 found that the effect of approach bias re-training on subsequent consumption was moderated by trait impulsivity, such that only highly impulsive participants ate a greater proportion of healthy food following training.

Overall, the findings contribute to emerging evidence for the role of automatic processing of appetitive food cues together with self-regulatory control and trait eating style in unhealthy eating behaviour. The results also contribute to a theoretical understanding of unhealthy eating based on recent dual-process models of behaviour (Strack & Deutsch, 2004), and inform the development of interventions designed to reduce such behaviour.

Declaration

‘I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.’

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CHAPTER 1: GENERAL INTRODUCTION

Chapter Overview

This introductory chapter aims to provide a brief overview of the research relevant to the cognitive underpinnings of unhealthy eating behaviour from the theoretical perspective of contemporary dual-process models (Strack & Deutsch, 2004). Specifically, the empirical research on automatic and self-regulatory control processes in the context of unhealthy eating is reviewed, followed by research on eating styles that is related to these two processes. This chapter concludes with a summary of the main aims of the thesis and an outline of its content.

Cognitive Underpinnings of Unhealthy Eating Behaviour

Rates of overweight and obesity in modern Western societies have more than doubled during the last few decades (WHO, 2014). It is estimated that worldwide 39% of adults can now be classified as overweight and 13% as obese (WHO, 2014). Being overweight or obese is considered a major health problem as individuals in the unhealthy weight range (body mass index [BMI] >25 kg/m^2) are at an increased risk of developing several chronic diseases, such as cardiovascular disease, diabetes, and some types of cancer (WHO, 2014). Excess weight is generally due to an energy imbalance that is largely driven by over-consumption of palatable, energy-dense foods that are high in fat, salt, and/or sugar (Hill, Wyatt, Reed, & Peters, 2003).

One acknowledged contributor to unhealthy eating behaviour is the contemporary ‘obesogenic environment’ in which we live, where an abundance of high-calorie foods are readily accessible (Polivy, Herman & Coelho, 2008). In this environment, individuals are continually exposed to cues associated with appetitive food through advertisements in various media outlets, such as on billboards, television, the internet, and in magazines (Brunner, van der Horst, Siegrist, 2010). An often overlooked contributor to unhealthy eating behaviour is the automatic processing of appetitive food and associated cues in the environment, which occurs with little awareness (Marteau, Hollands, & Fletcher, 2012). However, not everyone is affected to the same extent by the food-rich environment as some individuals do maintain a healthy weight. Therefore, it is important to develop an understanding of how automatic processing of food cues may interact with other constructs, such as self-regulatory control of responses to such cues and eating styles, in predicting unhealthy eating behaviour. Examining the mechanisms underlying eating behaviour is likely to inform the development of effective interventions to reduce consumption of high-calorie food that can lead to excess weight gain.

Section 1.2 begins with a description of recent dual-process models of behaviour to provide a theoretical account of how food cues in the environment may influence unhealthy eating behaviour. Next, research on automatic processing and self-regulatory control in eating behaviour is outlined. Finally, the potential role of individual differences in trait eating style in the interplay between these two processes is discussed.

Dual-Process Models of Behaviour

The premise that automatic and controlled processing both contribute to behaviour is based on contemporary dual-process models (Strack & Deutsch, 2004). According to these models, behaviour is determined by two different types of information processing: automatic and controlled processing. Automatic processing, which is fast, implicit, and effortless, can involve affective (e.g., attitudes, preferences) and cognitive (e.g., attending to, approaching) responses to rewarding cues in the environment, including unhealthy food. Components of automatic processing can often be biased. The two main types of biased automatic processing that have been identified are attentional bias, an automatic allocation of attention toward rewarding cues (MacLeod & Mathews, 2012), and approach bias, an automatic (action) tendency to reach out toward (approach) rather than move away from (or avoid) such cues (Wiers, Gladwin, Hofmann, Salemink, & Ridderinkoff, 2013). Behaviour can also be guided by an automatic appraisal of the affective properties of a stimulus, which can in turn drive approach toward that specific stimulus if it becomes associated with positive affect.

In contrast to automatic processing, controlled processing is slow, explicit, and more effortful, and is thought to be driven by conscious deliberation based on long-term goals and personal standards (e.g., to lose weight and maintain health). Dual-process models are also concerned with how these two types of processes work together to determine behaviour. Specifically, it is suggested that these automatic and controlled processes elicit conflicting signals when confronted with appetitive stimuli in the environment (Wiers et al., 2013). The outcome of this conflict is determined by the relative strength of each type of process. For example, consumption of unhealthy food may be determined by a strong attentional and/or approach bias or a positive evaluation of such food combined with poor self-regulatory control of responses (Hofmann, Friese, & Wiers, 2008; Strack & Deutsch, 2004). Dual-process models posit that self-regulatory control enables individuals to resist the cognitive-motivational drive of automatic processing to consume unhealthy food, so that eating behaviour can be regulated in line with long-term goals (e.g., to lose weight). Both state (e.g., inhibitory control) and trait (e.g., impulsivity) self-regulatory control can regulate the influence of automatic processing on behaviour.

Research on Automatic Processing and Eating Behaviour

Support for the role of automatic processing in eating behaviour has primarily come from research examining attentional and approach biases for food cues. Of these, attentional bias has by far been the most researched. Indeed, a number of studies have shown that both normal weight (e.g., Hollitt, Kemps, Tiggemann, Smeets, & Mills, 2010; Brignell, Griffiths, Bradley, & Mogg, 2009; Nijs, Franken, & Muris, 2009; Hou et al., 2011) and overweight or obese individuals (Castellanos et al., 2009; Mogg, Bradley, Hyare, & Lee, 1998; Njis, Muris, Euser, & Franken, 2010) are faster to respond to food cues relative to neutral (non-food) cues.

Studies have also demonstrated a positive relationship between attentional bias for unhealthy food and subsequent snack food consumption during laboratory taste tests in both normal weight and obese individuals (Nijs, et al., 2010; Werthmann et al., 2011). In addition, Calitri, Pothos, Tapper, Brunstrom, and Rogers (2010) found that an attentional bias for food predicted increased body weight over one year, although Pothos, Tapper, and Calitri (2009) found no such relationship. Nevertheless, some emerging evidence supports the proposition that biased automatic attentional processing of food is related to unhealthy eating behaviour.

More recently, researchers have begun to investigate approach bias for food cues. In particular, studies have shown that normal weight (Brignell et al., 2009; Kemps, Tiggemann, Martin, & Elliott, 2013; Veenstra & de Jong, 2010) and overweight or obese individuals (Havermans, Giesen, Houben, & Jansen, 2011; Kemps & Tiggemann, 2015; Mogg et al., 2012) are faster to approach than avoid food cues. Approach bias is likely to be a more important contributor to unhealthy eating behaviour than attentional bias due to its additional behavioural component. Indeed, two studies have shown that approach bias for unhealthy food is positively related to consumption of such food in normal weight samples (Hofmann, Gschwendner, Wiers, Friese, & Schmitt, 2008; Nederkoorn, Houben, Hofmann, Roefs, & Jansen, 2010). Thus, there is emerging evidence to support the role of approach bias for food in unhealthy eating.

Another aspect of automatic processing is implicit evaluation of food, which refers to an association between food stimuli and positive affect at an automatic level (Czyzewska & Graham, 2008). Unhealthy food is often evaluated positively as it is highly appetitive (Cohen & Farley, 2008). A number of studies have shown that a more positive implicit evaluation of unhealthy food predicts increased choice and consumption of unhealthy food, as well as a higher BMI (Conner, Perugini, O'Gorman, Ayres, & Prestwich, 2007; Friese et al., 2008; Haynes, Kemps, Moffitt, & Mohr, 2015; Hofmann & Friese, 2008; Hofmann et al., 2008; Hofmann, Rauch, & Gawronski, 2007; Perugini, 2005; Richetin, Perugini, Prestwich, &

O'Gorman, 2007). Thus, the evidence suggests that positive implicit food evaluation may contribute to unhealthy eating behaviour.

In line with dual-process models, existing empirical research in the eating domain has demonstrated a role for different aspects of automatic processing, including attentional and approach bias for food (cognitive component), as well as implicit food evaluation (affective component), in predicting unhealthy eating behaviour and excess weight gain. These findings emphasise the importance of understanding how the automatic processing of food cues might impact upon unhealthy eating with little conscious awareness.

Research on Self-Regulatory Control and Eating Behaviour

Support for the other component of dual-process models comes from research on self-regulatory control in unhealthy eating behaviour. A growing number of studies have shown that inhibitory control, the 'ability to inhibit a behavioural impulse' (Houben, Nederkoorn, Wiers, & Jansen, 2012, p. 550), is related to unhealthy eating and weight gain. For example, Loeber et al. (2012) found that both normal weight and obese individuals are less effective at inhibiting responses to food cues relative to neutral (non-food) cues. Studies have also shown that obese individuals are less effective than their normal weight counterparts at inhibiting responses to food cues (Nederkoorn, Smulders, Havermans, Roefs & Jansen, 2006). Poor inhibitory control has been associated with increased consumption of unhealthy food in both normal weight (Guerrieri, Nederkoorn, & Jansen, 2007b) and overweight women (Appelhans et al., 2011). Finally, poor inhibitory control predicted an increase in BMI over a one-year period in normal weight women (Nederkoorn, et al., 2010). Together, these studies suggest that poor state self-regulatory control for food cues may undermine the ability to resist unhealthy food cues, which in the long-term, could lead to overeating and weight gain.

While studies have often considered the role of state self-regulatory control in eating behaviour, there are also stable differences. Specifically, trait impulsivity refers to a general tendency to act or think without regarding the consequences (Hofmann et al., 2008). Studies have shown that impulsivity is positively associated with unhealthy eating behaviour, such as increased food consumption during a laboratory taste test (Appelhans et al., 2011; Guerrieri, Nederkoorn & Jansen, 2007a; Guerrieri et al., 2007) and a higher BMI (Batterink, Yokum, & Stice, 2010; Cohen, Yates, Duong & Convit, 2011). Highly impulsive people are also more likely to be overweight or obese (Nederkoorn, et al., 2010; Ryden et al., 2003; Guerrieri, Nederkoorn & Jansen, 2008). In support of dual-process models, the previous literature has shown a role for different aspects of self-regulatory control, including inhibitory control for food-related cues and trait impulsivity, in predicting unhealthy eating behaviour and excess weight gain. The findings highlight the importance of understanding self-regulatory control as it may determine the ability to resist appetitive food and related cues in the environment.

Research on Trait Eating Style and Eating Behaviour

Trait eating style refers to individual differences in the habitual way of eating due to early learning experiences, which develop over time to become a stable characteristic of that person (Carnell & Wardle, 2007; Larsen, van Strien, Eisinga, & Engels, 2006). Researchers have typically focused on three different types of eating style: restrained, emotional and external eating, most often assessed by the Dutch Eating Behaviour Questionnaire (DEBQ; van Strien, Frijters, Bergers, & Defares, 1986). Restrained eating refers to the tendency to restrict intake of food; the major component of Herman and Polivy’s (1980) restraint theory. Emotional eating refers to the tendency to eat in response to negative affect due to a lack of interoceptive awareness and is derived from Bruch’s (1964) psychosomatic theory of obesity. External eating is the tendency to eat when exposed to external food-related cues, such as the sight or smell of food, in line with Schachter’s (1968) classic externality theory of obesity.

A number of studies (but not all) have shown that the three types of eating style are associated with increased unhealthy food consumption (e.g., Anschutz, van Strien, van De

Ven, & Engels, 2011; Elfhag, Tholin, & Rasmussen, 2008; Wardle et al., 2002) and higher BMI in unselected samples (e.g., Burton, Smit, & Lightowler, 2007; Elfhag & Linne, 2005; Jasinska et al., 2012; Snoek, van Strien, Janssens, Rutger, & Engels, 2007). Of these eating styles, the most reliable findings have been demonstrated for external eating. Taken together, the evidence suggests that trait eating styles contribute to eating behaviour and weight gain.

Eating styles primarily comprise factors such as personality traits (Elfhag & Morey, 2008), emotional regulation (Topham et al., 2011), and feeding practices in the early home environment (Kral & Faith, 2009), but also involve aspects of cognitive processing. Research has shown that eating styles are related to automatic processing (Ayres, Prestwich, Connor & Smith, 2011; Brignell et al., 2009; Hollitt et al., 2010; Hou et al., 2011; Kemps, et al., 2013; Nijs et al., 2009; Veenstra & de Jong; 2010) and self-regulatory control (Elfhag & Morey, 2008; Hou et al., 2011). Thus, evidence suggests that eating styles might include both types of processes. Cognitive biases (attentional and approach) may contribute to the development of eating style and in turn be reinforced by them, as both are likely to be determined by trait sensitivity to rewarding food cues (Brignell et al., 2009). Likewise, inhibitory control may play a role in, and be influenced by eating style characteristics that involve self-regulation.

Automatic Processing, Self-Regulatory Control and Trait Eating Style

A growing body of research shows that both automatic processes and self-regulatory control individually determine unhealthy eating behaviour. While most research to date has examined these two types of processes separately, contemporary dual-process models posit that behaviour is guided by their combination. In particular, biased automatic processing and poor self-regulatory control are both likely contributors to unhealthy eating behaviour. At the outset of the current thesis, the interaction between automatic processing and self-regulatory control in predicting behaviour was yet to be examined in the food domain. Examining both types of processes together may contribute to a greater understanding of why people engage in unhealthy eating behaviour.

Furthermore, individual differences in eating style might influence susceptibility to biased automatic processing of unhealthy food and the ability to regulate responses to such food. The studies presented in the current thesis attempted to expand upon previous research by investigating the potential interactions between automatic processing and self-regulatory control or trait eating style in the prediction of unhealthy eating behaviour. Developing an increased understanding of the mechanisms underlying unhealthy eating is important for informing and designing interventions that are aimed at modifying such behaviour.

Modifying Automatic Processing and Self-Regulatory Control

According to dual-process models, it should be possible to change behaviour through training either automatic or controlled processing. For automatic processing, researchers have begun to investigate the effectiveness of training aimed at reducing attentional and approach biases using Cognitive Bias Modification techniques (CBM; Koster, Fox, & MacLeod, 2009). Research on CBM in the eating domain has generally focused on modifying attentional bias. Previous literature reviews indicate that attentional bias modification for appetitive cues tends to produce small effects on attention and behaviour (e.g., Beard, Sawyer, & Hofmann, 2012).

A more recently researched CBM technique is approach bias modification, which aims to reduce automatic approach biases for appetitive cues. The available studies on approach bias modification and consumption behaviour suggest that it may be a useful intervention as it is generally successful at reducing consumption of appetitive substances; however, there is some variability in its effects on consumption. Therefore, it is important to determine under which conditions approach bias modification is most likely to be effective and for whom it is most beneficial. Developing a better understanding of the crucial aspects of approach bias re-training is likely to enhance its effectiveness as a technique for modifying unhealthy eating.

For controlled processing, researchers have investigated the effectiveness of training aimed at increasing inhibitory control. A number of studies have shown that training people to inhibit responses to unhealthy food cues (using either a go/no-go task or stop-signal task) reduced subsequent consumption of unhealthy food (Houben, 2011; Houben & Jansen, 2011, 2015; Lawrence, Verbruggen, Morrison, Adams & Chambers, 2015; Veling, Aarts & Papies, 2011), and snack food choice (van Koningsbruggen, Veling, Stroebe & Aarts, 2014; Veling, Aarts & Stroebe, 2013a; Veling, Aarts & Stroebe, 2013b). However, a recent meta-analysis found that the effect size on consumption is small (Allom, Mullan, & Hagger, 2015), which suggests that the effectiveness of inhibitory control training can be improved.

One way of making inhibitory control training, as well as approach bias modification, more effective derives from a theoretical understanding of unhealthy eating behaviour based on contemporary dual-process models (Strack & Deutsch, 2004). According to such models, it should be more useful to modify automatic and controlled processes together. Interventions could target both processes simultaneously to reduce unhealthy eating behaviour.

Aims of the Thesis

The current thesis had two primary aims. The first was to investigate how automatic processing interacts with self-regulatory control or trait eating style in order to obtain a better understanding of these constructs in the context of unhealthy eating behaviour. Chapters 2-4 present the results of Studies 1, 2 and 3, which investigated automatic processing of food cues (cognitive bias or implicit evaluation) combined with self-regulatory control (inhibitory control) or trait eating style as predictors of unhealthy eating behaviour. The second aim of the thesis was to determine whether interventions designed to modify automatic and/or controlled processes are effective for reducing unhealthy eating and/or promoting healthy eating. A literature review was conducted on the effectiveness of approach bias modification as a technique for reducing consumption of unhealthy substances (Chapter 5). Study 4 investigated whether approach bias modification was more effective when combined with inhibitory control training to reduce unhealthy eating (Chapter 6), while Study 5 examined whether approach bias modification was effective for promoting healthy eating (Chapter 7).

Outline of the Thesis

Chapters 2-4 address the first aim of the thesis and contain reports of studies testing various combinations of automatic processing and self-regulatory control or eating styles in predicting unhealthy eating behaviour. Specifically, Chapter 2 presents the results of Study 1, which aimed to address one of the key theoretical propositions of recent dual-process models by investigating the combined effects of attentional and approach bias with inhibitory control on unhealthy food consumption. Chapter 3 presents Study 2, which examined whether the affective aspect of automatic processing and emotional eating interact in predicting unhealthy eating. Finally, Chapter 4 presents the results of Study 3, which tested the combined effect of approach bias and eating style on consumption in normal weight and overweight individuals. To obtain sufficient overweight individuals, participants from Study 1 and the control groups from Studies 4 and 5 were pooled. It was expected that approach bias and trait eating style would better predict unhealthy food consumption in overweight individuals than in normal weight individuals, as both factors have been related to unhealthy eating and excess weight.

The next three chapters (Chapters 5-7) address the second aim, which was to examine whether interventions designed to modify automatic processing and/or self-regulatory control can discourage unhealthy eating behaviour. Chapter 5 presents a review of the literature on the effectiveness of approach bias modification for appetitive substances in general (i.e., in the alcohol, cigarette, and unhealthy food domains). Chapter 6 then reports on the results of Study 4, an experiment that aimed to investigate the effectiveness of reducing approach bias for unhealthy food cues and strengthening inhibitory control to discourage unhealthy eating behaviour. This study builds upon the finding from Study 1 (Chapter 2), which showed that approach bias and inhibitory control interactively predicted greater consumption of unhealthy food. Chapter 7 presents the results of Study 5, an experiment that aimed to extend the use of approach bias modification from only reducing unhealthy eating behaviour to also increasing healthy eating. An aspect of self-regulatory control, namely, trait impulsivity, was assessed as a potential moderator of the effectiveness of training.

The final chapter (Chapter 8) presents a general discussion of the main findings from all of the studies. It also considers the theoretical and practical implications for the main aims of the thesis and provides recommendations for future research directions.

All of the chapters in the current thesis (except for Chapters 1 and 8) are formatted as manuscripts for publication. Chapter 2 is published in the journal *Appetite* and Chapter 5 is published in the journal *Addictive Behaviors*. Chapter 6 is currently under revision, while Chapters 3, 4, and 7 are under review. The formatting of each chapter varies slightly as the manuscripts were prepared according to the requirements of each particular journal. There is considerable repetition of the background information and methodology in the Introduction and Method sections of each chapter.

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CHAPTER 2: STUDY 1

Combined Effects of Cognitive Bias for Food Cues and Poor Inhibitory Control on Unhealthy Food Intake

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Abstract

The present study aimed to investigate the combined effects of cognitive bias (attentional and approach biases) and inhibitory control on unhealthy snack food intake. Cognitive biases reflect automatic processing, while inhibitory control is an important component of controlled processing. Participants were 146 undergraduate women who completed a dot probe task to assess attentional bias and an approach-avoidance task to assess approach bias. Inhibitory control was measured with a food-specific go/no-go task. Unhealthy snack food intake was measured using a so-called "taste test". There was a significant interaction between approach bias and inhibitory control on unhealthy snack food intake. Specifically, participants who showed a strong approach bias combined with low inhibitory control consumed the most snack food. Theoretically, the results support contemporary dual-process models which propose that behaviour is guided by both automatic and controlled processing systems. At a practical level, the results offer potential scope for an intervention that combines re-training of both automatic and controlled processing.

Introduction

During the last three decades, the global prevalence of overweight and obesity has doubled, with 35% of adults classified as overweight and 11% as obese (WHO, 2013). One important contributor to chronic health problems such as overweight and obesity is unhealthy eating (NHMRC, 2003). The contemporary Western diet is characterised by unhealthy eating, in particular consuming too much fat, salt and sugar. Given the potential negative health consequences of unhealthy eating, it is important to investigate the cognitive mechanisms that underlie such behaviour. Specifically, recent theoretical perspectives and empirical evidence suggest that automatic and controlled cognitive processing make important contributions to unhealthy behaviour.

Dual-process models (e.g., Strack & Deutsch, 2004) propose that our behaviour is determined by two different information processing systems, i.e., automatic and controlled processing. Automatic processing is fast, implicit and effortless, and includes affective (i.e., attitudes, preferences) and motivational (i.e., attending to, approaching) responses to relevant stimuli, such as unhealthy food cues. In contrast, controlled processing is effortful, slow, and explicit, and involves conscious decisions based on personal goals and standards (e.g., health and weight loss). These two processing systems elicit conflicting signals, and the outcome is determined by the relative strength of each processing system. According to dual-process models, behaviour is guided by automatic processing and regulated by controlled processing (if cognitive resources are available). For example, the presence of unhealthy food cues may elicit a conflict between the two systems, i.e., automatically attending to and approaching such cues while maintaining incompatible goals related to health and weight. Thus, a strong automatic system (an attentional or approach bias for food cues) and a weak controlled system (poor inhibitory control or working memory capacity) may result in unhealthy eating.

Automatic and controlled processing systems have given rise to two separate lines of research. Support for the role of automatic processing in eating behaviour generally comes from research investigating cognitive biases for food cues. A cognitive bias refers to "systematic selectivity in information processing that operates to favour one type of information over another" (MacLeod & Matthews, 2012, p. 191). Most research has focused on attentional bias, which refers to the automatic allocation of attention to food cues in preference to other cues (MacLeod & Matthews, 2012). More recently, researchers have turned their focus toward approach bias, which is the automatic behavioural tendency to move toward rather than avoid food cues (Wiers et al., 2013a). Studies have demonstrated biased attentional processing of high-caloric food cues in relation to neutral (non-food) cues in healthy weight participants (Nijs, Franken, & Muris, 2010; Werthmann et al., 2013). Both attentional and approach biases for food cues have also been documented in populations with eating-related issues. Specifically, restrained (Hollitt, Kemps, Tiggemann, Smeets, & Mills, 2010; Veenstra & de Jong, 2010) and external eaters (Brignell, Griffiths, Bradley, & Mogg, 2009; Hou et al., 2011; Nijs, Franken, & Muris, 2009), as well as overweight and obese individuals (Castellanos et al., 2009; Havermans, Giesen, Houben, & Jansen, 2011; Nijs et al., 2010a; Nijs, Muris, Euser, & Franken, 2010b), are faster to detect and approach high-caloric food cues relative to neutral cues.

Furthermore, research has demonstrated a positive correlation between attentional biases for unhealthy food cues (e.g., cake, salted peanuts) and the subsequent consumption of snack foods during a laboratory taste test in both healthy weight and obese participants (Nijs, Muris, Euser, & Franken, 2010; Werthmann et al., 2011). Research from our laboratory (Kakoschke, Kemps, & Tiggemann, 2014; Kemps, Tiggemann, Martin, & Elliot, 2013; Kemps, Tiggemann, Orr, & Grear, 2014), as well as others (Werthmann, Field, Roefs, Nederkoorn, & Jansen, 2013), has also found that experimentally reducing an attentional bias for unhealthy food cues decreases unhealthy food intake. This evidence is consistent with the idea that cognitive biases for food cues play a causal role in consumption (Berridge, 2009). Similar findings have also been shown for alcohol (Field & Eastwood, 2005) and cigarettes (Attwood, O'Sullivan, Leonards, Mackintosh, & Munafo, 2008). Nevertheless, the evidence is mixed as some studies have found no such link between attentional bias and consumption of food (Hardman, Rogers, Etchells, Houstoun, & Munafo, 2013), alcohol (Field et al., 2007; Fadardi & Cox, 2009), and cigarettes (Field, Duka, Tyler, & Schoenmakers, 2009). In contrast, the smaller amount of research on approach bias shows a more consistent link between approach bias and consumption of alcohol (Wiers et al., 2009; Wiers, Rinck, Kordts, Houben, & Strack 2010) and cannabis (Cousijn et al., 2011). One possible explanation for these contradictory findings is that attentional and approach biases behave differently, as has been evidenced by research in the alcohol domain. Specifically, Sharbanee, Stritzke, Wiers, and MacLeod (2013) demonstrated that these two cognitive biases are distinct mechanisms that can make independent contributions to consumption. Another potential explanation for the overall mixed evidence is that the previous research has not taken into account the role of controlled processing in consumption.

Research investigating the role of controlled processing in eating behaviour has primarily focused on inhibitory control (or response inhibition), which has been defined as “the ability to inhibit a behavioural impulse in order to attain higher-order goals, such as weight loss” (Houben, Nederkoorn, & Jansen, 2012, p. 550). A recent study by Loeber et al. (2012) found that both healthy weight and obese participants were less effective at inhibiting behavioural responses to food cues relative to neutral (non-food) cues. Furthermore, studies have shown that obese participants were less effective at inhibiting responses to neutral cues (Nederkoorn, Braet, Van Eijs, Tanghe, & Jansen, 2006) as well as to food-related cues (Nederkoorn, Smulders, Havermans, Roefs & Jansen, 2006) than healthy weight participants.

Several studies have also demonstrated that poor inhibitory control is associated with increased food intake during a laboratory taste test in both healthy weight (Guerrieri, Nederkoorn, & Jansen, 2007) and overweight or obese women (Appelhans et al., 2011). In addition, poor inhibitory control predicted an increase in weight (BMI) over a one year period in a sample of healthy weight women (Nederkoorn, Houben, Hofmann, Roefs & Jansen, 2010). Some studies have also shown that experimentally increasing inhibitory control reduces chocolate (Houben & Jansen, 2011) and alcohol (Houben, Nederkoorn, Wiers, & Jansen, 2011) consumption; however, Guerrieri et al. (2007b) found that experimentally increasing behavioural inhibition had no effect on milkshake consumption in a laboratory taste test. Furthermore, inhibitory control is related to working memory capacity, which is the ability to store and process goal-relevant information (Conway, Kane & Engle, 2003). A recent study found that experimentally increasing working memory capacity reduced alcohol intake in a sample of problem drinkers (Houben, Wiers, & Jansen, 2011).

As indicated above, prior research has largely focused on automatic or controlled processing separately. However, it may be their combination that is most important for consumption. In line with dual-process models, recent meta-analyses suggest that a cognitive bias for appetitive cues combined with poor inhibitory control may result in unhealthy behaviour, such as consuming appetitive substances like drugs and alcohol (Field & Cox, 2008; Coskunpinar & Cyders, 2013). Nederkoorn et al. (2010) investigated this theoretical prediction in the food domain and found that automatic and controlled processing interacted in determining an increase in BMI over a one year period in healthy weight women. Specifically, women with strong implicit preferences for food and low inhibitory control gained the most weight. Other studies have shown that the combination of strong implicit preferences and low inhibitory control predicts candy (Hofmann, Friese, & Roefs, 2009) and alcohol (Houben & Wiers, 2009) intake on a laboratory taste test. The above studies measured automatic processing with the implicit association task, which assesses evaluative attitudes for appetitive cues. However, we chose to focus on the motivational bias component of automatic processing. Similarly, in the alcohol domain, Peeters et al. (2012) recently found that the combination of an approach bias for alcohol and low inhibitory control (measured by the Stroop task) predicted alcohol use in adolescent drinkers. To the best of our knowledge, this finding has not been demonstrated in the food domain. In addition, the above studies have all measured inhibitory control in general, not specifically related to food. Yet specific food-related inhibitory control needs to be examined as a more proximal potential mechanism associated with unhealthy eating (Appelhans et al., 2011; Meule et al., 2014).

The aim of the current study was to investigate the combined effects of automatic and controlled processing on unhealthy food intake. Cognitive biases for food cues were assessed as an indicator of automatic processing, and food-specific inhibitory control was assessed as an important component of controlled processing. Both of the two main forms of cognitive bias, namely attentional bias and approach bias were included. Attentional bias was assessed by the often used dot probe task, developed by Macleod, Matthews and Tata (1986). Approach bias was assessed by the approach-avoidance task of Rinck and Becker (2007). Inhibitory control was assessed using the food-related go/no-go task of Houben and Jansen (2011). A so-called “taste test” was used to measure unhealthy food consumption. It was predicted that a stronger cognitive bias together with lower inhibitory control would lead to increased unhealthy food intake. This was tested for the two different components of cognitive bias (attentional and approach) separately.

Method

Participants

Participants were 146 women recruited from the Flinders University undergraduate student population. They were aged 18-25 years (*M* = 20.20, *SD* = 2.64). Most participants were within the healthy weight range (i.e. 18.5-24.9 kg/m^2) with a mean BMI of 22.9 kg/m^2, (*SD* = 5.11). Only women were recruited as they have shown a greater tendency to overeat (Burton, Smit, & Lightowler, 2007). Participants were included if they spoke English as their first language, liked most foods, and did not have any food allergies or dietary requirements. As hunger has been linked to cognitive biases for food cues (Mogg, Bradley, Hyare, & Lee, 1998; Seibt, Hafner, & Deutsch, 2007) and poor inhibitory control (Nederkoorn, Guerrieri, Havermans, Roefs, & Jansen, 2009), participants were instructed to eat something two hours before the testing session to ensure they were not hungry. All participants reported having complied with this instruction. Participants also rated their current level of hunger on a 100 mm visual analogue scale ranging from “not hungry at all” to “extremely hungry” (Grand, 1968). Mean hunger ratings were around the mid-point of the scale (*M* = 49.7, *SD* = 24), and did not correlate with measures of cognitive biases, inhibitory control, or consumption ($.03 < r < .08$, *p*s > .05).

Materials

Stimuli. The stimuli were 80 digital coloured photographs (presented in a resolution of approximately 1024 x 768 pixels) comprising 20 food and 60 animal pictures. The food pictures depicted food items high in sugar, salt and/or fat (e.g., chocolate, potato chips). Animals were chosen for the comparison category of neutral non-food stimuli as they, like food, are overall appealing. Animal pictures depicted well-liked species that are not commonly consumed in Western society (e.g., giraffe, koala.). For the dot probe task, the pictures were divided into 20 critical pairs (food-animal) and 20 control non-food pairs (animal-animal). Each picture pair was individually matched on characteristics such as quality, brightness, and size, as well as ratings of pleasure and arousal. These ratings were obtained from a previous pilot study, in which 21 women aged 17-45 years (*M* = 23.67, *SD* =

8.28) rated 590 food and animal pictures on 9-point pleasure and arousal scales (Kemps, Tiggemann, & Hollitt, 2014). The same stimulus set was used for all three computer tasks.

Dot probe task. Following the procedure of MacLeod et al. (1986), each trial began with the display of a fixation cross in the centre of the computer screen presented for 500 ms. This was followed by the presentation of a picture pair for 500 ms. The pictures were displayed on the left and right hand side of the screen and each were an equal distance from the centre. When the pictures disappeared, a small dot probe appeared in the location of one of the pictures and remained there until the participant responded. Participants were asked to press the corresponding key on the keyboard (the key labelled “L” for left or “R” for right) to indicate, as quickly as possible, whether the dot probe replaced the picture on the left or right hand side of the screen. Each picture pair was presented four times so that every combination of the replacement of the dot probe position (left or right picture location and left or right dot probe location) was presented, for a total of 160 trials.. The picture pairs were presented in a different random order for each participant and the dot probes replaced the pictures in each pair with equal frequency (50/50). Participants’ reaction times (ms) were recorded on each trial. An attentional bias score was calculated for each participant by subtracting the reaction times to the dot probes replacing unhealthy food pictures from the reaction times to the dot probes replacing animal pictures. Therefore, positive scores indicate an attentional bias towards unhealthy food, while negative scores indicate an attentional bias away from unhealthy food.

Approach-Avoidance task. Following Rinck and Becker (2007), the approach-avoidance task was used to measure an approach-avoidance bias. This task, originally developed for anxiety disorders was adapted here for the food domain. The approach-avoidance task consisted of 160 trials. On each trial, participants began by pressing the start button on the top of a joystick. A picture of an unhealthy food or an animal then appeared in the centre of the screen. Participants were instructed to pull (approach) or push (avoid) the joystick according to whether the picture was presented in portrait or landscape format. These instructions were counterbalanced (i.e., half of the participants pulled for portrait and pushed for landscape and half vice versa). Pulling the joystick increased the picture size (as if physically approaching the picture), while pushing the joystick decreased the picture size (as if moving away from the picture). The picture disappeared once the participant had pulled or pushed the joystick. Participants were asked to respond as quickly and accurately as possible. Each picture was presented four times, twice in portrait format and twice in landscape format, and participants were asked to pull and push the food and animal pictures with equal frequency (50/50). The joystick was part of an apparatus that was connected to the table to prevent it from moving around during the task.

Participants' reactions times were recorded on each trial. For each participant, reaction time scores were calculated for pulling and pushing the food and animal pictures. The primary outcome measure was approach bias for food, which was calculated as the difference between median pushing and pulling reaction times for food pictures. Positive scores indicate an approach bias for food (i.e., tendency to pull faster than push an image), whereas negative scores indicate an avoidance bias for food (i.e., faster push than pull) (Wiers et al., 2013).

Go/no-go task. Following Houben and Jansen (2011), a food-related version of the go/no-go task was used to measure inhibitory control. The go/no-go task consisted of two blocks of 160 trials. On each trial, a picture was presented together with a go or a no-go cue (i.e., the letters 'p' or 'f') for 1500 ms. The go/no-go cues were displayed in black font type and were presented randomly in one of four locations near the outside corners of the pictures. Participants were instructed to press the space bar when a go cue was displayed on the picture, and to refrain from responding when a no-go cue was displayed. Instructions regarding letter type (‘p’ versus ‘f’) and response assignment (go versus no-go) were counterbalanced. The food and animal pictures were each presented eight times so that every combination of letter type (‘p’ or ‘f’) and letter location (left: top, bottom; right: top, bottom) was presented. Pictures were presented in a different random order for each participant, and food and animal pictures were paired with a go cue with equal frequency (50/50). The number of commission errors (i.e., space bar pressed in response to a no-go cue) and the number of omission errors (i.e., space bar not pressed in response to a go cue) were recorded. Following previous studies (e.g., Bezdjian, Baker, Lozano, & Raine, 2009; Muele & Kubler, 2014), the primary outcome measure was the percentage of commission errors in response to food pictures, with a higher percentage of errors indicative of poorer inhibitory control

Consumption. Consumption was measured using a so-called taste test. Participants were presented with a platter comprising four snacks (two sweet and two savoury): milk-chocolate M&Ms, chocolate-chip biscuits, plain potato chips, and pretzels. The four foods 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 bowls was counterbalanced across participants using a 4 × 4 Latin square. Participants were instructed to taste and rate each snack on several dimensions (e.g., flavour, likelihood of purchase). They were given 10 minutes to complete their ratings and told that they could try as much of the food as they liked. The amount of each food consumed was calculated by subtracting the weight (in grams) of the snacks after the taste test from the weight of the snacks before the taste test. The weight in grams for each food was then converted into the number of calories consumed and summed to obtain a total measure of intake.

Procedure

The experiment took place in the Food Laboratory in the School of Psychology at Flinders University, South Australia. The testing session took approximately one hour. After providing informed consent, participants completed a brief demographics questionnaire, followed by the three computer tasks presented in counterbalanced order, and finally the taste test. The study was approved by the University's Social and Behavioural Research Ethics Committee.

Results

Statistical considerations

Data were examined to ensure assumptions underlying statistical analysis were met. Participants' response times for attentional bias and approach bias, as well as commission errors and consumption that were more than 3 *SD* from the mean were identified as outliers and were changed to plus or minus one unit from the first non-outlier (Tabachnick & Fidell, 1989). An alpha value of .05 was used to determine significant *p* values.

Descriptive statistics

As expected, participants showed an attentional bias for food cues as indicated by a positive mean bias score, although the large standard deviation indicated that there was a considerable range in scores ($M = 8.26$, $SD = 24.59$). To formally test this, a 2 (target [food] location: left vs. right) × 2 (probe/response location: left vs. right) repeated measures ANOVA was conducted on the mean reaction times of the critical trials. The means, as presented in Table 1, showed no main effects of target location, $F(1, 145) = 1.95$, $p = .165$, or probe location, $F(1, 145) = .114$, $p = .736$. However, the interaction was significant, $F(1, 145) = 16.66$, $p < .001$. The results confirm that, irrespective of probe/response position, participants were faster to respond on compatible trials (when the probe replaced the target [food]) ($M = 373.46$, $SD = 51.61$), than on incompatible trials (when the probe replaced the non-target [animal]) ($M = 381.79$, $SD = 54.98$), which shows an attentional bias for food cues.

Table 2 presents the approach bias scores for both food and animal cues (although only the approach bias for food is of interest). As expected, participants showed an approach bias for food cues, as indicated by a positive mean bias score (*M* = 32.32, *SD* = 103.09). They also showed an approach bias for animal cues (*M* = 31.05, *SD* = 127.11). A 2 (picture type: food vs. animal) × 2 (joystick movement: push vs. pull) repeated measures ANOVA confirmed a significant main effect of joystick movement, $F(1, 145) = 12.132$, $p = .001$, whereby participants were faster to pull the joystick (‘approach’) than to push it. The main effect of picture type, $F(1, 145) = .024$, $p = .876$, and the interaction were not significant, $F(1, 145) = .045$, $p = .833$. This indicates that participants showed an approach bias for food (and animals).

Table 1

Mean reaction times in ms (with standard deviations) depending on target (food) location and probe/response location.

	Target (food) location	
	Food left/animal right	Food right/animal left
Probe/response location	*M (SD)*	*M (SD)*
Left	375.33 (53.44)	380.84 (55.83)
Right	382.73 (62.05)	371.58 (57.10)

Table 2

Mean reaction times in ms (with standard deviations) depending on picture type and joystick movement.

	Picture type	
	Food left/animal right	Food right/animal left
Joystick movement	*M (SD)*	*M (SD)*
Push	917.59 (190.09)	916.54 (192.00)
Pull	885.28 (168.06)	885.49 (164.24)
Approach Bias (Push - Pull)	32.32 (103.09)	31.05 (127.11)

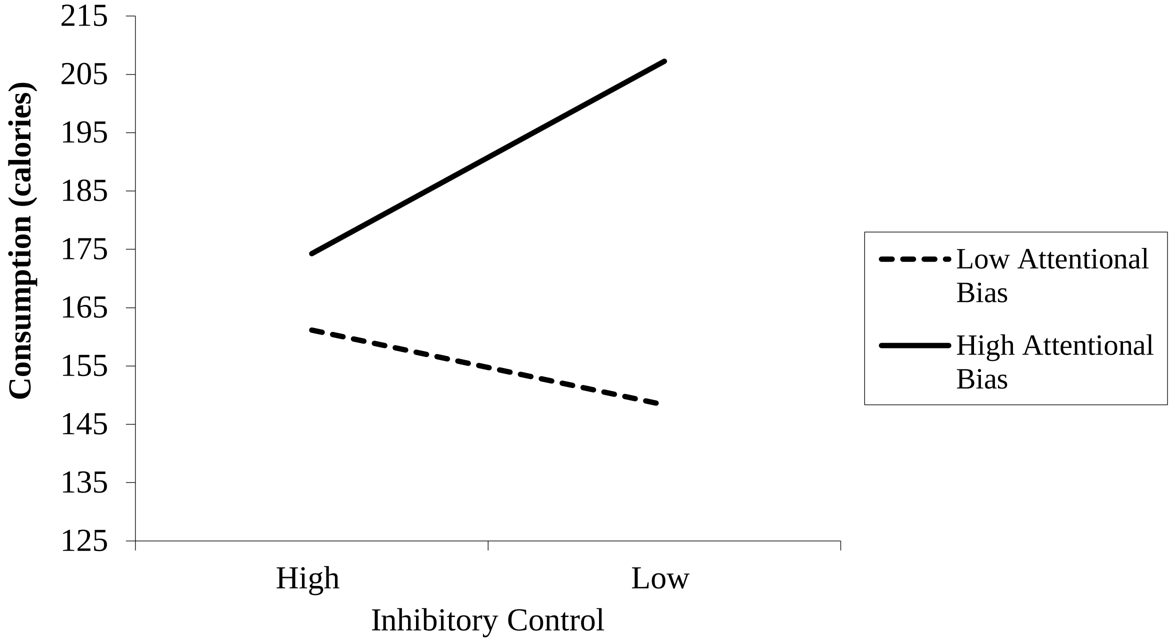
For inhibitory control for food, participants produced a relatively low percentage of commission errors (*M* = 3.04, *SD* = 4.81), indicating on average good inhibitory control. Overall, there were very few omission errors (*M* = .015%, *SD* = .097), indicating good attention.

Effects of cognitive bias and inhibitory control for food on consumption

A series of hierarchical multiple regression analyses was conducted to investigate the combined effects of cognitive bias and inhibitory control for food on consumption. This analysis was done separately for attentional bias and approach bias (see Fig. 1 for graphical representations of the results).

For attentional bias, centred attentional bias scores and commission errors were entered in Step 1, and the product term representing the interaction between these two variables in Step 2. As can be seen in Fig. 1a, the attentional bias results were in the predicted direction. However, they fell short of significance. The main effects of neither attentional bias, R^2 = .007, F(1, 143) = 1.02, p = .315, nor inhibitory control, R^2 = .00, F(1, 144) = .00, p = .879, explained a significant proportion of the variance in consumption. Nor did the product term explain any additional variance in consumption, R^2_{Change} = .016, F_{Change} (1, 141) = 1.23, p = .269.

A similar analysis was conducted for approach bias. In this case, approach bias for food, approach bias for animals, and inhibitory control for food were entered in Step 1, and the two-way interaction terms with inhibitory control (approach bias for food × inhibitory control; approach bias for animals × inhibitory control) were entered in Step 2. Step 1 showed no significant main effects of approach bias for food, R^2 = .003, F(1, 144) = .50, p = .481, approach bias for animals, R^2 = .012, F(1, 144) = .02, p = .881, or inhibitory control for food, R^2 = .00, F(1, 144) = .00, p = .879. However, Step 2 showed that the product terms explained a significant additional 8.1% of the variance in food consumption, R^2_{Change} = .036, F_{Change} (1, 142) = 3.597, p = .031. Specifically, the approach bias for food × inhibitory control interaction was significant (β = .355, p = .009), whereas the approach bias for animals × inhibitory control interaction was not (β = −.055, p = .567).



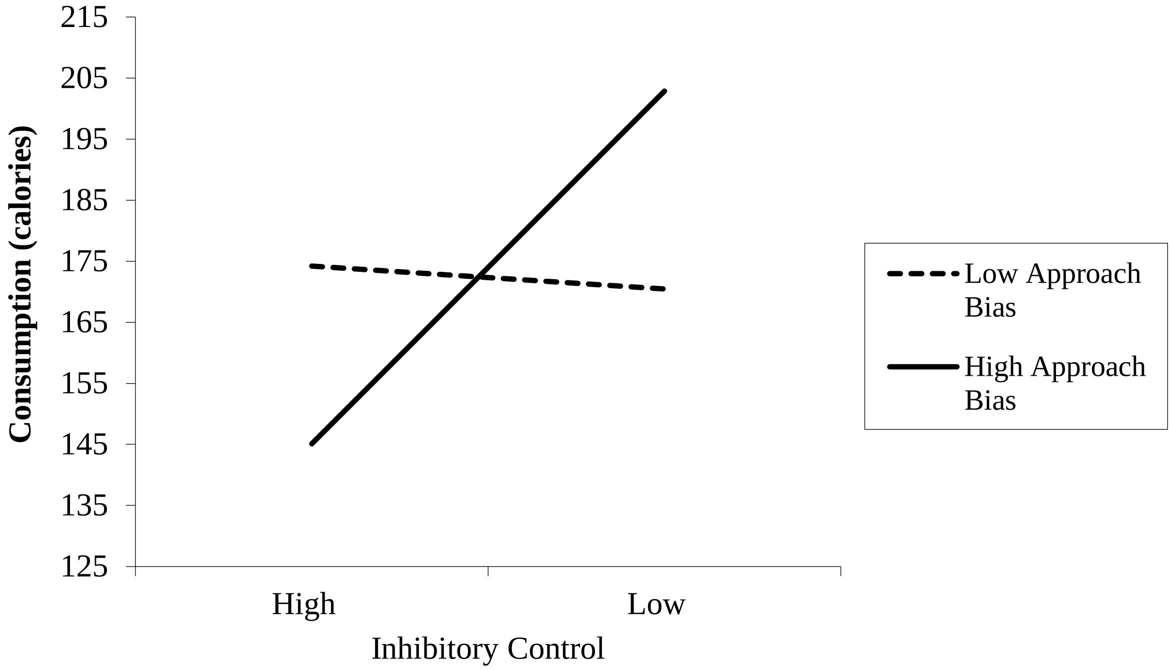


Fig 1. Interaction between inhibitory control and (a) attentional bias and (b) approach bias on consumption (calories).

In order to determine the form of the significant interaction, simple slopes analyses were conducted. As shown in Fig. 1b, inhibitory control for food had no effect on food consumption in women with a low approach bias, $B = -1.63$, $t(145) = -1.02$, $p = .308$. In contrast, for women with a high approach bias, those who made a higher percentage of commission errors (indicating lower inhibitory control) consumed significantly more food than those who made a lower percentage of commission errors (indicating higher inhibitory control), $B = 6.417$, $t(145) = 2.04$, $p = .044$. Thus, individuals who consumed the most unhealthy snack food showed a high approach bias for food cues and low inhibitory control (i.e., a high percentage of commission errors) for food cues.

Discussion

The aim of this study was to investigate the combined effects of automatic and controlled processing on unhealthy food intake. Attentional and approach biases were assessed as an indicator of automatic processing, and inhibitory control was assessed as an indicator of controlled processing. Results indicated that neither type of cognitive bias nor inhibitory control alone predicted unhealthy food intake. However, approach bias for food interacted with inhibitory control to predict unhealthy food intake. Specifically, for women with a higher approach bias, those with lower inhibitory control consumed more food than those with higher inhibitory control. In contrast, for women with a lower approach bias, their level of inhibitory control did not predict the amount of food consumed. These findings suggest that consumption of unhealthy food is determined by a combination of automatic and controlled processing. Specifically, participants who showed a high approach bias for food combined with low inhibitory control consumed the most unhealthy snacks.

These findings extend to the food domain previous research which has shown that implicit preferences for alcohol cues (as measured by an IAT with word stimuli) interact with inhibitory control to predict increased alcohol intake (Houben & Wiers, 2009). Further, previous research has shown that tasks which use word stimuli, like the IAT, may be less effective than tasks using pictorial stimuli, like the approach-avoidance task used in the present study, in determining automatic processing of real-world food cues (Roefs, Werrij, Smulders, & Jansen, 2006). The current study has also extended previous research on implicit preferences for food cues (Hofmann et al, 2009 and Nederkoorn et al, 2010) to another component of automatic processing, namely motivational cognitive biases. In addition, food-specific inhibitory control was measured, rather than a general inability to inhibit responses (Houben & Wiers, 2009; Peeters et al., 2012). Food-specific inhibitory control has been argued to be particularly important with regard to achieving a more detailed understanding of the mechanisms which may be associated with unhealthy eating (Appelhans et al., 2011; Meule, 2014). In support, neuroimaging research has shown that brain regions associated with motivation and disinhibition are activated in obese people in response to unhealthy food images (Carnell, Gibson, Benson, Ochner, & Geliebter, 2012).

The current findings are consistent with contemporary dual-process models (Strack & Deutsch, 2004) which propose that behaviour is determined by a combination of automatic and controlled processing. Specifically, the current study has demonstrated that motivational cognitive biases and inhibitory control interact to predict unhealthy eating behaviour. Appetitive food cues elicit automatic approach-action tendencies in some individuals. Individuals with a strong controlled system are able to inhibit responses to such cues. In contrast, those with a weaker controlled system are unable to inhibit this response, which leads to the consumption of unhealthy food. Thus, the present study provides empirical support for the theoretical predictions of dual-process models, as well as recent meta-analyses (Coskunpinar & Cyders, 2013; Field, Cox, 2008).

Neither attentional nor approach bias alone made a significant contribution to food intake. The finding for attentional bias is not surprising as previous research has been inconsistent, and some studies have shown no link with consumption (Fadardi & Cox, 2009; Field et al, 2007, Field et al, 2009 and Hardman et al, 2013). Questions have also been raised regarding the reliability of the dot probe task (Price et al, 2014 and Schmukle, 2005). Approach bias for food also did not make an independent contribution to consumption, but interacted with inhibitory control for food in predicting unhealthy eating. One possible explanation is that a main effect of approach bias will be dependent on the sample. Specifically, the interaction showed relatively less effect of approach bias on consumption for participants with high inhibitory control. In contrast, approach bias did have the predicted effect on consumption for participants with low inhibitory control. Therefore, a main effect of approach bias may be more likely found in samples with low inhibitory control (e.g., overweight or obese individuals) than in the present sample (which had on average good inhibitory control). Taken together, the results confirm that attentional and approach biases are two distinctive types of cognitive bias, which is consistent with previous research in the alcohol domain (Sharbanee et al., 2013). Although both attentional and approach biases are components of automatic processing, the current findings suggest that approach bias may be more pertinent to understanding the association between food cues and eating behaviour. This may be due to the behavioural component of approach bias (i.e., moving towards or away from food cues) in addition to the cognitive one. However, future research needs to determine whether such findings apply to other appetitive substances, such as alcohol and cigarettes.

The present study also has some important practical implications. The results suggest that strong automatic tendencies to approach food cues as well as an inability to inhibit these responses can lead to unhealthy food intake. The current study used a healthy weight sample. It remains to be tested whether these findings apply to overweight and obese populations, who have been shown to have an approach bias for food (Havermans et al., 2011) and low inhibitory control (Nederkoorn et al, 2006 and Nederkoorn et al, 2006). If so, the findings point the way towards a new form of intervention. Thus far, research has shown that automatic and controlled processes can be modified individually. For example, cognitive bias modification can be used to reduce approach biases for alcohol (Eberl et al., 2013;Wiers et al, 2011 and Wiers et al, 2010) and chocolate (Kemps, Tiggemann, Martin, & Elliott, 2013). Other research has shown that cognitive control training can increase inhibitory control for alcohol (Houben et al, 2011 and Houben et al, 2011), food in general (Houben, 2011), and chocolate cues (Houben & Jansen, 2011). However, it is likely that the effectiveness of these interventions will differ among individuals and, as yet, the combined effect has not been investigated in any population. Thus, it would be useful to determine whether a combined approach leads to a better overall success rate in clinical samples. If so, this form of implicit training might provide a useful addition to existing treatments, such as cognitive-behavioural therapy, which target the explicit aspect of cognitive processing (MacLeod, Matthews, 2012, Wiers et al, 2013 and Wiers et al, 2013).

In summary, the present study has demonstrated that a particular combination of automatic and controlled processing predicts unhealthy food intake in young women. These findings are consistent with dual-process models, and contribute to an understanding of the mechanisms that underlie unhealthy eating behaviour. Accordingly, the results have practical implications in suggesting that interventions modify both automatic and controlled processing for maximal effectiveness in discouraging unhealthy food intake. This is particularly important in contemporary Western society, which is characterised by unhealthy eating behaviour.

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CHAPTER 3: STUDY 2

Implicit Food Evaluation and Emotional Eating Interact to Predict Unhealthy Food Choice

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Abstract

The current study aimed to examine implicit evaluations of unhealthy food and an emotional eating style together in predicting unhealthy food choice. Participants were 80 undergraduate women aged 17 to 25 years who completed a self-report measure of emotional eating (the Dutch Eating Behaviour Questionnaire), a Single-Category Implicit Association Task, and a food choice task. Results indicated that a more positive implicit evaluation of unhealthy food predicted both higher trait emotional eating and unhealthy snack food choice. In addition, there was an interaction between implicit unhealthy food evaluation and emotional eating in predicting eating behaviour, such that the relationship between a more positive implicit food evaluation and a greater number of unhealthy snack foods chosen was stronger for those lower, rather than higher, in trait emotional eating. It was concluded that both implicit food evaluation and emotional eating play a role in determining unhealthy eating behaviour.

1. Introduction

The present study focused on the relationship between implicit evaluation of food and unhealthy eating behaviour. In particular, we were interested in the moderating role of a trait emotional eating style on this relationship. Previous research has found that a more positive implicit evaluation of unhealthy food predicts unhealthy eating behaviour, such as increased intake and snack choice. Likewise, higher trait emotional eating has been related to unhealthy eating behaviour. However, few studies have examined implicit food evaluations and emotional eating together. The present study aimed to extend the literature by examining both the additive and interactive effects of implicit food evaluation and emotional eating in predicting unhealthy eating behaviour.

Unhealthy eating behaviour, such as consuming too much food containing a high fat, salt and sugar content, has been linked to weight gain, as well as consequent overweight and obesity (WHO, 2014). One factor that has contributed to the increasing rates of overweight and obesity over the last few decades is an “obesogenic” environment, in which high-calorie food is easily accessible and readily available (Hill, Wyatt, Reed, & Peters, 2003). It has been proposed that the automatic processing of environmental cues associated with such food may result in unhealthy eating behaviour (Cohen & Babey, 2012; Kemps, Tiggemann & Hollitt, 2014; Marteau et al., 2012). One automatic mechanism that has been shown to contribute to such behaviour is an implicit evaluation of food, which refers to an association between food stimuli and positive affect at an automatic level (Czyzewska & Graham, 2008). It is important to examine implicit evaluations of unhealthy food given the role of processing of such cues in predicting unhealthy food intake (Hofmann, Gschwendner, Friese, Wiers, & Schmitt, 2008).

The suggestion that an affective reaction to unhealthy food cues may influence eating behaviour corresponds to a key theoretical prediction of contemporary dual-process models.

Specifically, these models propose that both automatic and controlled processes play an important role in determining behaviour (Strack & Deutsch, 2004). On the one hand, the automatic system involves processing that is fast, effortless, and associative. This system guides behaviour based on an automatic appraisal of the affective properties of a stimulus and is influenced by emotion (Strack & Deutsch, 2004). On the other hand, the reflective system involves processing that is slow, controlled, and conscious. This system guides behaviour based on long-term goals and personal standards (Strack & Deutsch, 2004). Thus, it may be that automatically associating unhealthy food with positive affect compromises conscious reflection on long-term goals such as weight loss, resulting in unhealthy eating behaviour.

Implicit evaluations have commonly been measured using tasks such as The Implicit Association Test (IAT; Greenwald, McGhee, & Schwartz, 1998; Friese, Hofmann, & Wanke, 2008). In recent years, a number of studies using the IAT have shown that a more positive, implicit evaluation of unhealthy food is associated with increased choice of unhealthy food over healthy food, as well as higher self-reported and laboratory-based consumption of unhealthy food, and higher BMI (Conner, Perugini, O'Gorman, Ayres, & Prestwich, 2007; Friese et al., 2008; Haynes, Kemps, Moffitt, & Mohr, 2015a; Hofmann & Friese, 2008; Hofmann et al., 2008; Hofmann, Rauch, & Gawronski, 2007; Perugini, 2005; Richetin, Perugini, Prestwich, & O'Gorman, 2007). Thus, a large body of evidence suggests that a more positive implicit evaluation of unhealthy food predicts unhealthy eating behaviour.

Another factor that has been shown to influence unhealthy eating behaviour is a trait eating style, in particular, emotional eating. Emotional eating refers to the tendency to overeat in response to emotional cues, such as negative affect (e.g., distress or boredom; van Strien, Schippers, & Cox, 1995; Macht & Simons, 2000). Rather than a general tendency to eat more, emotional eating is triggered by a negative emotional state and is typically assessed with a subscale of the Dutch Eating Behavior Questionnaire (DEBQ; van Strien, Frijters, Bergers, & Defares 1986). Studies have found that self-identified female emotional eaters reported greater consumption of unhealthy snack food in response to a negative emotional state than low emotional eaters (Elfhag, Tholin, & Rasmussen, 2008; de Lauzon et al., 2004; Newman, O'Connor, & Conner, 2007; Wallis & Hetherington, 2009). Evidence also suggests that emotional eating may increase the risk of overweight and obesity as individuals who eat to cope with negative emotions are more likely to choose high-calorie foods (Macht, 1999; Bennett, Greene, & Schwartz-Barcot, 2013), which have been shown to reduce stress (Mercer & Holder, 1997). However, consuming too much high-calorie food can result in an energy imbalance (Fay & Finlayson, 2011) and as such, trait emotional eating has been associated with a higher BMI (Verhoeven et al., 2015) and weight gain (Greene et al., 2011).

However, not all studies have documented increased unhealthy eating behaviour in emotional eaters. Some correlational research has found that emotional eating was unrelated to unhealthy snack food consumption (Adriaanse, de Ridder, & Evers, 2011; Anschutz, van Strien, van de Ven, & Engels, 2009; Lluch, Herbeth, Mejean, & Siest, 2000; Wardle et al., 1992). Studies have also shown that emotional eating did not predict being overweight in a sample of adolescent girls (Snoek, van Strien, Janssens, & Engels, 2007) or weight gain in healthy weight undergraduate students (Lowe, Annunziato, & Markowitz, 2006). In addition, some experimental studies found no difference between high and low emotional eaters in unhealthy snack food intake after a sad versus neutral mood induction (Evers, de Ridder, & Adriannse, 2009; Werthmann et al., 2014). The mixed evidence suggests that it is important to determine the conditions under which emotions may predict unhealthy eating behaviour.

While both implicit food evaluation and emotional eating have been shown to predict eating behaviour independently, few researchers have examined both of these factors within the same study. Two relevant studies conducted in the laboratory investigated whether more positive implicit food evaluations guide eating behaviour under different emotional states. In these studies, emotional eating was conceptualised as eating in response to an experimentally manipulated mood state. Friese, Hofmann and Schmidt (2008) instructed participants to either suppress their emotions or let them flow while watching an emotional film segment. They found that positive implicit evaluations (of chips) predicted increased consumption of chips following exposure to the film, but only for the participants who were instructed to suppress their emotions. More recently, Holland, de Vries, Hermsen, and Knippenberg (2012) manipulated mood by using both happy and sad film segments. They found that implicit food evaluation predicted eating behaviour for individuals who were in an induced positive mood, but not for those in a negative mood. Specifically, implicit food evaluations were predictive of unhealthy food choice (a candy bar as opposed to an apple) when people were in a happy, but not a sad mood. In summary, implicit evaluation was less predictive of eating behaviour under negative mood states.

Thus far, only one study has examined the role of individual differences in trait emotional eating in the link between implicit food evaluation and eating behaviour (Ayres, Prestwich, Connor, & Smith, 2011). Specifically, Ayres et al. found an association between a more positive implicit food evaluation (i.e., increased liking of chocolate) and self-reported daily chocolate intake over the following week. They also found that emotional eating scores were positively correlated with implicit liking of chocolate, but not with self-reported intake. Importantly, Ayres et al. found that implicit evaluations and trait emotional eating interacted in predicting eating behaviour, such that liking of chocolate was more predictive of habitual chocolate intake in emotional eaters. As the emotional eating subscale indicates a tendency to eat in response to negative affect, this result contrasts with the findings of the two previous laboratory studies, which showed that implicit food evaluations predicted eating behaviour in individuals who suppressed their emotions (Friese et al., 2008) or were in a positive mood state (Holland et al., 2012). However, it should be noted that Ayres et al. measured self-reported consumption, unlike in the previous two experimental studies. Indeed, the authors suggested that it is important to confirm their findings using a behavioural measure of eating, such as food choice.

The aim of the current study was to further investigate the role of implicit unhealthy food evaluation and emotional eating together on unhealthy eating behaviour. Specifically, it was predicted that implicit evaluation of food and emotional eating would interact to predict unhealthy food choice. This hypothesis was based on the idea that associative processing is influenced by emotion, as well as evidence which suggests that increased automatic eating behaviour occurs in emotional eaters. Following Ayres et al.'s (2011) suggestion, emotional eating was conceptualized as a trait and a food choice task was used to provide a behavioural measure of unhealthy eating. Such a task allows insight into decision-making related to food (Jasinska et al., 2012).

2. Method

2.1 Participants

Participants were 80 women recruited from the undergraduate student population at Flinders University. They were aged 17 to 27 years (M = 20.28, SD = 2.31) and had a mean body mass index of 22.86 kg/m^2 (SD = 4.52), which is classified as being within the healthy weight range (i.e., 18.5–24.9 kg/m^2). Only women were recruited, as they have shown higher levels of emotional eating than men (Keller & van der Horst, 2013) and have a greater tendency to overeat (Burton, Smit, & Lightowler, 2007). Participants were recruited if they spoke English as their first language, liked most foods, and did not have any food allergies, intolerances, or dietary requirements.

2.2 Procedure

Participants were recruited for a study entitled 'Food Preferences and Eating Habits in Women' through flyers posted around campus, and the School of Psychology's online study participation system. The testing session lasted approximately 30 minutes and was conducted in a quiet laboratory. After giving informed consent, participants provided some background information, and completed the Implicit Association Task, followed by the food choice task. As a trait measure, the emotional eating subscale of the DEBQ was administered last to ensure that food choice was not influenced by its completion. The study was approved by the University's Social and Behavioural Research Ethics Committee.

2.3 Measures

2.3.1 Emotional eating. Emotional eating was measured by the Emotional Eating subscale of the Dutch Eating Behaviour Questionnaire (DEBQ; van Strien et al., 1986). This subscale contains 13 items about eating in response to negative emotions (e.g., 'Do you have a desire to eat when you are emotionally upset?'). Participants were asked to indicate how well each of the items related to them on a five-point scale ranging from 'never' (= 1) to 'very often' (= 5). Responses for each item were averaged to produce an emotional eating score, with higher scores reflecting higher levels of emotional eating. Internal reliability was high in the present sample ($\alpha = .96$), comparable with a previous sample ($\alpha = .95$; Ayres et al., 2011, Study 2).

2.3.2 Implicit unhealthy food evaluation. Implicit evaluation of unhealthy food was measured using a single-category implicit association task (SC-IAT; Karpinski & Steinman, 2006). The target category was unhealthy food and the evaluative categories were 'I like' and 'I dislike' (Olson & Fazio, 2004). Participants were asked to categorise pictures (presented one at a time in the centre of the computer screen) into one of three categories: unhealthy food (target), positive (evaluative), or negative (evaluative). The target stimuli were six pictures of unhealthy food (i.e., cake, chocolate, ice-cream, chips, hamburger, and pizza). Evaluative stimuli were six positive and six negative pictures (unrelated to food) selected from the IAPS[1] (Lang, Bradley & Cuthbert, 2001). These pictures have been used in previous studies (e.g., Nederkoorn et al., 2010).

The SC-IAT consisted of three phases. In the first phase, participants practiced classifying the positive and negative pictures into the evaluative categories of “I like” and “I dislike” using two response keys (i.e., left = ‘E’ and right = ‘I’). This phase consisted of 24 trials with the six positive and the six negative pictures each presented twice. In the second practice phase, participants were asked to categorise the pictures into both of the evaluative categories (positive and negative) as well as the target category (unhealthy food). This phase consisted of 36 trials with the six positive, six negative and six unhealthy food pictures each presented twice. The unhealthy food pictures shared a response key with positive pictures in half of the trials and with negative pictures in the other half. The key side assigned to the response to the target category was counterbalanced across participants. The third phase was the same as the second, but the number of trials increased to 144 with each positive, negative, and food picture presented eight times. Participants were given a short break at half way.

IAT scores were calculated using the D600-algorithm (Greenwald, Nosek, & Banaji, 2003), modified for application to SC-IATs (Karpinski & Steinman, 2006). Mean response times of food paired with positive trials were subtracted from mean response times of food paired with negative trials. The difference between mean response times on these two trial types was divided by the standard deviation of all correct response times on food trials, with higher scores indicative of a more positive implicit evaluation of unhealthy food. Incorrect responses were discarded, following Karpinski and Steinman (2006). Response times below 300ms and above 3000ms were also removed as these times are regarded as anticipatory or delayed, respectively (Palfai & Ostafin, 2003).

[1] IAPS picture numbers: 1300, 1603, 2070, 2550, 5480, 5623, 6550, 6570, 8200, 9220, 9340, 9600

2.3.3 Food choice. Following Veling, Aarts, and Stroebe (2013), we used a touch-screen food-choice task to assess participants' hypothetical selection of foods that they would like to obtain to take home and consume. The food pictures comprised eight healthy (i.e., carrots, bananas, strawberries, almonds, crispbread, avocado, apple, fruit salad) and eight unhealthy (i.e., cheese, M&Ms, cookie, corn chips, chocolate, muffin, potato crisps, pretzels) snacks, which were arrayed in a 4 x 4 square grid on a computer touch-screen. Participants were asked to select eight of these 16 foods by touching the picture of the food on the screen. They were given a time limit of 15 seconds to make their selections as food choices are often made under time pressure. A touch-screen was used to represent reaching out to select a food, similar to using buttons to select a snack from a vending machine. The main dependent variable was the number (out of 8) of unhealthy snack foods selected.

3. Results

3.1 Descriptive Statistics

Participants' implicit unhealthy food evaluation scores ranged from -1.07 to 1.04 (*M* = -.04, *SD* = .46), which was comparable to Ayres et al.'s (2011; Study 2) sample (*M* = -.17, *SD* = .39). The mean score for emotional eating (*M* = 2.89, *SD* = 1.05) was also similar to Ayres et al.'s sample (*M* = 2.72, *SD* = .80). For the food choice task, unhealthy snack food choices ranged from 1 to 7 (*M* = 3.54, *SD* = 1.66).

3.2 Relationships between implicit evaluation, emotional eating, and food choice

A series of correlational analyses was conducted to examine the inter-relationships between implicit positive food evaluation, emotional eating and unhealthy food choice. There was a significant positive correlation between implicit food evaluation and both emotional eating, $r = .25$, $p = .03$, and unhealthy food choice, $r = .24$, $p = .04$. The positive correlation between emotional eating and unhealthy food choice was not significant, $r = .16$, $p = .15$.

3.3 Combined effect of implicit evaluation and emotional eating on food choice

A moderated regression analysis was conducted to examine whether implicit food evaluation and an emotional eating style interacted in predicting unhealthy snack food choice. Centered implicit food evaluation and emotional eating scores were entered in Step 1. The product term was entered in Step 2. In Step 1, unhealthy food choice was not predicted by either implicit unhealthy food evaluation, *B* = .689, *p* = .094, or emotional eating, *B* = .212, *p* = .238, *F* (2, 71) = 2.83, *p* = .07, R^2 = .074. In Step 2, however, the product term (implicit food evaluation x emotional eating) explained significant additional variance in unhealthy snack food choice, *B* = -1.04, *p* = .015, F_{Change} (1, 70) = 6.16, *p* = .015, R^2_{Change} = .075.

The above analysis indicates that implicit food evaluation and an emotional eating style interact in predicting unhealthy snack food choice. Simple slopes analyses were conducted to determine the form of this significant interaction. As can be seen in Fig. 1, implicit food evaluation was positively associated with unhealthy food choice in participants lower in emotional eating (one SD below the mean), *B* = .792, *t*(70) = 2.01, *p* = .048, but was unrelated to food choice in participants higher in emotional eating (one SD above the mean), *B* = .308, *t*(70) = .090, *p* = .466.

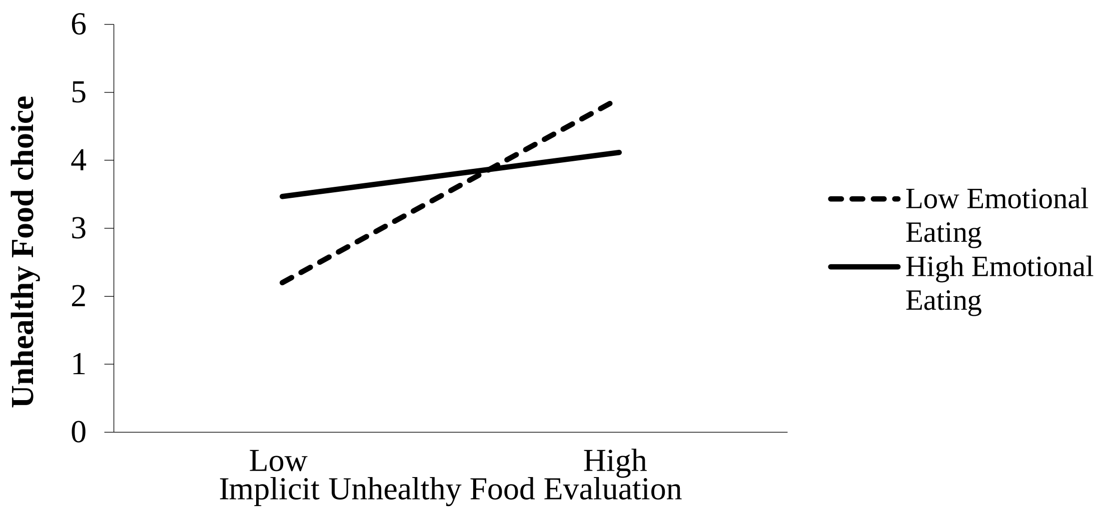

Fig 1. Unhealthy food choice as a function of implicit unhealthy food evaluation and trait emotional eating.

4. Discussion

The current study aimed to examine the potential interactive effects of implicit food evaluation and an emotional eating style on unhealthy snack food choice. As expected, a more positive implicit evaluation of unhealthy food was associated with higher emotional eating and increased unhealthy snack food choice. In contrast, emotional eating was not correlated with unhealthy food choice. Most importantly, implicit evaluations of unhealthy food and emotional eating interacted in predicting unhealthy food choice, such that positive implicit food evaluation was more predictive of snack food choice in those with lower emotional eating scores.

Not surprisingly, an implicit positive evaluation (i.e., liking) of unhealthy food was positively correlated with unhealthy snack food choice. This finding shows that individuals who implicitly like unhealthy snack food more have a greater tendency to choose such foods when given the option of choosing from an array of healthy and unhealthy snack foods. This finding is consistent with previous research (Ayres et al., 2011; Conner et al., 2007; Dube, 2007; Friese et al., 2008; Hofmann et al., 2008; Perugini, 2005; Prestwich et al., 2011; Richetin et al., 2007) and supports contemporary dual-process models, which posit that behaviour is partly determined by automatic processing (Strack & Deutsch, 2004). Clearly, appetitive food cues elicit automatic affective reactions for some individuals.

In addition, higher emotional eating was associated with greater implicit liking of unhealthy food. This finding supports the results of Ayres et al. (2011), who likewise found that higher emotional eating was associated with greater implicit liking of chocolate, and extends it to implicit evaluations of unhealthy food more generally. Together, the findings suggest that the tendency to eat for emotional reasons is related to a greater implicit liking of unhealthy food.

We did not find a significant association between emotional eating and unhealthy snack food choice. This finding is not surprising given the previous inconsistent results, with some studies showing that an emotional eating style predicts increased unhealthy eating behaviour (e.g., Elfhag, et al., 2008; de Lauzon et al., 2004; Newman, et al., 2007; Wallis & Hetherington, 2009), and other studies finding no such relationship (Adriaanse, et al., 2011; Anschutz, et al., 2009; Lluch, et al., 2000; Wardle et al., 1992). In particular, Ayres et al. (2011) found no relationship between emotional eating and self-reported chocolate intake. Thus, an emotional eating style on its own may not predict increased unhealthy food choice or intake.

The main contribution of the present study, however, was to investigate the combined effect of implicit evaluation of unhealthy food and emotional eating on unhealthy snack food choice. Specifically, our interaction finding shows that implicit food evaluation was more predictive of unhealthy eating behaviour in individuals with lower, rather than higher, trait emotional eating. This finding contrasts with that of Ayres et al. (2011), who showed the opposite pattern of results also using the emotional eating subscale. However, the current finding aligns better with the results of the two laboratory-based studies, which showed that individuals who supressed their emotions ate less food (Friese et al., 2008) and those in an induced negative mood were less likely to choose an unhealthy snack (Holland et al., 2012).

Thus, it remains to be determined as to why the present result differs from that of Ayres et al. (2011). One possible explanation lies in the nature of the measure used to assess eating behaviour. Specifically, both the current study and the two previous experimental studies (Friese et al., 2008; Holland et al., 2012) used a behavioural measure collected in the laboratory, while Ayres et al. used a self-report measure of food intake which may be less reliable (e.g., Giuliani, Tomiyama, Mann, & Berkman, 2015). Another possibility is that Ayres et al. investigated responses to chocolate, rather than unhealthy food in general, as in the present study. Rogers and Smit (2000) have argued that chocolate has a special place among foods in contemporary Western society because it is both highly palatable and can even be addictive, while generating ambivalence (i.e., ‘naughty but nice’). Chocolate is also valued as a reward and is associated with gift-giving (Hetherington & MacDiarmid, 1993), and thus may function differently from unhealthy foods in general. Future research might investigate both chocolate and unhealthy food more generally in the same study protocol.

It is also important to note that questions have recently been raised about the nature of the emotional eating subscale. Specifically, the scale assesses whether people tend to eat in response to negative emotions. However, individuals can also overeat in response to positive emotions (Bongers, Jansen, Havermans, Roefs, & Nederkoorn, 2013). Indeed, Holland et al. (2012) showed that those in a happy mood state were more likely to choose an unhealthy snack than people who were in a sad mood state. As a set, the studies support the importance of determining how different emotions might influence the eating behaviour of self-identified emotional eaters.

The present study has some important practical implications. The finding that greater implicit liking of unhealthy food predicts increased unhealthy snack food choice provides support for interventions that target implicit food evaluation. Several tasks can be used to re-train implicit evaluations, such as evaluative conditioning protocols or a modified version of the IAT. Both of these tasks involve consistently pairing unhealthy food stimuli with negative affective cues (Ebert, Steffens, von Stulpnagel, & Jelenec, 2009; Hollands, Prestwich, & Marteau, 2011). Previous studies have shown that these tasks can reduce implicit liking of unhealthy snack food (Ebert et al., 2009; Haynes, Kemps, & Moffitt, 2015b; Hollands et al., 2011; Lebens et al., 2011), as well as subsequent unhealthy snack food intake (Haynes et al., 2015b) and choice (Hollands et al., 2011). However, some studies have found no effect on subsequent food choice (Eberl, et al., 2009; Lebens et al., 2011). The present results suggest that one reason for the mixed findings may be due to the trait level of emotional eating in the particular samples. Indeed, Hensels and Baines (2016) recently showed that an evaluative conditioning task was effective at changing implicit food evaluations and snack choice for participants with lower, but not those with higher trait emotional eating scores. Thus, future studies could usefully consider the role of emotional eating in protocols designed to modify implicit food evaluations.

In conclusion, the main finding of the present study is that a more positive implicit food evaluation predicts increased unhealthy snack food choice for individuals lower, rather than higher, in emotional eating. The findings contribute to our theoretical understanding of how both implicit food evaluation and trait eating styles can influence unhealthy eating behaviour.

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CHAPTER 4: STUDY 3

Differential Effects of Approach Bias and Eating Style on Unhealthy Food Consumption in Overweight and Normal Weight Women

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Abstract

Objective: The current study aimed to examine the effects of approach bias for unhealthy food and trait eating style on consumption of unhealthy food in overweight and normal weight individuals. **Method:** Participants were 245 undergraduate women aged 17 to 26 years. They completed an Approach-Avoidance Task, the Dutch Eating Behaviour Questionnaire (to assess restrained, emotional, and external eating), and a taste test to measure consumption of unhealthy food. **Results:** An external eating style predicted increased consumption of unhealthy food. Among overweight participants, external and emotional eating style individually moderated the relationship between approach bias for unhealthy food and subsequent consumption. Specifically, approach bias was positively related to consumption in high external and emotional eaters, but negatively related to consumption in low external and emotional eaters. These interactions were not observed among normal weight participants. **Conclusion:** Practically, the results suggest that overweight individuals who are external or emotional eaters may benefit from interventions that aim to modify approach bias toward unhealthy food cues to reduce problematic eating behaviour.

Introduction

The prevalence of overweight and obesity has more than doubled during the last few decades in contemporary Western societies. Worldwide, 39% of adults are now classified as overweight and 13% as obese (WHO, 2014). Individuals in the unhealthy weight range (body mass index [BMI] >25 kg/m^2) are at an increased risk of developing chronic health conditions, such as cardiovascular disease, diabetes, and cancer (WHO, 2014). Excess weight gain is partly driven by unhealthy eating behaviour, such as overeating or a tendency to consume foods high in fat, salt, and/or sugar (Hill, Wyatt, Reed, & Peters, 2003). One of the contributors to unhealthy eating behaviour is a continual exposure to an abundance of appetitive, high-caloric food cues through advertising on the internet, television, billboards, and in magazines (Brunner, van der Horst, Siegrist, 2010). Exposure to appetitive food cues in this 'obesogenic' environment is thought to contribute to unhealthy consumption behaviour through biased cognitive processing of such cues (Marteau, Hollands, & Fletcher, 2012). However, not all individuals overeat and gain weight in such an environment, which suggests that individual differences may play a role in the responsiveness to appetitive food and eating-related cues (Carnell, Kym, & Pryor, 2012).

Contemporary dual-process models suggest that biased cognitive processes are crucial for understanding health behaviour (Strack & Deutsch, 2004). According to such models, behaviour is determined by two cognitive processing systems: automatic processing, which is fast, implicit, and effortless, and controlled processing, which is slow, explicit, and effortful. Dual process models posit that automatic processing generally guides our behaviour unless the controlled system is able to regulate such processing. Furthermore, it has been proposed that the automatic processing system may be driven by cognitive biases, such as an approach bias (the tendency to reach out toward rather than move away from an appetitive stimulus), which can override conscious control and contribute to the consumption of appetitive substances (Wiers, Gladwin, Hofmann, Salemink, & Ridderinkhof, 2013).

In support, a number of studies have demonstrated an approach bias toward a variety of food cues in both normal weight (e.g., Brockmeyer, Hahn, Reetz, Schmidt, & Friederich, 2015; Kemps, Tiggemann, Martin, & Elliott, 2013) and overweight or obese samples (Craeynest, Crombez, Koster, Haerens, & De Bourdeaudhuij, 2008; Havermans, Giesen, Houben, & Jansen, 2011; Mogg et al., 2012). However, only one study to date has directly compared approach bias toward food cues between normal weight and overweight individuals. Kemps and Tiggemann (2015) demonstrated an approach bias for food among obese women, but not among normal weight women. This finding suggests that automatic approach tendencies toward food cues may be strongest in overweight and obese individuals. A few studies have also shown a link between approach bias for unhealthy food cues and increased consumption of such food in mostly normal weight undergraduate student samples (Hofmann, Gschwendner, Wiers, Friese, & Schmitt, 2008; Nederkoorn, Houben, Hofmann, Roefs, & Jansen, 2010). As yet, this relationship has not been tested in overweight samples.

A different kind of contributor to unhealthy eating behaviour may be individual differences in eating style. Research has commonly used the Dutch Eating Behaviour Questionnaire (DEBQ; van Strien, Frijters, Bergers, & Defares, 1986) to measure three different types of trait eating style: restrained, emotional, and external eating. Restrained eating is the tendency to restrict food intake. Emotional eating is the tendency to eat when experiencing negative emotions. External eating is the tendency to eat in response to external food cues, such as the sight or smell of food. Although a number of studies have shown that all three types of eating style are associated with increased unhealthy food consumption (Anschutz, van Strien, van De Ven, & Engels, 2011; Elfhag, Tholin, & Rasmussen, 2008; van Strien, 2000; van Strien, Herman & Verheijden, 2012; Wardle et al., 2002), this has been shown most reliably for external eating. For example, some studies have found that emotional eating did not predict increased unhealthy food consumption (Anschutz et al., 2011; van Strien et al., 2009; Wardle et al., 2002).

Trait eating style has also been associated with higher BMI in unselected undergraduate student samples (Burton, Smit, & Lightowler, 2007; Elfhag & Linne, 2005; Greene et al., 2011; Jasinska et al., 2012; Snoek, van Strien, Janssens, Rutger, & Engels, 2007; Verhoeven et al., 2015), although not all studies have found this for restrained eating (Boschi, Iorio, Margiotta, D'Orsi, & Falconi, 2001). Research has also shown that overweight individuals are more likely to display emotional or external eating than their normal weight counterparts (Braet & van Strien, 1997; Braet et al., 2008; de Lauzon-Guillain et al., 2006; Konttinen, Haukkala, Sarlio-Lähteenkorva, Silventoinen, & Jousilahti, 2009; van Strien, Herman, & Verheijden, 2009). Taken together, the findings suggest that trait eating style contributes to the eating behaviour of both normal weight and overweight people. As findings appear most consistent for the role of external eating in unhealthy food consumption and excess weight, this may be a particularly problematic trait.

The evidence suggests that both automatic approach tendencies toward food cues and trait eating style individually contribute to unhealthy eating behaviour, but their combination has not been investigated. As both approach bias for food and trait eating style tend to be greater in overweight than in normal weight individuals, their combination may be especially important for overweight and obese individuals. Furthermore, it has been suggested that automatic approach tendencies for food may play a particularly important role in the eating behaviour of individuals susceptible to eating in response to negative emotions or external food-related cues (Brockmeyer et al., 2015; Nijs & Franken, 2012) or after a period of restricted eating (Roefs & Jansen, 2002; Veenstra & de Jong, 2010). If so, then trait eating style may also play a moderating role in the effect of approach bias for food on consumption.

To date, no study has examined approach bias and eating styles together in predicting unhealthy eating behaviour; nor have the combined effects been compared between normal weight and overweight individuals.

Thus, the main aim of our study was to investigate the combined effect of approach bias for food and trait eating style on unhealthy food consumption in normal weight and overweight individuals. To obtain sufficient overweight participants, we combined three existing datasets of unselected samples. It was expected that approach bias and trait eating styles would better predict unhealthy food consumption in overweight people compared with normal weight people, and that trait eating style would moderate the effect of approach bias for food on consumption.

Method

Participants

The pooled sample included 245 participants from three studies that were conducted for different research purposes (Kakoschke et al., 2015; under review [control group]; submitted [control group]). All studies included measures of approach bias, trait eating style and snack food consumption. Participants were women aged 17 to 26 years (*M* = 20.20, *SD* = 2.47) recruited from the undergraduate student population at Flinders University. Participants' weight and height were measured to calculate BMI (weight [kg]/height^2 [m^2]). They were subsequently categorised as normal weight (BMI 18.5 – 24.9 kg/m^2) or overweight (BMI >25 kg/m^2) on the basis of the current accepted cut-off (WHO, 2013). This resulted in 180 normal weight participants (BMI *M* = 20.77, *SD* = 2.3) and 65 overweight participants (BMI *M* = 29.90, *SD* = 5.0).

Materials

Approach-Avoidance Task. The Approach-Avoidance Task (AAT) was used to measure approach bias for unhealthy food based on a previous protocol (Wiers, Eberl, Rinck, Becker, & Lindenmeyer, 2011). The stimuli were 40 digital coloured photographs (presented in a resolution of 1024 x 768 pixels), comprising 20 pictures of unhealthy foods and 20 pictures of non-food stimuli (depicting animals not normally eaten in Western society). Animals were chosen for the non-food comparison category 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 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). Pictures were selected on the basis that categories did not significantly differ on mean ratings of pleasure and arousal (all *p*s >.05). Another 12 images of common objects were used for practice trials preceding the task.

The approach-avoidance task consisted of 160 trials. On each trial, participants began by pressing the start button on the top of a joystick. A picture of an unhealthy food or an animal then appeared in the centre of the screen. Participants were instructed to pull (approach) or push (avoid) the joystick according to whether the picture was presented in portrait or landscape format. These instructions were counterbalanced (i.e., half of the participants pulled for portrait and pushed for landscape and half vice versa). Pulling the joystick increased the picture size (simulating approach), while pushing the joystick decreased the picture size (simulating avoidance). The picture disappeared once the participant had pulled or pushed the joystick. Participants were asked to respond as quickly and accurately as possible. Each picture was presented four times, twice in portrait format and twice in landscape format. Thus, participants pulled and pushed the food and animal pictures with equal frequency (50/50).

For each participant, approach-avoidance scores for unhealthy food were calculated by subtracting median reaction times for pulling from pushing unhealthy food pictures (Wiers et al., 2011). Positive scores indicated an approach bias for food (i.e., faster pull than push), whereas negative scores indicated an avoidance bias away from food (i.e., faster push than pull).

Dutch Eating Behaviour Questionnaire (DEBQ). Trait eating styles were measured by the widely used DEBQ (van Strien et al., 1986), which comprises three subscales. Restrained Eating consists of 10 items (e.g., 'Do you try to eat less at mealtimes than you would like to eat?'). Emotional Eating consists of 13 items (e.g., 'Do you have a desire to eat when you are emotionally upset?'). External Eating consists of 10 items (e.g., **'**If foods smells and looks good, do you eat more than usual?'). Each item is rated on a five-point scale ranging from 'never' (1) to 'very often' (5). For each subscale, a mean score is calculated, with higher scores indicating a greater level of restrained, emotional, or external eating. In the present sample, internal reliability was good for restrained eating (α = .93) and emotional eating (α= .95), while it was acceptable for external eating (α = .78), which is comparable to a previous sample (van Strien et al., 1986).

Taste Test. Unhealthy snack food consumption was measured using a so-called taste test. Although the snacks in the taste test differed somewhat across the studies, all studies included chocolate M&Ms and potato crisps. These snacks were chosen as they are frequently consumed and are bite-sized to facilitate eating. They were presented in equally-filled bowls. Participants were instructed to taste as much or as little of the food as they liked so that they could rate each of the snacks on several characteristics (e.g., 'How sweet is this food?'). They were given 10 minutes to complete their ratings after which time the bowls were 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 before the taste test. The weight of each food was then converted into the number of calories consumed and summed to obtain a total measure of snack consumption.

Procedure

All participants were tested in the Food Laboratory in the School of Psychology at Flinders University during a single session. Although other tasks were included in the different experiments, participants always completed the three tasks reported here in the same order, i.e., the Approach-Avoidance Task first, then the taste test, and finally, the measure of eating style (DEBQ). As a trait measure, the DEBQ was administered last to ensure that food consumption was not influenced by its completion.

Results

Sample Characteristics

As can be seen in Table 1, approach bias scores for unhealthy food were positive for both normal weight and overweight participants. When these were tested by one-sample *t*-tests, results showed that overweight participants had a significant approach bias (different from zero), $t(64) = 2.48$, $p = .016$, while normal weight participants did not, $t(181) = 1.64$, $p = .102$. However, when scores were compared between groups, the difference was not significant. For trait eating style, Table 1 shows minimal differences between normal weight and overweight participants. Finally, for consumption, although the overweight participants ate more unhealthy food, this difference was not statistically significant.

Table 1

Means (and standard deviations) and inferential tests of differences between normal weight and overweight participants.

	Normal Weight	**Overweight**	**Inferential Statistics**
Variables	***M* (SD)**	***M* (SD)**	***t*(245)**
Approach bias for unhealthy food	11.18 (91.88)	26.36 (85.68)	1.16, *p* = .246
DEBQ: Restrained eating score	2.79 (0.93)	2.80 (1.00)	0.06, *p* = .951
DEBQ Emotional eating score	3.31 (0.57)	3.34 (0.77)	0.56, *p* = .576
DEBQ External eating score	2.93 (1.03)	3.01 (1.01)	0.39, *p* = .697
Consumption of unhealthy food	84.41 (70.05)	97.87 (75.21)	1.31, *p* = .193

Effect of approach bias and eating style on food intake in normal weight and overweight women

A series of hierarchical regression analyses was conducted to examine whether approach bias for food and trait eating style predicted unhealthy snack food consumption. BMI group was included to determine whether the effects differed between normal weight and overweight participants. These analyses were performed separately for restrained, emotional, and external eating. For each analysis, centred approach bias and eating style scores, as well as BMI group were entered in Step 1. The two-way product terms were entered in Step 2 and the three-way product term was entered in Step 3. The resulting descriptive and inferential statistics are presented in Table 2. The significant interactions are indicated by change in R^2 (ΔR^2).

For restrained eating, results showed that none of Step 1, Step 2, or Step 3 was significant. For emotional eating, Step 1 and Step 2 were not significant. However, Step 3 was significant as the three-way product term (emotional eating x approach bias x BMI group) explained unique additional variance in unhealthy food consumption. For external eating, Step 1 was significant. In particular, it can be seen that external eating uniquely predicted unhealthy food consumption. Step 2 was not significant, but Step 3 was; the three-way product term (external eating x approach bias x BMI group) explained additional variance in consumption.

The three-way interactions involving BMI indicate that the results were different for normal weight and overweight participants. Thus, separate regression analyses were conducted for the two weight groups. Results (Table 3) showed no significant main effects or interactions for normal weight participants. In contrast, for overweight participants, there was a significant interaction between approach bias and emotional eating, and approach bias and external eating, but not between approach bias and restrained eating. As indicated by total R^2

for each group, the amount of variance explained in consumption was significant in the overweight group for emotional (19.9% and external eating (15.3%), but was not significant in the normal weight group (1.9% and 0.3% respectively).

Figure 1 displays the interactions for emotional and external eating style, significant in the above regression analyses. In line with what can be seen in Figure 1, simple slopes analyses showed no significant effects for normal weight participants. For overweight participants, however, there was a clear pattern. For participants high in emotional eating (one *SD* above the mean), approach bias was positively related to consumption, $\beta = .302$, $t(61) = 2.24$, $p = .029$, and for those low in emotional eating (one *SD* below the mean), approach bias was negatively related to consumption, $\beta = -.432$, $t(61) = -2.38$, $p = .020$. Likewise, approach bias was positively related to consumption for participants high in external eating, $\beta = .318$, $t(60) = 2.24$, $p = .021$, and was negatively related for those low in external eating, $\beta = -.273$ $t(60) = -.313$, $p = .069$ (although the latter did not reach statistical significance).

Table 2

Regression analyses of approach bias for food and scores on subscales of the DEBQ with BMI group in predicting unhealthy food consumption (calories).

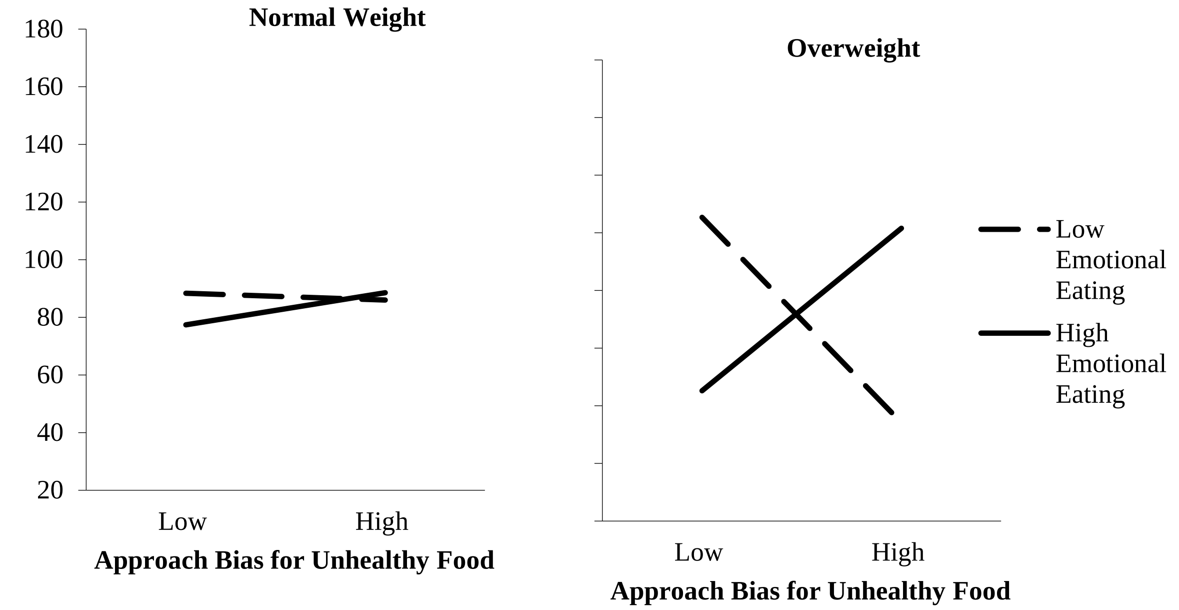
		Restrained Eating				Emotional Eating				External Eating			
Step	**Predictors**	***B***	**SE**	**b**	***p***	***B***	**SE**	**b**	***p***	***B***	**SE**	**b**	***p***
1	Approach bias	.027	.051	.033	.603	.024	.051	.031	.638	.013	.051	.017	.796
	Eating style	6.45	4.82	.086	.181	-.897	4.58	-.013	.845	19.38	7.32	.169	.009*
	BMI group	11.32	10.39	.070	.277	11.86	10.62	.072	.265	11.16	10.55	.067	.291
		R^2 (3, 241) = .014, *F* = 1.13, *p* = .338				R^2 (3, 240) = .006, Δ*F* = .520, *p* = .668				R^2 (3, 239) = .034, Δ*F* = .283, *p* = .039*			
2	Approach bias × eating style	-.601	.061	-.067	.317	.111	.054	.135	.041*	.161	.085	.121	.061
	Approach bias × BMI group	.048	.123	.079	.698	-.028	.124	-.047	.820	.039	.119	.065	.742
	Eating style × BMI group	-1.804	10.87	-.033	.868	2.71	10.73	.050	.801	3.73	15.27	.047	.807
		ΔR^2 (3, 238) = .005, *F* = .401, *p* = .753				ΔR^2 (3, 237) = .018, Δ*F* = 1.50, *p* = .218				ΔR^2 (3, 236) = .016, Δ*F* = 1.33, *p* = .266			
3	Approach bias × eating style × BMI group	-.143	.133	-.217	.282	.324	.126	.525	.011*	.452	.181	.478	.013*
		ΔR^2 (1, 237) = .005, *F* = 1.16, *p* = .282				ΔR^2 (1, 240) = .026, Δ*F* = 6.56, *p* = .011*				ΔR^2 (1, 235) = .025, Δ*F* = 6.22, *p* = .013*			
	Total	R^2 (7, 244) = .024, *F* = .819, *p* = .573				R^2 (7, 243) = .051, *F* = 1.82, *p* = .084				R^2 (7, 242) = .075, *F* = 2.72, *p* = .010*			

Table 3

Regression analyses of approach bias for food and scores on subscales of the DEBQ in predicting unhealthy food consumption (calories) separately for normal weight and overweight participants.

		Normal Weight				Overweight			
Step	**Predictors**	***B***	**SE**	**b**	***p***	***B***	**SE**	**b**	***p***
1	Approach bias	.018	.058	.102	.762	.048	.113	.055	.671
	Restrained eating	7.65	5.64	.102	.177	4.03	9.61	.054	.676
		R^2 (2, 177) = .011, *F* = .1.004, *p* = .368				R^2 (2, 62) = .005, *F* = .154, *p* = .857			
2	Approach bias x restrained eating	-.018	.072	-.019	.801	-.161	.117	-.180	.173
		ΔR^2 (1, 176) = .000, ΔF = .064, *p* = .801				ΔR^2 (1, 61) = .030, ΔF = 1.90, *p* = .173			
	Total	R^2 (3, 176) = .012, *F* = .687, *p* = .561				R^2 (3, 61) = .035, *F* = .738, *p* = .534			
1	Approach bias	.019	.057	.025	.743	.038	.115	.043	.745
	Emotional eating	-2.06	5.16	-.030	.691	2.54	10.03	.034	.801
		R^2 (2, 179) = .001, *F* = .123, *p* = .884				R^2 (2, 59) = .004, *F* =.105, *p* = .900			
2	Approach bias x emotional eating	.036	.060	.045	.550	.360	.112	.413	.002*
		ΔR^2 (1, 178) = .002, ΔF = .358, *p* = .550				ΔR^2 (1, 58) = .150, ΔF = 10.27, *p* = .002*			
	Total	R^2 (3, 178) = .003, *F* = .201, *p* = .895				R^2 (3, 58) = .153, *F* = 3.51, *p* = .021*			
1	Approach bias	.003	.057	.004	.953	.055	.111	.063	.624
	External Eating	16.74	9.15	.137	.069	24.45	12.72	.245	.059
		R^2 (2, 179) = .019, *F* = 1.72, *p* = .182				R^2 (2, 58) = 062, *F* = 1.92, *p* = .156			
2	Approach bias x external eating	.017	.102	.012	.872	.469	.150	.375	.003*
		ΔR^2 (1, 178) = .000, ΔF = .026, *p* = 872				ΔR^2 (1, 57) = .137, ΔF = 9.74, *p* = .003*			
	Total	R^2 (3, 178) = .019, *F* = 1.15, *p* = .331				R^2 (3, 57) = .199, *F* = 4.72, *p* = .005*			

(a) Emotional Eating



(b) External Eating

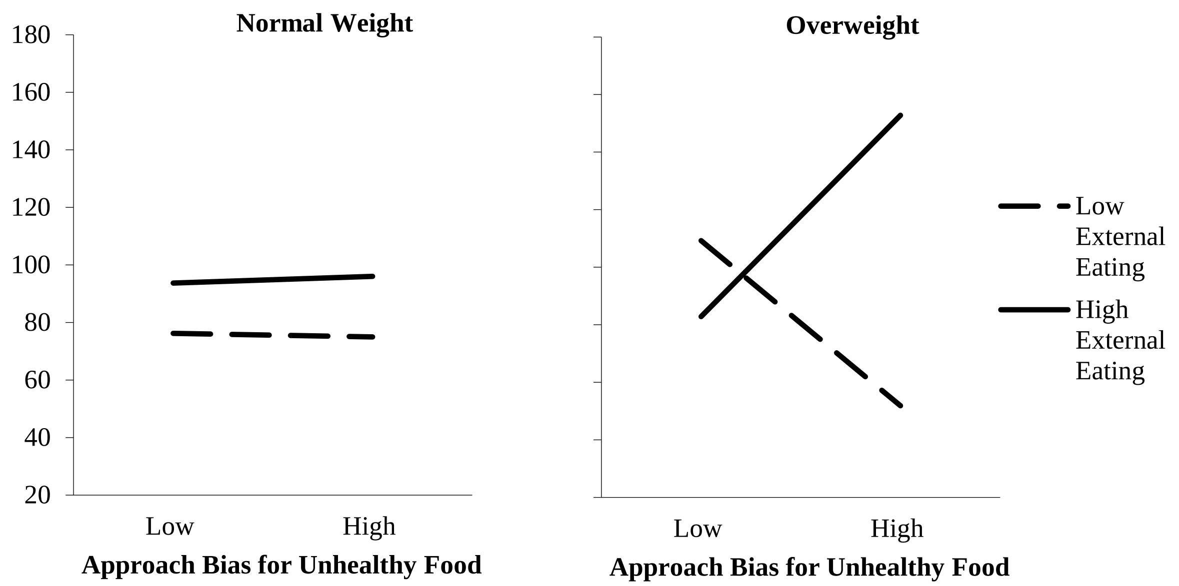


Figure 1. Interactions between approach bias and (a) emotional and (b) external eating on unhealthy food consumption (calories) separately for normal weight and overweight women.

Discussion

The current study aimed to examine the combined effects of approach bias for unhealthy food and trait eating style in predicting consumption of unhealthy food in normal weight and overweight individuals. Contrary to predictions, there were no mean differences in approach bias, eating style, or snack food consumption between weight groups. The results did show that trait external eating predicted increased consumption of unhealthy food. Importantly, there were differences in the combined prediction of unhealthy food consumption between normal weight and overweight participants. Among overweight participants, external and emotional eating style individually moderated the relationship between approach bias and consumption. Specifically, approach bias for unhealthy food was positively related to consumption in high external and emotional eaters, but negatively related to consumption in low external and emotional eaters. These interactions were not observed among normal weight participants.

The results indicated that the overweight group showed a significant approach bias for unhealthy food while the normal weight group did not. This finding is consistent with that of a previous study, which showed an approach bias for food in obese, but not in normal weight, individuals (Kemps & Tiggemann, 2015). Our failure to find a group difference in approach bias might be due to our less extreme overweight sample, which comprised mostly of people (63%) in the overweight category (BMI = 25-30) rather than in the obese category (BMI > 30). Future research could specifically investigate differences between normal weight, overweight and obese individuals in their approach bias for unhealthy food and subsequent consumption.

In terms of individual predictors of eating behaviour, the current finding that an approach bias for unhealthy food did not predict unhealthy food consumption is at odds with two studies that showed this effect in unselected student samples (Hofmann & Gschwendner et al., 2008; Nederkoorn et al., 2010). However, these latter studies also showed that the automatic approach bias was more predictive of eating behaviour for individuals with poor self-regulatory control. Thus, it might be that approach bias toward unhealthy food cues results in increased unhealthy food consumption in combination with other predictors of eating behaviour.

For trait eating style, the finding that restrained or emotional eating were not unique predictors of unhealthy food consumption is not altogether surprising as the previous research has been somewhat mixed. Importantly, however, external eating did predict consumption of unhealthy food. This is consistent with the literature showing that external eating is the most robust eating style for predicting unhealthy food consumption (e.g., Anschutz et al., 2011; Elfhag et al., 2008; Wardle et al., 2002). This finding that a heightened responsiveness to external food-related cues predicts unhealthy eating supports the underlying premise of Schachter's classic externality theory (Schachter, 1968), which posits that external eaters are more susceptible to eating in response to cues such as the sight and smell of food, rather than internal cues (hunger). This is particularly important in the current ‘obesogenic’ environment where such individuals might find it particularly difficult to resist the lure of advertising and ready availability of fast food.

The major contribution of the present study, however, was that the combined effect of approach bias for food and trait eating style better predicted consumption of unhealthy food in overweight than in normal weight people, and that eating style moderated the effect of approach bias on consumption in the overweight group. Specifically, it was found that approach bias for unhealthy food together with high external or emotional eating predicted increased consumption of unhealthy food. In regards to external eating, it is likely that a heightened responsiveness to external food-related cues and a greater tendency to approach unhealthy food will be particularly problematic for overeating and weight gain in an environment that continually exposes people to an abundance of appetitive food and related cues. In terms of emotional eating, a predisposition to eat in response to negative emotions together with a greater tendency to approach unhealthy food likely contributes to excessive food consumption and weight gain. It is important to note that while the measure of emotional eating used in the present study (DEBQ) assessed the tendency to eat in response to negative emotions, some recent studies have demonstrated that overeating also occurs in response to positive emotions (Bongers, Jansen, Havermans, Roefs, & Nederkoorn, 2013; Holland, de Vries, Hermsen, & van Knippenberg, 2012). Future research could examine how experiencing different emotions might influence the eating behaviour of overweight people in combination with an approach bias toward unhealthy food.

Although we did not find that approach bias and eating style (except for external eating) individually predicted unhealthy eating behaviour, the results highlight that their combined effect is important for predicting consumption in overweight, but not in normal weight, individuals. The absence of findings for normal weight people is somewhat surprising based on the results of some previous studies (e.g., Hofmann & Gschwendner et al., 2008; Nederkoorn et al., 2010). One potential reason for these mixed findings is that unselected undergraduate student samples undoubtedly contain overweight individuals as well as normal weight individuals, given that more than 52% of the general population are overweight or obese (WHO, 2014). Our results suggest the intriguing possibility that it may be the overweight people who are driving the observed effects of approach bias for food and eating style in the prior unselected samples.

Theoretically, the current findings lend some support to the proposition that unhealthy eating behaviour is partly determined by automatic processing of appetitive food cues (Strack & Deutsch, 2004). Although approach bias for food did not predict eating behaviour alone, it did so in some individuals. In particular, the current results suggest that overweight people who tend to eat high-calorie food when they are feeling sad or distressed (emotional eaters), as well as those who tend to eat when they see or smell an appealing food, such as a piece of chocolate cake (external eaters), might be especially susceptible. Thus, appetitive food and related cues in the environment likely do elicit automatic approach tendencies, but more so for certain individuals.

The present study has some important practical implications. The finding that approach bias interacted with trait eating style in predicting consumption in overweight people suggests that approach bias modification training might be useful for emotional and external eaters. The most commonly used task for re-training approach bias is the Approach-Avoidance Task (Rinck & Becker, 2007). In this task, participants are trained to avoid appetitive pictures (e.g., unhealthy food) by consistently presenting such cues in a format that requires them to be pushed (avoided) and control pictures in a format that requires them to be pulled (approached). Studies have shown that successfully reducing approach bias for unhealthy food can decrease unhealthy snack choice and consumption of chocolate (Becker, Jostmann, Wiers, & Holland, 2015, Study 1; Fishbach & Shah, 2006, Study 5; Kakoschke et al., under review; Schumacher, Kemps, & Tiggemann, 2016). However, other studies have found no effect of approach bias re-training on food consumption or choice (Becker et al., 2015, Study 2, Study 3; Dickson, Kavanagh, & MacLeod, 2015). Thus, the mixed findings might be due to individual differences in weight status and/or eating style not being taken into account. The current results suggest that overweight individuals may benefit more from approach bias re-training, particularly if they are external or emotional eaters. Future studies might usefully pursue the identification of individuals most likely to benefit from such re-training.

In conclusion, the present study has clearly shown combined effects of approach bias for food and external or emotional eating in predicting unhealthy food consumption in overweight, but not in normal weight, individuals. The findings contribute to a theoretical understanding of the automatic processes underlying unhealthy eating behaviour for overweight and obese people. At a practical level, approach bias for food presents a potential target for modifying unhealthy eating behaviour, particularly among overweight individuals who have a tendency to eat in response to negative emotions or when exposed to external food cues.

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CHAPTER 5: LITERATURE REVIEW

Approach Bias Modification Training and Consumption: A Review of the Literature

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Abstract

Recent theoretical perspectives and empirical evidence have suggested that biased cognitive processing is an important contributor to unhealthy behaviour. Approach bias modification is a novel intervention in which approach biases for appetitive cues are modified. The current review of the literature aimed to evaluate the effectiveness of modifying approach bias for harmful consumption behaviours, including alcohol use, cigarette smoking, and unhealthy eating. Relevant publications were identified through a search of four electronic databases (PsycINFO, Google Scholar, ScienceDirect and Scopus) that were conducted between October and December 2015. Eligibility criteria included the use of a human adult sample, at least one session of avoidance training, and an outcome measure related to the behaviour of interest. The fifteen identified publications (comprising 18 individual studies) were coded on a number of characteristics, including consumption behaviour, participants, task, training and control conditions, number of training sessions and trials, outcome measure, and results. The results generally showed positive effects of approach-avoidance training, including reduced consumption behaviour in the laboratory, lower relapse rates, and improvements in self-reported measures of behaviour. Importantly, all studies (with one exception) that reported favourable consumption outcomes also demonstrated successful reduction of the approach bias for appetitive cues. Thus, the current review concluded that approach bias modification is effective for reducing both approach bias and unhealthy consumption behaviour.

1. Introduction

Engagement in damaging health behaviours including excessive alcohol use, smoking and unhealthy eating can lead to the development of chronic health conditions (WHO, 2016). In particular, the current Western diet, characterised by the overconsumption of high-calorie food, has been linked to obesity, while the use of alcohol and tobacco is related to the three major causes of death in the world, namely heart disease, cancer and accidents (WHO, 2016). Therefore, it is important to develop interventions that aim to modify unhealthy behaviours to improve health outcomes. Health behaviour change interventions are typically information-based and aim to encourage individuals to reflect upon and monitor their own behaviour; however, such interventions are not always effective (Marteau, Hollands, & Fletcher, 2012). One reason is that health behaviour interventions occur within a larger context, namely in an environment in which advertisements for alcohol, tobacco and unhealthy food are abundant (Amanzadeh et al., 2015, Bestman et al., 2015; Zimmerman & Shimoga, 2014). It has been further argued that the automatic processing of cues in such advertisements can lead to harmful consumption behaviours (Cohen & Babey, 2012; Kemps et al., 2014; Marteau et al., 2012), a consideration of which could improve the effectiveness of these interventions (Hofmann, Friese, & Wiers, 2008).

One automatic mechanism implicated in the development of unhealthy behaviour is biased cognitive processing of appetitive cues (Marteau et al., 2012). A cognitive bias refers to the selective processing of relevant cues over other cues in the environment (MacLeod & Mathews, 2012). Contemporary dual-process models of behaviour posit that both automatic and controlled processing determine health behaviour (Strack & Deutsch, 2004). Automatic processing, the focus of the current review, is fast, implicit, and effortless, while controlled processing is slower and involves conscious reflection based on long-term goals and personal standards. Moreover, automatic processing can involve biases, including both attending to (attentional bias) and approaching (approach bias) unhealthy appetitive cues (e.g., a slice of chocolate cake) in the environment (Wiers, Gladwin, Hofmann, Salemink, & Ridderinkoff, 2013). Most research to date on cognitive biases has focused on attentional bias, which refers to an automatic allocation of attention to particular cues in the environment (Beard et al., 2012; MacLeod & Mathews, 2012). More recently, however, researchers have turned their focus toward approach bias, which is the automatic tendency to reach out toward (i.e., approach) rather than move away from (i.e., avoid) appetitive cues (Wiers, Gladwin, et al., 2013). Approach bias toward appetitive cues is likely to be an important contributor to unhealthy consumption due to the additional behavioural component over and above attentional bias.

The existence of approach biases has been documented for a variety of appetitive cues, including alcohol (e.g., Wiers et al., 2009; Wiers et al., 2010), cigarettes (e.g., Bradley et al., 2008; Wiers et al., 2013), cannabis (Cousijn et al., 2011; Field et al., 2006) and unhealthy food (e.g., Havermans et al., 2011; Veenstra and de Jong, 2010). Furthermore, some researchers have demonstrated that approach biases are linked to increased consumption of alcohol (Wiers et al., 2009, Wiers et al., 2010; Palfai & Ostafin, 2003), cigarettes (Watson et al., 2013; Wiers et al., 2013), cannabis (Cousijn et al., 2011; Cousijn et al., 2012) and unhealthy food (Kakoschke et al., 2015; Nederkoorn et al., 2010). Thus, evidence suggests that the automatic tendency to approach rather than avoid appetitive cues may play a key role in unhealthy consumption behaviour.

Importantly, researchers have begun to investigate whether approach biases can be modified. While several specific tasks can be used to modify approach bias, most researchers have used the Approach-Avoidance Task (AAT), originally designed for the anxiety domain (Rinck & Becker, 2007). In this task, participants are instructed to respond to a picture based on an irrelevant feature (e.g., portrait versus landscape orientation) by pushing or pulling a joystick. Participants are asked to respond based on a feature of the picture, rather than its content, to ensure that the task captures automatic cognitive processing (Wiers, Gladwin, et al., 2013). The AAT also has a ‘zooming’ feature, such that pulling the joystick will increase the picture size while pushing the joystick will decrease the picture size, which gives participants a sense of respectively approaching or avoiding the cue (Neumann & Strack, 2000).

An avoidance of appetitive cues can be trained using the AAT by manipulating the contingencies of the target (appetitive) and control pictures. Specifically, the target pictures are consistently presented in a format that requires them to be pushed (avoided) and control pictures 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 condition) is when the target and control pictures are approached and avoided with equal frequency. Avoidance-training is considered successful if training reduces the approach bias for a specific appetitive substance. Although there has been considerable variability in the protocols used (e.g., the number of training trials varies from 48 to 600), there is evidence to suggest that the AAT can reliably modify approach bias (e.g., Eberl et al., 2013).

The focus of the present literature review is to evaluate the effectiveness of modifying approach biases for appetitive substances. In their more general review of cognitive training techniques for addictive behaviours, Wiers, Gladwin, et al. (2013) included three studies concerning approach bias for alcohol cues. The review concluded that approach-avoidance training was effective for re-training approach bias to alcohol cues and consumption behaviour in both undergraduate and clinical samples. However, since then, approach-avoidance training has been examined for a range of unhealthy consumption behaviours beyond (excessive) alcohol consumption, in particular, for cigarette smoking and unhealthy eating. Therefore, the current review of the approach bias modification literature extends upon the review of Wiers et al. by including more recent studies on alcohol, as well as studies on cigarette smoking and eating.

2. Method

2.1 Search strategy

The Preferred Reporting Items for Systematic Review (PRISMA) guidelines (Moher, Liberati, Tetzlaff, & Altman, 2009) were followed. Relevant articles were identified through a search of four electronic databases (PsycINFO, Google Scholar, ScienceDirect and Scopus) conducted between October and December 2015. The search terms used were: (approach bias modification OR approach avoidance training) AND (eating OR eating behaviour OR food OR smoking OR cigarettes OR alcohol OR drinking). To the best of our knowledge, no studies had been published prior to 2006, so searches were limited to studies published during the last 10 years (2006 to current). Articles were included if they had been peer-reviewed, published, and contained an original empirical study. Papers were excluded if they were a review article, conference paper, study protocol, abstract, or an unpublished dissertation or thesis. Searches were also limited to articles available in the English language. In addition, manual searches were conducted of the reference sections of all included articles to identify other potentially eligible studies, which resulted in the identification of one additional paper (Fishbach & Shah, 2006). An outline of the full literature search strategy for the four electronic databases, including any search limits used, is provided in Appendix A.

2.2 Eligibility criteria

To be included in the current literature review, studies needed to meet the following eligibility criteria. First, studies had to recruit a sample of human adult participants (i.e., aged over 18 years). Second, studies had to use at least one session of approach-avoidance training to re-train participants to avoid appetitive cues. Finally, studies had to measure a behavioural outcome, such as self-reported consumption or intake during a laboratory-based taste test.

2.3 Study selection

In total, the literature search retrieved 437 articles. After removing duplicates, 263 articles were title screened. Based on the eligibility criteria previously outlined, 214 articles were excluded. Abstracts of the remaining 49 articles were examined to determine eligibility, resulting in the exclusion of a further 29 articles that did not include consumption behaviour. An additional five articles were excluded based on an in-depth assessment of the full text. Thus, 15 articles (comprising 18 individual studies) were identified for inclusion in the current literature review (refer to Figure 1 for a detailed explanation of each of the steps).

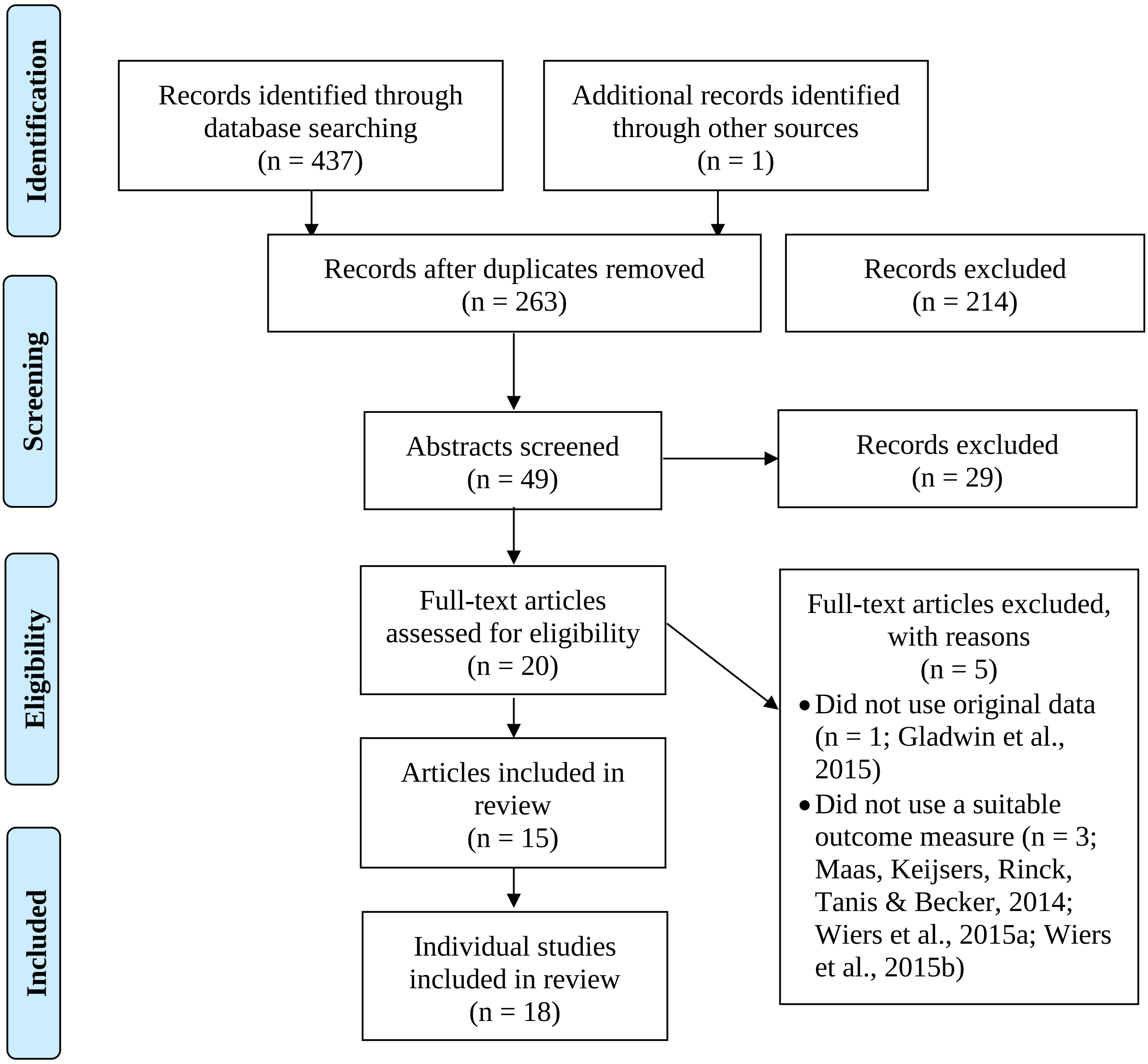

Figure 1. Flow diagram for the search and inclusion criteria of studies in the literature review.

3. Results

3.1 Study characteristics

Detailed information was extracted from the 15 articles (comprising 18 individual studies) that met the inclusion criteria for this review. Included articles were reviewed based on the following characteristics: consumption behaviour, participants, task type, training and control conditions, number of training sessions and trials in each session, success of approach bias re-training, outcome measure, and results (see Table 1 for a detailed description). The included articles examined alcohol consumption (n = 7), cigarette smoking (n = 3), and eating behaviour (n = 5). Samples comprised both undergraduate students and clinical inpatients, and ranged in size from 24 to 475. The majority of the included studies used the AAT as their training protocol (only two used a different task). As per one of the eligibility criteria, all of the studies included a training condition that was designed to train an avoidance of appetitive cues. However, the comparison condition varied between studies (approach training, sham-training, or no training). The number of training sessions varied between 1 and 12, while the number of trials in each session ranged from 100 to 600. The outcomes comprised subjective (self-reported consumption) and objective measures (consumption in a laboratory 'taste test').

3.2 Alcohol consumption

Seven articles, comprising eight studies, focused on alcohol consumption. All of these used the AAT to train avoidance of alcohol cues. Three studies with clinical samples of alcohol-dependent inpatients compared avoidance training with a no-training condition (Eberl et al., 2013, Eberl et al., 2014; Wiers et al., 2011). Three studies compared avoidance training with sham-training in self-identified heavy drinkers recruited from undergraduate students (Lindgren et al., 2015, Study 1 and Study 2) or the community (Wiers et al., 2015). The remaining two studies compared avoidance-training and approach-training in undergraduate samples with self-identified hazardous drinkers (Sharbanee et al., 2014; Wiers et al, .2010).

Table 1

Characteristics and Effect Sizes of Studies Included in the Literature Review.

Authors/Year	Consumption Behaviour	Participants	Task	Training condition	Control condition	Sessions; trials in each session	Was approach bias modified?	Outcome measure	Result (training versus control)
Becker et al. (2015; Study 1)	Eating behaviour	52 students	AAT	Avoid unhealthy food	Sham-training	1; 360	No	Self-reported and behavioural food choice	Training group chose healthier snacks*; *d* = .74
Becker et al. (2015; Study 2)	Eating behaviour	104 students	AAT	Avoid unhealthy food	Sham-training	1; 360	No	Self-reported food choice	n.s.; *d* = .14
Becker et al. (2015; Study 3)	Eating behaviour	103 students	AAT	Avoid unhealthy food	Sham-training	1; 320	No	Chocolate consumption in taste test	Training group consumed more chocolate; *d* = .46
Brockmeyer et al. (2015)	Eating behaviour	30 female students; trait food cravers	AAT	Avoid unhealthy food	No control group	10 across 5 weeks; 402	Yes	Self-reported trait food craving; daily eating habits	Training group had reduced cravings, *d* = 1.11; improved daily eating habits
Eberl et al. (2013)	Alcohol Consumption	475 alcohol dependent patients	AAT	Avoid Alcohol	No training	12 across 12 weeks; 200	Yes	Relapse rates at one-year follow-up	Training group had lower relapse rates; $\eta^2 = .09$
Eberl et al. (2014)	Alcohol Consumption	111 alcohol dependent patients	AAT	Avoid Alcohol	No training	12 across 12 weeks; 200	Yes	Relapse rates at one-year follow-up	Training group had lower relapse rates; n/a
Fishbach & Shah (2006; Study 5)	Eating behaviour	24 female students	Joystick category judgement	Push unhealthy food	Push healthy food	1; 120	Yes	Behavioural food choice	Training group made healthier choices; *d* = .96
Kemps et al. (2013; Study 2)	Eating behaviour	96 female students	IAT	Avoid chocolate	Approach chocolate	1; 240	Yes	Self-reported chocolate craving	Training group had lower cravings; n.s. *d* = .21

Kong et al. (2015)	Cigarette Smoking	60 adolescent smokers	AAT	Avoid cigarettes	Sham-training	4 across 4 weeks; 260	No	Self-reported 7-day cigarette consumption	n.s., *d* = .54
Lindgren et al. (2015; Study1)	Alcohol Consumption	300 students; social drinkers	AAT	Avoid alcohol	Sham-training	2 across 2 weeks; 600	No	Self-reported drinking intention	n.s; η^2 = .02
Lindgren et al. (2015; Study 2)	Alcohol Consumption	288 students; problem drinkers	AAT	Avoid alcohol	Sham-training	2 across 1 week; 600	No	Self-reported drinking intention	n.s; η^2 = .04
Machulska et al. (2016)	Cigarette Smoking	139 inpatient psychiatric adult smokers	AAT	Avoid cigarettes	Sham-training	4 across 4 consecutive days; 250	No	Self-reported daily cigarette consumption	Training group smoked fewer cigarettes (3 month follow-up); η^2 =.04
Schumacher et al. (2016)	Eating Behaviour	120 female students	AAT	Avoid chocolate	Approach chocolate	1; 240	Yes	Chocolate consumption in taste test	Training group consumed less chocolate; *d* = .37
Sharbanee et al. (2014)	Alcohol Consumption	74 students; social drinkers	AAT	Avoid alcohol	Approach alcohol or sham-training	1; 384	Yes	Beer consumption in taste test	Training group consumed less beer*; n/a
Wiers et al. (2010)	Alcohol Consumption	42 students; male problem drinkers	AAT	Avoid alcohol	Approach alcohol	1; 440	Yes	Beer consumption in taste test	Training group consumed less beer*; n/a
Wiers et al. (2011)	Alcohol Consumption	214 alcohol dependent patients	AAT	Avoid alcohol	Sham-training or no training	4 over 4 days; 200	Yes	Relapse rates at one-year follow-up	Training group had lower relapse rates; *d* = .28
Wiers et al. (2015)	Alcohol Consumption	136 problem drinkers	AAT	Avoid alcohol	Sham-training	4 across 2-14 days; 220	No (approach bias data was not reported)	Self-reported alcohol consumption	n.s.; n/a
Wittekind et al. (2015)	Cigarette Smoking	257 smokers	AAT	Avoid cigarettes	No training	1; 100	Approach bias not measured	Self-reported cigarette smoking	Training group smoked fewer cigarettes; η^2 = .06

Note. AAT = Approach-Avoidance Task; IAT = Implicit Association Task; # bias mediated effect of training group on outcome; n.s. = not statistically significant at .05 level; * = significant results obtained only for successfully trained participants. Effect sizes were partial eta² (η^2) for ANOVA and Cohen's *d* for t-tests; n/a = insufficient data available.

In terms of the results, five of the eight studies showed successful re-training of the approach bias (at least for some participants). All of these also showed that approach bias change translated into effects on consumption. Specifically, the three studies with alcohol-dependent inpatients found that those in the training group were less likely to have relapsed at one-year follow-up than those who received treatment as usual (Eberl et al., 2013; Eberl et al., 2014; Wiers et al., 2011). Although the two studies with undergraduate students found no main effect of training condition on alcohol consumption during a laboratory taste test, they did find the effect for a subset of participants who were successfully re-trained toward an avoidance of alcohol cues (Sharbanee et al., 2014; Wiers et al., 2010). This subset of participants showed a change in AAT score in the predicted direction from pre- to post-training. In addition, Eberl et al. (2013) explicitly tested for mediation and found that a change in approach bias for alcohol cues fully mediated the effect of training on relapse rates one-year later in a clinical sample. Similarly, Sharbanee et al. (2015) found a significant indirect effect of training condition on alcohol consumption through approach bias.

The remaining three studies investigated samples of problem drinkers and used sham-training as a control. Two found no significant effect of training condition on approach bias (Lindgren et al., Study 1 and Study 2), and one did not report approach bias scores (Wiers et al., 2015). Importantly, these three studies did not find any effect of training on consumption. Specifically, Lindgren et al. (2015; Study 1 and Study 2) found no difference between the training and control groups in self-reported cravings or intention to drink alcohol during the following week, while Wiers et al. (2015) found that self-reported alcohol consumption in the two-week period following training reduced equally for the training and control groups.

In summary, five out of eight studies (across undergraduate and clinical samples) found that the approach bias was successfully re-trained toward avoidance of alcohol cues (Eberl et al., 2013; Eberl et al., 2014; Sharbanee et al., 2015; Wiers et al., 2010; Wiers et al., 2011). In terms of behaviour, these same five studies also reported a significant group difference in alcohol consumption or relapse rates (at least in the successfully re-trained participants). Thus, it appears that the main difference between studies that did and those that did not produce a positive effect on consumption was the successful reduction of approach bias for alcohol. This interpretation is further strengthened by the two studies that showed that positive effects on behaviour were limited to successfully trained participants (Sharbanee et al., 201; Wiers et al., 2010), and by the two studies that explicitly tested and confirmed an indirect or mediating effect of training condition on behaviour through approach bias (Eberl et al. 2013; Sharbanee et al., 2015).

3.3 Cigarette smoking

All three studies that attempted to reduce cigarette smoking used the AAT. Kong et al. (2015) compared avoidance-training with sham-training over four weekly sessions in self-reported daily adolescent smokers with low nicotine dependence. They found no difference between groups in approach bias change or the number of cigarettes smoked in the week after training (smoking reduced in both groups). In contrast, Wittekind et al. (2015) compared a single online training session to a no-training control in a community sample of daily adult smokers who were moderately dependent and committed to quitting. They found that participants in the training group smoked significantly fewer cigarettes per day at four-week follow-up (they did not measure approach bias). Finally, Machulska et al. (2015) administered four sessions of avoidance or sham-training to psychiatric inpatients who were moderately dependent smokers. Participants had smoked during the past month and most were motivated to quit smoking. They observed an equal reduction in both approach bias for smoking cues and cigarette smoking in both groups after the last training session. However, at three-month follow-up, the training group reported smoking significantly fewer cigarettes per day than the control group (they did not measure approach bias at this later time).

In all three studies, training led to an absolute reduction in cigarette smoking. In the two studies with moderately dependent adult smokers, the training group showed a greater reduction in cigarette smoking at four weeks (Wittekind et al., 2015) and three months (Machulska et al., 2015). Thus, the emerging evidence suggests that avoidance-training can be a useful intervention for the cessation of cigarette smoking over the long term. However, more studies are needed to corroborate this conclusion.

3.4 Eating behaviour

There were five articles that focused on eating behaviour, comprising seven studies. Five of the studies used the AAT, while one employed a Joystick Category Judgement Task (participants pulled a joystick toward them or pushed a joystick away from them in response to healthy and unhealthy food words) and one used an Implicit-Association Task (participants categorised stimuli into one of two concept categories [chocolate and non-chocolate] and one of two attribute categories [approach and avoid]). All seven studies used food stimuli: four used pictures of a range of unhealthy foods (Becker et al., 2015; Becker et al., 2015; Study 1 and Study 2; Brockmeyer et al., 2015; Fishbach and Shah, 2006), while three used only chocolate pictures (Becker et al., 2015; Becker et al., 2015, Study 3; Kemps et al., 2013; Schumacher et al., 2016). Three of the studies compared the training with sham-training (Becker, Jostmann, et al., 2015; Studies 1, 2 and 3), while three used an approach-food condition (Fishbach and Shah, 2006, Kemps et al., 2013; Schumacher et al., 2016), and one study did not have a control group (Brockmeyer et al., 2015). Most studies used a single training session (*n* = 6) and all used undergraduate samples.

Five out of the seven studies (all except for Becker, Jostmann, et al., 2015, Study 2, Study 3) successfully re-trained the food-related approach bias. Importantly, four of these also found a significant reduction in eating behaviour across the sample, while one study found this for successfully re-trained participants (Becker et al., 2015; Becker et al., 2015, Study 1). Specifically, Brockmeyer et al. (2015) found that participants in the avoidance-training group reported less intense food cravings and improved daily eating habits, while Fishbach and Shah (2006) and Becker, Jostmann, et al. (2015, Study 1) found positive effects on healthy food choice. Of the two studies that investigated chocolate, Kemps et al. (2013) found that the training group reported less intense cravings for chocolate than the control group, while Schumacher et al. (2016) found that the training group consumed less chocolate during a laboratory taste test.

The remaining two studies reported no difference in approach bias between the training and control groups (Becker, Jostmann, et al., 2015, Study 2 and Study 3). These studies also found no benefit of training on eating behaviour. Specifically, Becker, Jostmann, et al. (2015) found no difference between groups in unhealthy food choice (Study 2), and that the training group actually consumed more chocolate during a laboratory taste test (Study 3).

In sum, the studies that reported positive effects on consumption had successfully re-trained approach bias toward an avoidance bias (Becker, Jostmann, et al., 2015, Study 1; Brockmeyer et al., 2015; Fishbach and Shah, 2006; Kemps et al., 2013; Schumacher et al., 2016). In contrast, the studies that did not report a positive effect on consumption also reported no difference between training and control groups on approach bias (Becker, Jostmann, et al., 2015, Study 2 and Study 3).

3.5 Summary of results

Across the domains of alcohol consumption, cigarette smoking, and eating behaviour, half of the included studies (n = 9) reported a significant difference between the training and control groups in approach bias, while the remainder reported no significant difference (n = 7) or did not measure approach bias (n = 2). In addition, the majority of the studies reported positive effects on consumption that favoured the training group (n = 12); some reported no difference between groups (n = 5), and one study reported an effect in the opposite direction

(Becker, Jostmann, et al., 2015, Study 3). As shown in Table 1, effect sizes (partial eta^2 and Cohen's d) for outcome measures varied. However, the overall conclusions drawn were the same across the three different consumption domains.

4. Discussion

The aim of the current review was to investigate the effectiveness of approach bias modification for reducing unhealthy consumption behaviours, including excessive alcohol use, cigarette smoking, and unhealthy eating. Specifically, we examined whether approach bias modification was effective at re-training approach biases for appetitive cues toward an avoidance bias, as well as subsequent effects on consumption. The main finding was that studies that successfully reduced the approach bias also changed unhealthy consumption behaviour. This appeared to be the case regardless of the number of training trials or sessions, and was evident across three different consumption domains. Thus, specific characteristics of the studies did not seem particularly important in determining the effectiveness of training.

The majority of studies included in this review found that approach bias modification was effective at changing the approach bias toward an avoidance bias for appetitive cues. This was particularly the case for alcohol and unhealthy food cues; as yet there is insufficient information on cigarette smoking. This finding suggests that approach biases for appetitive substances beyond alcohol (Wiers, Gladwin, et al., 2013) can be successfully modified with the Approach-Avoidance Task.

More importantly, the majority of studies reported positive effects of approach bias re-training on consumption. In particular, studies targeting alcohol consumption found that successfully re-trained participants consumed less alcohol during a laboratory taste test and alcohol-dependent inpatients had lower relapse rates one year after treatment than those in the control group. Similarly, participants trained to avoid smoking-related cues reported smoking fewer cigarettes over the longer-term. Finally, several studies from the eating domain found that modifying an approach bias for unhealthy food cues, including chocolate, encouraged healthier snack food choice and reduced food cravings and consumption in the laboratory. These findings extend the conclusions drawn by Wiers, Gladwin, et al. (2013) to show that approach bias modification is effective for reducing unhealthy consumption behaviours other than alcohol use, in particular, cigarette smoking and unhealthy eating.

Further, the current review was able to provide some insight into the main difference between the studies that reported positive effects on consumption behaviour (i.e., those that favoured the training group), and those that did not. It appears that avoidance-training was effective at reducing unhealthy consumption when the approach bias for appetitive cues was successfully changed toward an avoidance bias for such cues. For alcohol and tobacco, this was more apparent in samples with greater levels of substance dependence than in unselected samples. Nevertheless, the main conclusion of this review suggests that the mechanism underlying behaviour change is a reduction in approach bias, consistent with the theoretical predictions of contemporary dual-process models (Macleod et al., 2002). The finding that the effect of training condition on consumption was mediated by approach bias (Eberl et al., 2013) further supports this suggestion. Future studies may aim to replicate this finding. Importantly, the overall conclusion appeared to hold across a range of outcomes in three different domains, suggesting that the theoretical predictions of dual-process models apply to a number of appetitive substances.

The results of the current review have a number of practical and clinical implications. First, we found that effective re-training of the approach bias was what distinguished studies that successfully reduced consumption from those that did not; specific study characteristics (e.g., the number of training trials) did not affect outcomes. Nevertheless, it would be useful for future studies to determine the minimum number of trials needed to change approach bias and consumption. Second, the review showed that approach bias modification is successful across several different appetitive behaviours, including alcohol use, cigarette smoking, and eating behaviour. As suggested here and by dual-process models (Strack & Deutsch, 2004), if the mechanism underlying behaviour change is reduction in approach bias, then logically approach bias modification should be effective for other appetitive behaviours. Thus, future research should investigate the effectiveness of using approach bias modification for other substances, including cannabis (Field et al., 2006) and heroin (Zhou et al., 2012), for which approach biases have previously been documented.

While the majority of the reviewed studies were conducted in the laboratory, some studies delivered the training online. The delivery mode was not specific to the consumption domain and made no difference to the effectiveness of training on outcomes. However, future research could examine the optimal delivery mode for obtaining a positive effect on approach bias and behaviour and also determine which is the preferred delivery mode for participants. There may well be novel ways to implement effective training protocols, for example, via a smartphone app. Another possible avenue for future research would be the combined effect of avoidance training for unhealthy substances with approach training for healthy substances. This may provide additional benefit, as a recent study in the anxiety domain found that participants trained to approach positive cues showed a reduction in anxiety symptoms (Becker, Jostmann, et al., 2015). Using a similar ‘positivity training’ technique for consumption, participants could be simultaneously trained to approach a healthy substance, such as water or healthy food, and avoid an unhealthy substance, such as alcohol or chocolate. Interventions that not only discourage unhealthy choices but also promote healthy choices are likely to be more acceptable, an important consideration for cognitive training tasks (Wiers, Gladwin, et al., 2013).

The results of the current literature review are encouraging in terms of illustrating the effectiveness of approach bias modification for consumption behaviour. However, the body of literature reviewed has some limitations as the studies used a range of different outcome measures, making direct comparison across studies difficult. Nevertheless, this did not appear to have any effect on the observed effectiveness of training on consumption behaviour, and so strengthens the overall conclusions drawn. In addition, most of the studies did not examine the longer-term effects of approach bias modification on either approach bias or consumption behaviour, as only four out of the 18 studies reported any follow-up data (Eberl et al., 2013; Eberl et al., 2014; Machulska et al., 2015; Wiers et al., 2011). The current review also has some limitations. The review included 15 different publications (comprising 18 individual studies) that fulfilled the selection criteria. However, as an emerging area, there may be a number of studies under review or in progress that have not been included. In addition, all intervention studies are subject to publication bias (Scherer, Langenberg, & Elm, 2005).

In conclusion, the findings of the current literature review suggest that approach bias modification is effective at re-training approach biases for several appetitive cues. The main finding was that this protocol is also effective at reducing unhealthy consumption behaviour, but seemingly only when the approach bias has been successfully modified. Future research might investigate whether approach bias re-training is useful for other unhealthy consumption behaviours, whether training people to approach healthy appetitive cues is (more) effective, and whether training effects persist longer-term. Determining the clinical utility of approach bias modification is particularly important for the treatment of individuals who engage in harmful behaviours such as excessive alcohol consumption, smoking, and unhealthy eating.

Appendix A. Search strategy

- PsycInfo: (approach avoidance or approach bias) and (modification or training)

- ScienceDirect: pub-date > 2005 and "approach bias" modification OR "approach avoidance" training AND "eating behaviour" OR smoking OR alcohol [Journals(Psychology)].

- Google Scholar: "approach bias" modification OR "approach avoidance" training AND "eating behaviour" OR smoking OR alcohol

- Scopus: TITLE-ABS-KEY (approach bias modification OR approach avoidance training) AND PUBYEAR AFT 2005; Search limits: English

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CHAPTER 6: STUDY 4

The Effect of Combined Avoidance and Control Training on Implicit Food Evaluation and Choice

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Abstract

Background: Continual exposure to food cues in the environment contributes to unhealthy eating behaviour. According to dual-process models, such behaviour is partly determined by automatic processing of unhealthy food cues (e.g., approach bias), which fails to be regulated by controlled processing (e.g., inhibitory control). The current study aimed to investigate the effect of combined avoidance and control training on implicit evaluation (liking), choice, and consumption of unhealthy snack food. **Method:** Participants were 240 undergraduate women who were randomly allocated to one of four experimental conditions of a 2 (avoidance training: training versus control) x 2 (control training: training versus control) between-subjects design. **Results:** The combined training group had a more negative implicit evaluation of unhealthy food than either of the two training conditions alone or the control condition. In addition, participants trained to avoid unhealthy food cues subsequently made fewer unhealthy snack food choices. No significant group differences were found for food intake. **Limitations:** Participants were women generally of a healthy weight. Overweight or obese individuals may derive greater benefit from combined training. **Conclusions:** Results lend support to the theoretical predictions of dual-process models, as the combined training reduced implicit liking of unhealthy food. At a practical level, the findings have implications for the effectiveness of interventions targeting unhealthy eating behaviour.

1. Introduction

The increasing worldwide prevalence of overweight and obesity during the last few decades has become a primary health concern. In contemporary Western societies such as Australia, 64% of adults are now classified as overweight and 29% as obese (WHO, 2014). A major contributing factor to these high rates of overweight and obesity is unhealthy eating behaviour, in particular, the over-consumption of foods high in fat, salt, and sugar (WHO, 2014). One potential influence on unhealthy eating is exposure to a vast array of visual cues associated with food through advertising on the internet, billboards, magazines, and television (Havermans, 2013; Polivy, Herman & Coelho, 2008). Over time, exposure to unhealthy food cues can lead to biased automatic processing of such cues, which can translate into increased food intake if automatic responses to these cues are not inhibited (Cohen & Farley, 2008).

Contemporary dual-process models have been prominent in understanding why our health-related behaviours are not always consistent with long-term goals, such as weight loss (Hoffman, Friese, & Wiers, 2008; Strack & Deutsch, 2004). One of the key predictions is that behaviour is determined by a combination of automatic and controlled processing. Automatic processing is fast, effortless and associative. One such automatic process is an approach bias, which is the automatic action tendency to approach rather than avoid relevant cues in the environment (Wiers et al., 2013). In contrast, controlled processing is slow, controlled and conscious. One aspect of controlled processing is inhibitory control, which is 'the ability to inhibit a behavioural impulse in order to attain higher-order goals' (Houben, Nederkoorn, & Jansen, 2012, p. 550). Taken together, it may be that a rewarding stimulus (e.g., a slice of chocolate cake) in the environment elicits an automatic response, such as an approach action tendency, which can predict unhealthy choice or intake if this process occurs too quickly and effortlessly to be regulated by the slower controlled processing system.

Approach bias has been demonstrated for a range of appetitive substances, including alcohol (Wiers, Rinck, Kordts, Houben, & Strack, 2010), cigarettes (Wiers et al., 2013) and cannabis (Cousijn, Goudriaan, & Wiers, 2011). Importantly, approach bias has also been associated with increased consumption of some of these substances (alcohol: Wiers, Rinck, Dictus, & Van Den Wildenberg, 2009; Wiers, et al., 2010, cannabis: Cousijn, et al., 2011). In the eating domain, approach bias has been reliably demonstrated for a variety of unhealthy foods (Brignell, Griffiths, Bradley, & Mogg, 2009; Havermans, Giesen, Houben, & Jansen, 2011; Kemps & Tiggemann, 2015; Kemps, Tiggemann, Martin, & Elliott, 2013; Veenstra & de Jong; 2010), and has been associated with increased unhealthy food intake (Kakoschke, Kemps, & Tiggemann, 2015; Nederkoorn, Houben, Hofmann, Roefs, & Jansen, 2010). Thus, the evidence suggests that approach bias contributes to consumption of appetitive substances.

Furthermore, automatic processes underlying unhealthy behaviour can be manipulated using a computerised cognitive training paradigm. This is achieved in commonly used protocols such as the Approach-Avoidance Task (AAT), by presenting target pictures (e.g., unhealthy food) in a format that requires a push (i.e., avoidance) response and control pictures (e.g., animals) in a format that requires a pull (i.e., approach) response on the majority of trials. In the alcohol domain, the AAT has been used to train an avoidance of alcohol cues, which reduced implicit liking of such cues and subsequent beer consumption (Wiers et al., 2010). Importantly, these findings were extended to alcohol-dependent inpatients, whereby the training reduced relapse rates one year later (Wiers, Eberl, Rinck, Becker, & Lindenmeyer, 2011; Eberl et al., 2013).

Researchers in the eating domain have also begun to use the AAT. In an early study, Fishbach and Shah (2006) trained participants to avoid unhealthy food words (e.g., ‘cookie’) and approach healthy food words (e.g., ‘apple’), which translated into healthier snack food choices. More recently, Brockmeyer, Hahn, Reetz, Schmidt and Friederich (2015) successfully re-trained approach bias for unhealthy food, which reduced food cravings. Similarly, Becker, Jostmann, Wiers and Holland (2015, Study 1) found that participants who were successfully trained to avoid unhealthy food were more likely to choose a healthy snack. Schumacher, Kemps and Tiggemann (2016) found that participants trained to avoid chocolate cues ate less chocolate, while Dickson, Kavanagh and MacLeod (2016) found no difference in chocolate consumption between groups. Finally, Becker et al. (2015, Study 3) found that their training group actually ate more chocolate than the control group. Thus, research shows that approach bias for unhealthy food can be reduced, but the effect on eating behaviour is less consistent.

In terms of controlled processing, poor inhibitory control has been linked to several unhealthy behaviours. For example, research on alcohol has shown that for participants with low inhibitory control, positive implicit evaluations for alcohol predicted increased alcohol consumption (Friese & Hofmann, 2009; Friese, Hofmann, & Wänke, 2008; Houben & Wiers, 2009; Thush et al., 2008). In the eating domain, studies have consistently shown that poor inhibitory control predicts unhealthy eating behaviour, such as increased unhealthy snack food choice (Jasinska et al., 2012) and intake (Appelhans et al., 2011; Guerrieri et al., 2007).

Inhibitory control can be increased using tasks that involve pairing appetitive stimuli with a no-go cue (Veling, Holland, & van Knippenberg, 2008) or stop-signal (Verbruggen & Logan, 2009). In the alcohol domain, inhibitory control training reduced implicit liking and consumption of alcohol (Houben et al., 2012; Houben, Nederkoorn, Wiers & Jansen, 2011; Jones & Field, 2013, Study 1). Similarly, in the eating domain, inhibitory control training reduced chocolate intake (Houben & Jansen, 2011), as well as implicit liking (Houben & Jansen, 2015; Lawrence et al., 2015b; Veling, Holland, & Knippenberg, 2008; Veling, Aarts, & Stroebe, 2013a), choice (Veling, Aarts, & Stroebe, 2013b; Veling, Stroebe, & Aarts, 2014), and unhealthy food intake (Lawrence, Verbruggen, Morrison, Adams, & Chambers, 2015a).

Although inhibitory control training appears to be an effective technique for changing eating behaviour, a recent meta-analysis found that the effect size on consumption is small, leading the authors to suggest that it may be useful to supplement inhibitory control training with another type of intervention (Allom, Mullan, & Hagger, 2015). Two recent studies tested the combination of inhibitory control training with implementation intention training, which aims to improve eating behaviour by reminding people of their dieting goal. One study found that participants who received both interventions lost more weight over four weeks than those who received either one alone (Veling, van Koningsbruggen, Aarts & Stroebe, 2014), while the other found that the combined training was no more beneficial than either training task alone at reducing the amount of sweets participants selected (Koningsbruggen, Veling, Stroebe, & Aarts, 2014).

According to dual-process models, it should be possible to change unhealthy eating behaviour by re-training either automatic (e.g., approach bias) or controlled processing (e.g., inhibitory control). To date, these two types of interventions have been used individually with mixed success. However, the key prediction of dual-process models is that training automatic and controlled processing together should be more effective at changing behaviour. There is some evidence to support this suggestion, as one correlational study has shown that women who had a stronger approach bias for unhealthy food cues combined with lower inhibitory control consumed more unhealthy snack food during a taste test (Kakoschke et al., 2015).

Thus, the current study aimed to determine whether combining avoidance training with inhibitory control training was more effective than either training task alone at reducing implicit liking, choice and intake of unhealthy food. It was predicted that participants trained to avoid unhealthy food cues and inhibit responses to such cues would show reduced implicit liking of unhealthy food, eat less food in a taste test, and be less likely to choose an unhealthy snack than those who received either training alone or those in the control group.

2. Material and Methods

2.1. Participants

The sample consisted of 240 women, aged 18 to 25 years (*M* = 20.61, *SD* = 2.43), recruited from the undergraduate student population at Flinders University. The majority were within the healthy weight range (18.5-24.9 kg/m^2) with a mean BMI of 22.91 (*SD* = 4.90). Only women were recruited as they have shown a greater tendency to overeat (Burton, Smit, & Lightowler, 2007) and greater concern for weight and dieting goals (Keel, Baxter, Heatherton, & Joiner, 2007). Participants were included 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 to ensure that they were not hungry, as hunger has been associated with both a cognitive bias for unhealthy food cues (Mogg, Bradley, Hyare, & Lee, 1998; Seibt, Hafner, & Deutsch, 2007) and lower inhibitory control (Nederkoorn, Guerrieri, Havermans, Roefs, & Jansen, 2009). All participants reported having complied with this instruction, and subjective hunger ratings (100 mm visual analogue scale ranging from ‘not hungry at all’ to ‘extremely hungry’; Grand, 1968), fell slightly below the mid-point of the scale (*M* = 47.02, *SD* = 24.37).

2.2. Design

Participants were randomly allocated to one of four experimental conditions of a 2 (avoidance training: training vs. control) x 2 (control training: training vs. control) between-subjects design. The researcher was blind to condition during testing as participants were assigned a randomised login code for all computerised tasks. The dependent measures were implicit unhealthy food evaluation, consumption during the taste test, and first snack choice.

2.3. Materials

2.3.1. Stimuli

The stimuli were 40 digital coloured photographs (presented in a resolution of approximately 1024 x 768 pixels) comprising 20 food and 20 control (animal) pictures, a subset of those used in a previous study (Kakoschke et al., 2015). The pictures of unhealthy food depicted food items high in sugar, salt and/or fat (e.g., chocolate, potato chips). Animals were chosen for the non-food comparison category of stimuli as they are, like food, overall appealing. Animal pictures depicted species that are not commonly consumed in Western society (e.g., koala, giraffe). The unhealthy food pictures and the animal pictures were matched on characteristics such as quality, brightness, and size, as well as ratings of pleasure and arousal. These ratings were obtained from a previously conducted pilot study, in which 21 women aged 17-45 years (M = 23.67, SD = 8.28) rated 590 pictures of food and animals on 9-point pleasure and arousal scales (Kemps, Tiggemann, & Hollitt, 2014). The same stimulus set was used for both the modified Approach-Avoidance and the Go/No-Go task.

2.3.2. Avoidance training with a modified AAT

Following Wiers et al. (2011), an approach-avoidance task was used to induce an avoidance tendency away from unhealthy food. The task consisted of two blocks (100 trials each) with a break half-way. Participants began each trial by pressing the start button on top of a joystick. An unhealthy food or animal picture 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 or landscape format. Instructions were counterbalanced (i.e., half of the participants pulled the joystick for portrait format and pushed the joystick for landscape and vice versa). Pulling the joystick increased the picture size (simulating approaching), while pushing the joystick decreased it (simulating avoidance). The picture disappeared once the participant pulled or pushed the joystick so that the picture was at its largest or smallest size, respectively. Participants were asked to respond as quickly and accurately as possible. Pictures were presented in a different random order for each participant.

In the training condition, participants were trained to avoid pictures of unhealthy food. Specifically, unhealthy food pictures were presented in pull-format (approach) on 10% of trials and in push-format (avoid) on 90% of trials, with reversed contingencies for animal pictures. In the control condition, all of the pictures were presented in pull-format on 50% of trials and in push-format on 50% of trials.

For each participant, reaction time scores for correct responses were calculated for pulling and pushing the unhealthy food and animal pictures. An approach-avoidance score was calculated as the difference between median pushing and pulling reaction times for unhealthy food pictures (Wiers et al., 2011). Positive scores indicate an approach action tendency toward food (i.e., faster pull than push), whereas negative scores indicate an avoidance tendency away from food (i.e., faster push than pull).

2.3.3. Control training with a modified GNG task

Following Houben and Jansen (2011), a food specific version of the go/no-go (GNG) task was used to increase inhibitory control for unhealthy food cues. The task consisted of two blocks (160 trials each) with a break half-way. On each trial, a picture was presented together with a go or a no-go cue (the letters ‘P’ or ‘F’) for 1500 ms. Participants were instructed to press the space bar as quickly and accurately as possible when a go cue was presented together with the picture, and to refrain from pressing the space bar when a no-go cue was presented. Instructions regarding letter type (‘F’ versus ‘P’) and response assignment (go versus no-go) were counterbalanced. The go/no-go cues were displayed in black font type and presented in the corner of each picture (corner location was counterbalanced). Pictures were presented in a different random order for each participant.

In the training condition, participants were trained to inhibit responses to unhealthy food. Specifically, food pictures were paired with a no-go cue on 90% of trials and a go-cue on 10% of trials, with reversed contingencies for animal pictures. In the control condition, all pictures were paired with a go cue on 50% of trials and a no-go cue on 50% of trials.

Performance on the GNG task was assessed by calculating reaction times (i.e., correct responses on go trials) and the number of commission errors (i.e., incorrect responses on no-go trials) for unhealthy food cues. Faster reaction times and a higher number of commission errors are typically considered indicative of poor inhibitory control (Baker, Taylor & Leyva, 1995; Bezdjian, Baker, Lozano, & Raine, 2009; Halperin, Wolf, Greenblatt, & Young, 1991).

2.3.4. Implicit food evaluation

Implicit evaluations of unhealthy food were assessed using a recoding-free (RF; Rothermund, Teige-Mocigemba, Gast, & Wentura, 2009) variant of the single-category implicit association task (SC-IAT; Karpinski & Steinman, 2006). In the IAT-RF, the response key assignment to the target category switches between trials rather than blocks, which has been shown to be a more valid assessment of implicit evaluations than the traditional IAT (Houben, Rothermund, & Wiers, 2009). Specifically, participants respond to the target category on the basis of semantic membership rather than salience (Rothermund et al., 2009).

The target category was unhealthy food and the evaluative categories were ‘I like’ and ‘I dislike’ (Olson & Fazio, 2004). These evaluative category labels were used to reduce the effects of ‘extra-personal associations’ (Olson & Fazio, 2004) and have been used in previous food and eating research (Nederkoorn et al., 2010). Participants were asked to categorise pictures (presented one at a time in the centre of the computer screen) into one of three categories: unhealthy food (target), positive (evaluative), or negative (evaluative). The target stimuli were six pictures of unhealthy food (i.e., cake, chocolate, ice-cream, chips, hamburger, pizza), and following Houben et al. (2012), were a subset of those used in the

AAT and GNG tasks. Evaluative stimuli were six positive and six negative pictures (unrelated to food) selected from the IAPS[1] (Lang, Bradley & Cuthbert, 2001). These pictures have been used in previous research (e.g., Nederkoorn et al., 2010).

The SC-IAT consisted of three blocks. In the first block, participants were asked to categorise the positive and negative pictures into the evaluative categories of ‘I like’ and ‘I dislike’ using two response keys (i.e., left = ‘E’ and right = ‘I’). This block consisted of 24 trials with the six positive and the six negative pictures each presented twice. In the second block, participants were instructed to categorise pictures into both evaluative categories (i.e., positive and negative) and the target category (i.e., unhealthy food). This block consisted of 36 trials with each positive, negative and unhealthy food picture presented twice. The third block was the same as the second; however, the number of trials increased to 144 with each positive, negative, and food picture presented eight times. Participants were given a short break at half way. The response key (i.e., left or right) assigned to the evaluative categories remained constant throughout the task, and was counterbalanced between participants. However, the response key assigned to the target category switched randomly between trials, so that unhealthy food pictures shared a response key with the positive category on half of the trials and with the negative category on the other half.

Following standard protocols (e.g., Nederkoorn et al., 2010), scores on the IAT were calculated using the D600-algorithm (Greenwald, Nosek, & Banaji, 2003) and modified for application to SC-IAT (Karpinski & Steinman, 2006). Incorrect responses were replaced by ‘mean (correct) + 600 ms’. Mean response times on food paired with positive trials were subtracted from mean response times on food paired with negative trials. The difference between response times on these two trial types was divided by the standard deviation of all correct responses on food trials, with higher scores indicative of a more positive implicit

[1] IAPS picture numbers: 1300, 1603, 2070, 2550, 5480, 5623, 6550, 6570, 8200, 9220, 9340, 9600

evaluation of unhealthy food. Response times below 300ms and above 3000ms were removed as these times are regarded as anticipatory or delayed, respectively (Palfai & Ostafin, 2003).

2.3.5. Food intake

Food intake was measured using a so-called taste test. Participants were presented with a platter comprising four snacks (M&Ms, chocolate-chip biscuits, potato chips, and pretzels). These snacks were chosen as they are commonly consumed and are bite-sized to facilitate eating. The snack foods were presented in four equally filled separate bowls. The presentation order of the bowls was counterbalanced across participants using a 4 × 4 Latin square. Participants were instructed to taste and rate each snack on several dimensions (e.g., flavour, likelihood of purchase). They were told that they could try as much of the food as they liked and were given 10 minutes to complete their ratings. The amount consumed of each food was calculated by subtracting the weight (in grams) of the snacks after the taste test from the weight before the taste test. The weight in grams for each food was then converted into the number of calories consumed and summed to obtain a total measure of food intake.

2.3.6. Food choice

Following Veling, Aarts, and Stroebe (2013), we used a touch-screen food-choice task to assess participants' selection of foods that they would like to take home. Participants were asked to select eight of the 16 foods presented to them by touching the picture of the food on the screen. However, the first food chosen was used as an indicator of snack choice to ensure that an 'automatic' decision was captured (Furst, Connors, Bisogni, Sobal, & Falk, 1996). A touch-screen was used to represent reaching out to select a snack, similar to using buttons on a vending machine. The food pictures comprised eight healthy and eight unhealthy snacks, which were arrayed in a 4 x 4 square grid on a computer touch-screen. Participants were given a time limit of 15 seconds to make their selections as food choices are often made under time pressure.

2.4. Procedure

Participants were recruited for a study entitled ‘Food Preferences and Eating Habits in Women’ using flyers distributed around campus, and a listing on the School of Psychology’s online study participation system. The testing session lasted approximately 60 minutes and was conducted in a quiet laboratory. After giving informed consent, participants provided background information. They then completed the Approach-Avoidance and the Go/No-Go tasks in counterbalanced order in the combined training and the control only conditions. In the two conditions involving both a control and a training task, the control task was always completed before the training task so as to not reduce the effect of the training on subsequent outcome measures. Participants subsequently completed the implicit association task, a taste test (to assess immediate consumption), and the food choice task. The study was approved by The University's Social and Behavioural Research Ethics Committee.

3. Results

3.1. Statistical considerations

Following standard protocols (e.g., Wiers et al., 2010), incorrect trials (5.28%) were excluded and approach bias scores that were more than 3 *SD* from the mean were identified as outliers and were changed to plus or minus one unit from the first non-outlier (Tabachnick & Fidell, 1989). An alpha value of .05 was used to determine significant *p* values. Effect size measures were partial eta^2 (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).

3.2. Manipulation check

3.2.1. Approach-avoidance task

An independent samples t-test revealed a significant group difference in approach-avoidance scores, $t(214.98) = -11.69$, $p < .001$, $d = .15$. Participants in the avoidance training condition showed an avoidance tendency away from unhealthy food cues (*M* = -128.90, *SD* = 111.12), while those in the control condition showed an approach tendency toward such cues (*M* = 18.86, *SD* = 80.29).

3.2.2. Go/no-go task

An independent samples t-test revealed a significant group difference in response times on go trials, $t(238) = 4.11$, $p < .001$, $d = .53$. Participants in the control training condition were significantly slower to respond to unhealthy food cues (*M* = 621.71, *SD* = 84.79) than those in the control condition (*M* = 579.31, *SD* = 74.74). Although means were in the predicted direction, there was no difference in the number of commission errors between the training (*M* = 1.89, *SD* = 2.32) and control group (*M* = 1.47, *SD* = 2.01), $t(238) = 1.06$, $p = .290$, but participants made very few commission errors overall (1.57%).

3.3. Effect of training on implicit food evaluation

A 2 (AAT: training versus control) x 2 (GNG: training versus control) ANOVA was used to examine the effects of training on implicit food evaluation. Neither the main effect of AAT, $F(1, 230) = .778$, $p = .379$, $\eta^2 = .003$, nor GNG condition, $F(1, 230) = .780$, $p = .378$, $\eta^2 = .003$, was significant. However, as predicted, there was a significant interaction between AAT and GNG condition, $F(1, 233) = 4.76$, $p = .030$, $\eta^2 = .02$. As can be seen in Table 1, the combined training group showed a more negative implicit evaluation of unhealthy food than either training group alone or the control group. Thus, results indicate that the combination of AAT and GNG training was most effective at reducing implicit evaluation of unhealthy food.

3.4. Effect of training on food intake

A 2 (AAT: training versus control) x 2 (GNG: training versus control) ANOVA was also used to examine the effects of training on food intake. Neither the main effect of AAT, $F(1,189) = 2.35$, $p = .629$, or GNG condition, $F(1,189) = .392$, $p = .532$, was significant (see Table 1 for descriptive statistics). There was also no significant interaction between AAT and

GNG condition, *F*(1,189) = 1.92, *p* = .167. Thus, training condition did not affect food intake.

Table 1

Means (and standard deviations) for implicit food evaluation and consumption (calories), and observed count (and percentages) for healthy first food choice by AAT condition and GNG condition.

		AAT Training		AAT Control	
		GNG Training	GNG Control	GNG Training	GNG Control
Implicit Food Evaluation	*M*	-0.17	-0.01	-0.01	-0.07
	SD	(0.42)	(0.35)	(0.37)	(0.46)
Food Consumption (Calories)	*M*	157.32	181.73	163.11	147.13
	SD	(128.83)	(105.62)	(96.84)	(110.65)
Healthy First Food Choice	*N*	41	38	28	35
	%	(64.1%)	(67.9%)	(50.9%)	(54.7%)

3.5. Effect of training on food choice

Overall, participants were slightly more likely to choose a healthy snack food first (*n* = 142, 59%). A logistic regression analysis was conducted to test group differences. In Step 1, the Wald criterion indicated that AAT condition was a significant predictor of healthy first food choice, *B* = .55, SE = .27, $\chi^2(1) = 4.24$, *p* = .039, while GNG condition was not, *B* = -.16, SE = .27, $\chi^2(1) = .36$, *p* = .549. Those who completed AAT training were 1.73 times more likely to first choose a healthy snack food than an unhealthy one, Exp(B) odds ratio = 1.73 (95% CI = 1.03 – 2.93). In Step 2, the interaction between AAT and GNG condition was not significant, *B* = -.02, SE = .53, $\chi^2(1) = .561$, *p* = .454, which indicates that the combined training did not provide any additional benefit (see Table 1 for descriptive statistics). Overall, the results indicate that participants who were trained to avoid unhealthy food cues were less likely to choose an unhealthy snack first (34.2%) than those in the control condition (47.1%).

4. Discussion

The aim of the current study was to investigate the effect of combined avoidance and control training. The main findings were that the combined training was more effective than either training alone at reducing implicit evaluation of unhealthy food. However, there were no individual or combined effects of training on unhealthy food consumption during the taste test. Finally, the avoidance training did have an effect on food choice, as the training group was less likely than the control group to choose an unhealthy snack first over a healthy one.

Our manipulation check indicated that avoidance training was successful, in that participants in the training condition showed an avoidance tendency away from unhealthy food cues, whereas those in the control condition showed approach toward such cues. The effectiveness of control training at increasing inhibitory control was less clear. Participants in the training condition were slower to respond to unhealthy food cues than those in the control condition, but they did not make fewer food-related commission errors. However, the overall rate of commission errors was very low, indicating good control in our sample. Perhaps samples with poorer inhibitory control would receive more benefit from the control training.

To the best of our knowledge, the current study is the first to examine the effect of combined avoidance and control training on implicit evaluation of unhealthy appetitive cues. As predicted, participants who were trained to both avoid and inhibit responses to unhealthy food cues showed less liking for such cues. We did not find that the individual training tasks reduced implicit liking, in contrast to some previous studies in the alcohol (Wiers et al., 2010; Wiers et al., 2011) and eating domains (Houben et al., 2012; Lawrence et al., 2015; Veling et al., 2008; Veling et al., 2013). Perhaps our individual training tasks were less extensive than in previous studies due to the inclusion of both tasks in the session. Nevertheless, the finding that combined training was most effective at reducing implicit liking suggests that it may be useful to supplement one task with the other, even when the individual training is successful.

Although the training protocols produced changes in implicit liking of unhealthy food, there were no training effects on unhealthy food intake during the taste test. This finding is at odds with some previous studies in the alcohol domain (Wiers et al., 2010; 2011; Eberl et al., 2013; Sharbanee et al., 2014). However, the current finding is not surprising given previous inconsistent effects of avoidance and control training on food consumption. Some studies have shown that avoidance training reduces chocolate consumption (Schumacher et al., 2016), whereas others have found no difference between the training and control groups (Dickson et al., 2016), or have even shown the reverse effect with participants trained to avoid chocolate actually consuming more chocolate (Becker et al., 2015, Study 3).

Dickson et al. (2016) have suggested that food may be different from alcohol in that it constitutes a larger and less specific category. Consequently, alcohol in the taste test is likely to more closely match pictures presented during training than is the case for a range of foods. The same consideration may apply to research examining the effect of control training on food intake. While previous studies in the alcohol domain have generally shown that control training successfully reduces consumption (Houben et al., 2011; Houben et al., 2012; Jones & Field, 2013), studies in the eating domain have reported mixed results, with some finding no effect on consumption (Allom & Mullan, 2015; Lawrence et al., 2015b).

For food choice, we found that avoidance training led to reduced choice for unhealthy food. Specifically, participants who were trained to avoid unhealthy food were more likely to choose a healthy snack than those in the control group. Thus, inducing an avoidance tendency away from unhealthy food cues appears to translate into individuals making a quick, healthy decision when both healthy and unhealthy snacks are presented. This result is consistent with previous studies in the eating domain (Fishbach & Shah, 2006; Becker et al., 2015, Study 1). One potential reason as to why this effect differs from our consumption result is that selecting a snack (particularly under time pressure) may be relatively spontaneous compared to food intake, which may be more conscious. Another possible reason is that the food choice task included both healthy and unhealthy snacks, while the taste test included only unhealthy snacks. Finally, it is important to consider that the AAT may train cognitive control, as well as the acquisition of automatic avoidance tendencies (Koch, Holland, & van Knippenberg, 2008), which could explain the individual effect of avoidance training on snack food choice.

The current findings can be understood in the context of dual-process models (Strack & Deutsch, 2004). Specifically, approach bias (one aspect of automatic processing) is proposed to contribute to unhealthy eating, while inhibitory control (one aspect of controlled processing) is necessary for the successful regulation of automatic responses in predicting behaviour. In support, the current study demonstrated that combining avoidance with control training had interactive effects on inducing a more negative implicit evaluation of unhealthy food. More generally, it is possible that the varying findings for the different outcome measures used here reflect different proportions of automatic and controlled processing.

The current study has some important practical implications for the use of a combined avoidance and control training intervention. The present sample comprised primarily healthy weight women. Stronger training effects may be expected for individuals who are likely to be most at risk in an environment with an abundance of cues for unhealthy food. In particular, overweight or obese individuals may be more likely to benefit as they have been shown to have both a stronger approach bias for unhealthy food (Havermans, Giesen, Houben & Jansen, 2011; Kemps & Tiggemann, 2015) and lower inhibitory control (Batterink, Yokum & Stice, 2010; Nederkoorn, Smulders, Havermans, & Jansen, 2006). On the other hand, it is possible that it may be more difficult to modify the stronger approach tendencies and reduced inhibitory control of such individuals. Another important practical consideration concerns the stimuli used during training. An intervention that promotes healthy eating by training people to approach healthy food cues (rather than avoid unhealthy food cues) and respond to healthy food cues (rather than inhibit responses to unhealthy food cues) may prove a more positive acceptable protocol (Becker & Ferentzi et al., 2015).

In conclusion, the current study demonstrated that a combined training procedure can be used to modify approach-avoidance tendencies and inhibitory control for unhealthy food, aspects of automatic and controlled processing, respectively. In addition, the combination of avoidance and control training was most effective at reducing implicit liking for unhealthy food. While the combined training did not reduce consumption of unhealthy food, avoidance training on its own did reduce unhealthy snack food choice. These findings support some key theoretical predictions of dual-process models and contribute to developing an understanding of the effectiveness of training aimed at changing cognitive processes underlying unhealthy eating. Future research could extend the current findings to interventions that are aimed at encouraging individuals with problematic eating behaviour to make healthier food choices.

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CHAPTER 7: STUDY 5

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 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. 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 /approach healthy food condition. Importantly, the effect of training on consumption was moderated by trait impulsivity. Participants high in impulsivity consumed a greater proportion of healthy snack food following the ‘avoid unhealthy/ 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.

Introduction

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, 2014). Excess body weight can lead to negative health consequences such as cancer, cardiovascular disease and diabetes (Must et al., 1999). 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 posit that health behaviours are determined by two types of processing: automatic and controlled (Strack & Deutsch, 2004). Automatic processing is fast, implicit, and effortless, while controlled processing is slower and involves conscious reflection based on long-term goals and personal standards. Moreover, automatic processing is thought to involve cognitive biases, such as an approach bias, which is the automatic tendency to reach out toward (i.e., approach) rather than move away from (i.e., avoid) attractive cues (e.g., a piece of chocolate cake) in the environment (Wiers, Gladwin, Hofmann, Salemink, & Ridderinkoff, 2013). The influence of automatic processes on behaviour is argued to be regulated by controlled processes; however, there exist individual differences in the ability to regulate automatic processing. For example, trait impulsivity, which refers to 'a general tendency to act without deliberation' may allow automatic processing of cues to exert a greater influence on behaviour due to poor self-regulatory control (Hofmann, Friese, & Wiers, 2008, p. 113). Indeed, research shows that impulsivity is associated with increased unhealthy food intake (Guerrieri, Nederkoorn, & Jansen, 2007; Nederkoorn, Braet, Van Eijs, Tanghe, & Jansen, 2006; Kakoschke, Kemps, & Tiggemman et al., 2015b).

Researchers have documented approach biases for a variety of appetitive substances, including alcohol (Wiers, Rinck, Kordts, Houben, & Strack, 2010), cigarettes (Wiers & Kuhn et al., 2013) and cannabis (Cousijn, Goudriaan, & Wiers, 2011). Furthermore, research shows that approach bias predicts increased consumption of alcohol (Wiers, Rinck, Dictus, & Van Den Wildenberg, 2009; Wiers et al., 2010) and cannabis (Cousijn et al., 2011). Similarly, in the eating domain, approach bias has been reliably demonstrated for a variety of unhealthy foods (Brignell, Griffiths, Bradley, & Mogg, 2009; Havermans, Giesen, Houben, & Jansen, 2011; Kemps & Tiggemann, 2015; Kemps, Tiggemann, Martin, & Elliott, 2013; Veenstra & de Jong; 2010). Importantly, approach bias for food has been shown to be linked to increased unhealthy food intake (Hofmann, Gschwendner, Wiers, Friese, & Schmitt, 2008; Kakoschke, Kemps, & Tiggemann, 2015a; Nederkoorn, Houben, Hofmann, Roefs, & Jansen, 2010). The evidence suggests that approach bias contributes to the consumption of appetitive substances.

Recently, researchers have begun to investigate whether approach bias for appetitive substances can be modified using a computerised cognitive training paradigm. In commonly used protocols such as the Approach-Avoidance Task (AAT), participants are instructed to respond to a picture based on an irrelevant feature (e.g., portrait or landscape orientation) by pushing or pulling a joystick. Responses are based on a feature of the picture, rather than its content, to ensure that the task captures automatic processing (Wiers & Gladwin et al., 2013). An avoidance of appetitive cues can be trained using a modified AAT, which manipulates the contingencies of target (appetitive) and control pictures. Specifically, target pictures are presented in a format that consistently requires them to be pushed (avoided) and control pictures in a format that consistently 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) is when the target and control pictures are approached and avoided with equal frequency.

Previous studies have shown that approach bias for appetitive cues can be modified by manipulating the contingencies of the AAT. Specifically, research shows that the AAT can be used to successfully reduce the 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, such training has been found to reduce subsequent consumption of alcohol (Wiers et al., 2010) and chocolate (Schumacher et al., 2016) in laboratory taste tests. A recent review of the literature concluded that approach bias modification is an effective intervention for reducing approach biases for unhealthy substances and 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 because there is no biological requirement to consume them. However, food is a substance that is essential for human survival; complete avoidance is not possible. Instead, a healthy diet is about developing the right balance between eating enough healthy food and avoiding eating too much unhealthy food. It may be that an approach bias modification protocol that simultaneously encourages the avoidance of unhealthy food and the approach of healthy food lends itself best to promoting a healthy diet. Moreover, interventions that not only discourage an unhealthy behaviour, but also promote a healthy one, are likely to be more attractive and acceptable to participants, an important consideration for cognitive bias modification tasks (Wiers et al., 2013).

A few studies have investigated the use of approach bias modification to promote healthy eating. In an early study, Fishbach and Shah (2006, Study 5) trained participants to approach healthy and avoid unhealthy food or alternatively, to approach unhealthy and avoid healthy food. They found that participants in the approach healthy/avoid unhealthy food condition subsequently made healthier snack choices. More recently, Dickson et al. (2016) compared approach healthy food/avoid chocolate training with approach chocolate/avoid healthy food training. Although approach bias was trained in the expected direction, there was no group difference in chocolate consumption. In another recent study, Maas, Keijers, Rinck, Tanis and Becker (2015) found that approach healthy/avoid unhealthy food training resulted in increased avoidance of unhealthy and approach of healthy food. However, they did not measure eating behaviour. Finally, Becker et al. (2015, Study 1) found no difference between approach healthy/avoid unhealthy food training and a control group (sham-training) in healthy snack choice. Thus, the evidence for approach bias modification of healthy eating is inconsistent.

One potential methodological explanation for the mixed findings lies in the particular comparison condition used. Similar to previous studies in the alcohol domain, 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 food/approach unhealthy food. In contrast, Becker et al. (2015), who did not obtain positive results, compared approach healthy/avoid unhealthy food training with a less extreme condition (i.e., sham-training). Thus, it may be that a more extreme comparison is necessary to obtain a significant difference in healthy eating. To date, no previous 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 of the approach bias and subsequent consumption, we included two further training 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 or not the training promotes successful regulation of approach bias in determining consumption behaviour. To date, no study has tested the potential moderating role of trait impulsivity in the effect of approach bias training on consumption. Here, we predicted that participants with higher levels of impulsivity would show greater benefit from the training because automatic processes likely play a more important role for individuals who tend to have difficulty with self-regulatory control.

In sum, the main aim of the study was to investigate whether approach bias for both healthy food and unhealthy food can be re-trained using approach bias modification, 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 have a greater increase in approach bias for healthy food and 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 expected that participants trained to approach healthy food and avoid unhealthy food would consume the greatest proportion of healthy rather than unhealthy snack food. The second aim was to investigate the potential moderating role of trait impulsivity. Specifically, it was predicted that training effects would be greater for highly impulsive individuals.

Method

Participants

A total of 200 women were recruited from the undergraduate student population at Flinders University. They were aged 17 to 26 years (*M* = 20.16, *SD* = 2.24) and had a mean body mass index of 23.12 kg/m^2 (*SD* = 4.83), which is classified as being within the healthy weight range (i.e., 18.5–24.9 kg/m^2). 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 Weirs et al. (2010), the Approach-Avoidance Task was adapted to measure and modify approach bias for healthy food and unhealthy food. 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. 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 and unhealthy food, and animal categories did not significantly differ on mean ratings of pleasure and arousal (all ps >.05). 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.

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

Table 1

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

	Contingencies	
Approach-Avoidance Training Condition	**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

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. An overall measure which included healthy and unhealthy food was calculated as the proportion of healthy food consumed relative to 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 impulsivity aspects such as 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 ranging from 1 = ‘rarely/ never’ to 4 = ‘almost always/always’. Scores are summed to provide a total score, with scores of 72 or above indicating high impulsivity (Stanford et al., 2009). In the current study, 49 participants were classified as highly impulsive and 151 were classified as low. 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 (α = .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 eta^2 (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 standard protocols (e.g., Wiers et al., 2010), incorrect responses and extreme reaction times (i.e., <300ms or >3000 ms) were removed. Individual reaction times that were more than 2.5 *SD* from the mean were identified as outliers and were changed to plus or minus one unit from the first non-outlier (Tabachnick & Fidell, 1989).

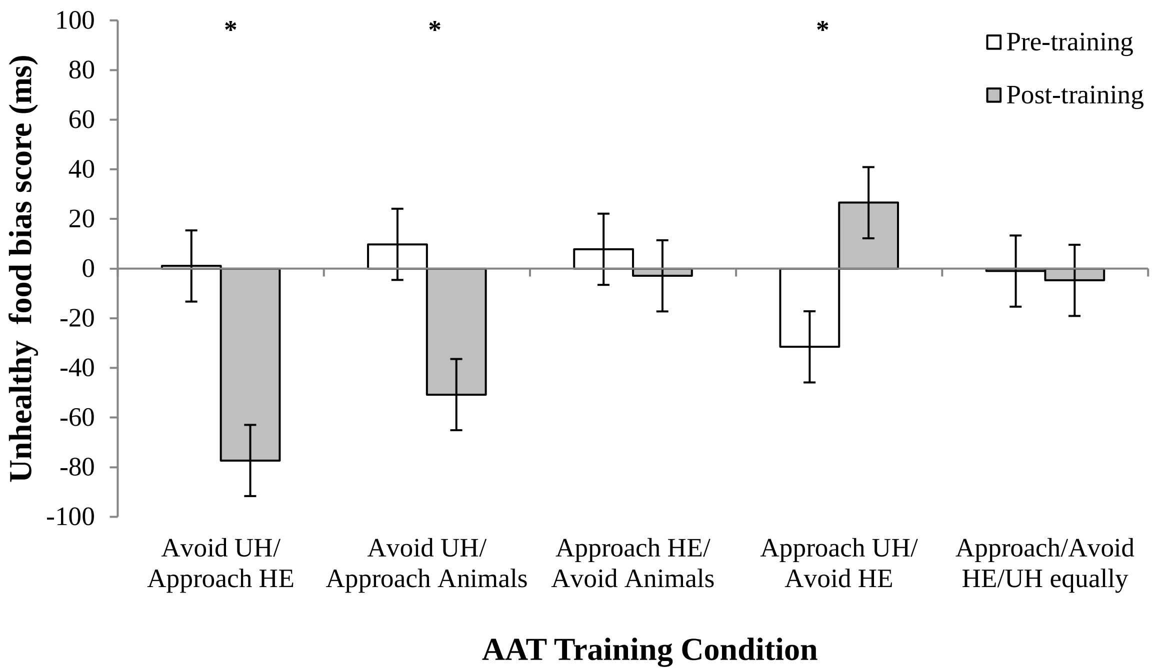
Changes in approach bias scores were assessed using a 5 (AAT condition: avoid unhealthy/approach healthy food, avoid unhealthy food/ approach animals, approach healthy/ avoid animals, approach unhealthy/avoid healthy food, approach/avoid healthy/unhealthy food equally) x 2 (picture: healthy food, unhealthy food) x 2 (time: pre-training, post-training) mixed model ANOVA. Results revealed significant condition x picture, $F(1, 195) = 10.05$, $p < .001$, $\eta^2 = .170$, and picture x time interactions, $F(1, 195) = 5.52$, $p = .020$, $\eta^2 = .028$. Importantly, there was a significant condition x picture x time interaction, $F(1, 195) = 9.032$, $p < .001$, $\eta^2 = .156$.

The nature of the three-way interaction was further examined using separate pairwise comparisons for healthy and unhealthy food 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,

$F(1,195) = 16.48$, $p < .001$, $\eta^2 = .078$, and in the avoid unhealthy food/approach animals condition, $F(1, 195) = 9.84$, $p = .002$, $\eta^2 = .048$. In addition, approach bias for unhealthy food significantly increased in the approach unhealthy/avoid healthy food condition, $F(1, 148) = 9.06$, $p = .003$, $\eta^2 = .044$. 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, $F(1,195) = 4.47$, $p = .036$, $\eta^2 = .022$. Approach bias for healthy food also trended toward a decrease from pre- to post-training in the approach unhealthy/avoid healthy food condition, $F(1,195) = 3.31$, $p = 0.70$, $\eta^2 = .017$. 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.

(a) Unhealthy Food



(b) Healthy Food

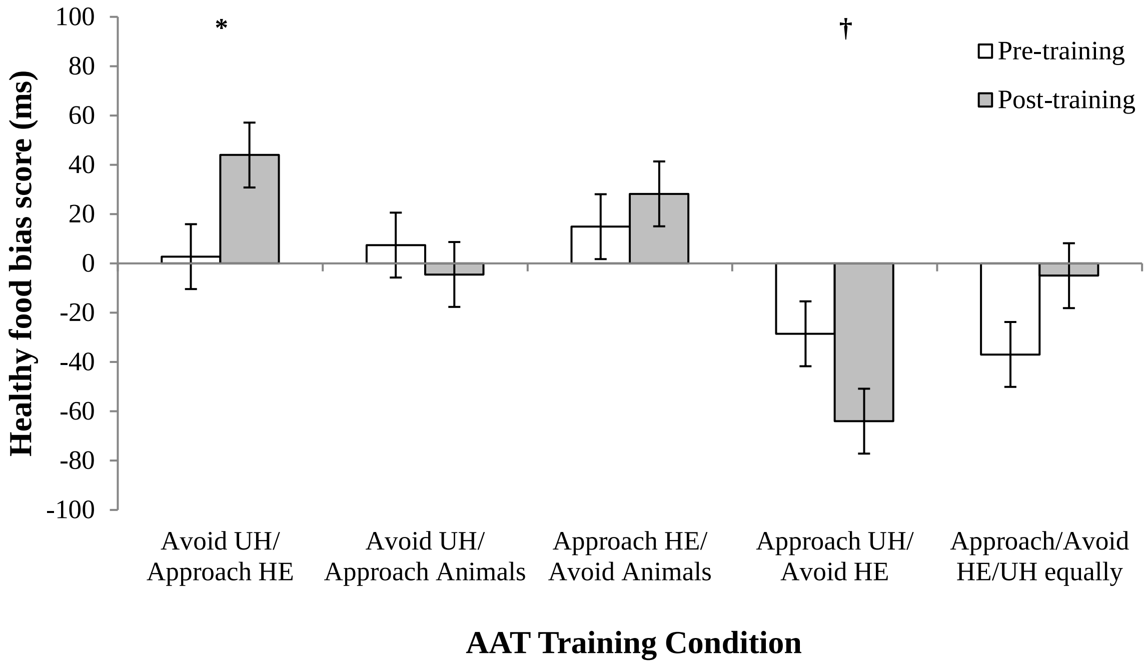


Fig 1. Mean approach bias scores (with 95% confidence intervals [CI]) for AAT training condition at pre- and post-training for (a) unhealthy and (b) healthy food. Within-subjects 95% CIs were calculated using formulae from Masson and Loftus (2003). $^{*}p < .05$, $^{\dagger}p = .07$.

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 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).

Table 2

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

	Proportion of Healthy Food Consumed	
Approach-Avoidance Training Condition	**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

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, $F(1, 190) = .091$, $p = .764$, $\eta^2 = .001$, nor any interactions involving impulsivity (all p's >.10). 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 indicates that the effect of the training on the relative amount of healthy food consumed was found only in participants with high impulsivity.

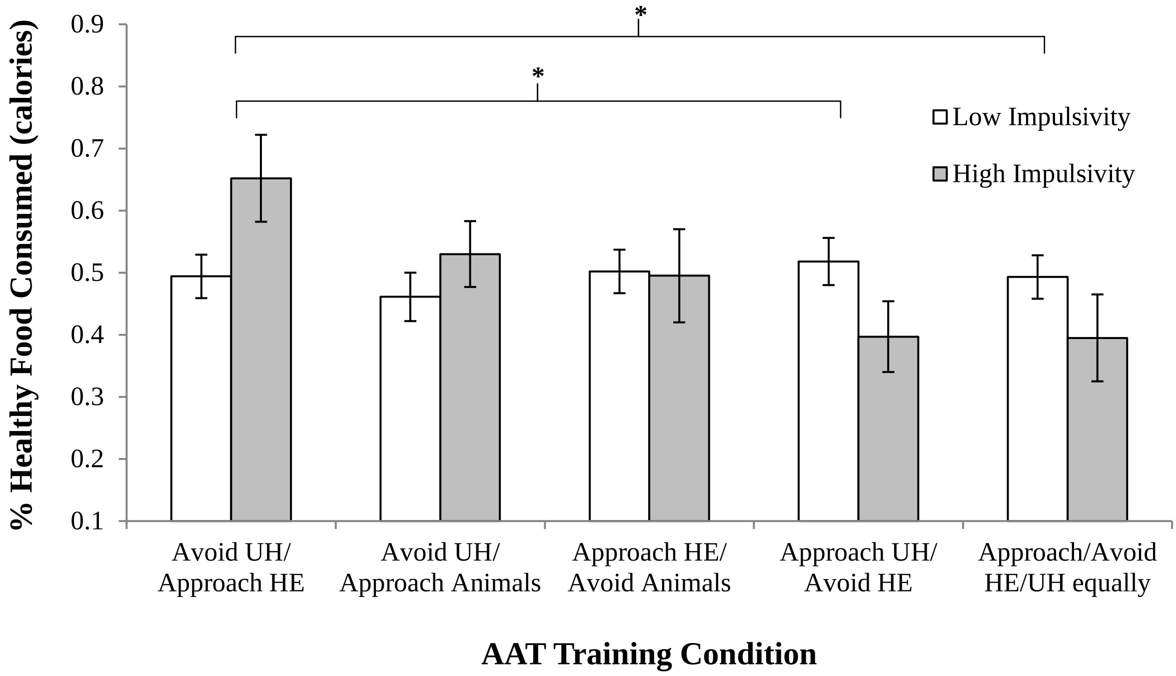


Fig. 2. Proportion of healthy food consumption in calories (with standard error bars) as a function of AAT training condition and trait impulsivity. $*p < .05$

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 ‘avoid unhealthy’ components are needed to increase approach bias for healthy food, whereas only the ‘avoid unhealthy’ component is needed to produce an avoidance of unhealthy food. More generally, it is evident that the control comparison condition chosen (‘avoid healthy/approach unhealthy’ or ‘sham’ training) is important in evaluating the effectiveness of approach training for healthy food.

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 food over an unhealthy one than those trained to avoid healthy food. However, our finding is consistent with some previous studies that likewise found no benefit for eating behaviour (Becker et al., 2015, Study 1; Dickson et al., 2016).

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. 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 expected, 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 are consistent with the idea that impulsivity affects behaviour, rather than automatic processing. The result also suggests that interventions that target approach bias for food may only be effective at changing subsequent consumption for highly impulsive individuals. Thus, future studies should examine the effect of training on consumption 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 eating behaviour is determined by both automatic and self-regulatory control processes. 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 more likely to be guided by automatic processes when self-regulatory control of impulsive responses is poor (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 high on impulsivity, for example, overweight and obese people, who tend to be more impulsive than normal-weight people (Nederkoorn et al., 2006; Nederkoorn et al., 2006; Kakoschke, Kemps, & Tiggemann, 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.

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 behaviours driven by impulsivity.

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CHAPTER 8: GENERAL DISCUSSION

Chapter Overview

As outlined in Chapter 1, the thesis had two primary aims. The first was to investigate how automatic processing interacts with self-regulatory control or trait eating style in order to obtain a better understanding of these constructs in the context of unhealthy eating behaviour. The second aim was to assess whether intervention strategies aimed at modifying automatic and/or controlled processing are effective for discouraging unhealthy eating behaviour, and also for encouraging healthier eating. Five empirical studies and one literature review were conducted, each with their own specific aims but drawn from the overarching aims of this thesis. This final chapter aims to provide an integrated discussion of the main findings. First, a brief summary of the findings is provided. Next, theoretical and practical implications are discussed. Finally, methodological issues and directions for future research are considered.

Summary of Findings

Studies 1, 2 and 3 addressed the first aim, namely to develop an understanding of unhealthy eating behaviour by investigating possible underlying mechanisms, in particular, automatic processing in conjunction with self-regulatory control or trait eating style. Study 1 aimed to address one of the key theoretical predictions of recent dual-process models by empirically investigating the combined effects of automatic (attentional and approach bias) and controlled (inhibitory control) processing on consumption of unhealthy food. The study demonstrated attentional and approach biases for unhealthy food cues, but neither predicted consumption. Importantly, approach bias, but not attentional bias, was found to interact with inhibitory control in predicting increased consumption; participants who showed a stronger approach bias for food combined with low inhibitory control consumed the most snack food.

Study 2 turned to address the affective component of automatic processing by testing implicit evaluation of unhealthy food on unhealthy eating behaviour. The findings showed that there was an interaction between implicit evaluation of unhealthy food and emotional eating style. Specifically, a positive implicit food evaluation (increased liking) predicted increased choice for unhealthy snack food in participants with lower emotional eating.

Study 3 then investigated the combined effect of approach bias for food and eating style on unhealthy food consumption in normal weight and overweight individuals using a pooled sample from Study 1 and the control groups of Studies 4 and 5. Among overweight participants, an external and emotional eating style individually moderated the relationship between approach bias for unhealthy food and subsequent food consumption, such that approach bias was positively related to consumption in high external or emotional eaters, but negatively related in low external or emotional eaters. These interactions were not observed among normal weight participants.

These studies, as a set, contribute to a theoretical understanding of how automatic and controlled processing interact in predicting unhealthy eating behaviour (Study 1), and in what way eating styles moderate the influence of both the affective (Study 2) and cognitive (Study 3) components of automatic processing to determine such behaviour. In general, the findings support the role of automatic processing of unhealthy food cues and help to determine when, and for whom, automatic processing can influence unhealthy eating behaviour.

Studies 4 and 5 addressed the second aim of the thesis, which was to examine whether interventions designed to modify automatic processing and/or self-regulatory control can reduce unhealthy eating behaviour and/or promote healthier eating. These were preceded by a literature review on the effectiveness of approach bias modification as an intervention for reducing the consumption of appetitive substances in general (i.e., alcohol, cigarettes, and unhealthy food). The review concluded that approach bias re-training generally had positive effects on behaviour, including reduced consumption in the laboratory, lower relapse rates, and improvements in self-reported measures (e.g., craving). Importantly, all reviewed studies (with one exception) that reported a favourable outcome for consumption also showed a successful reduction of approach bias for appetitive cues. Effects were most consistent in the alcohol domain and more varied in the eating domain. In general, the review concluded that it is important for future research to determine how approach bias re-training can be improved.

Study 4 experimentally examined the effectiveness of approach bias re-training for unhealthy food cues and/or strengthening inhibitory control for reducing unhealthy eating behaviour. Although the combined re-training of approach bias along with inhibitory control was more effective than either training task alone for reducing implicit evaluation (liking) of unhealthy food, no significant training effects were found for unhealthy food consumption. Nevertheless, approach bias re-training was effective for reducing unhealthy snack food choice. Study 5 aimed to extend the use of approach bias re-training to the domain of healthy eating by modifying approach biases for both unhealthy and healthy food simultaneously, and examining effects on subsequent food consumption. It was found that the effect of training on consumption was moderated by trait impulsivity, such that only highly impulsive participants consumed a greater proportion of healthy snack food following training.

As a set, these latter studies show that re-training automatic approach biases may be an effective intervention for reducing unhealthy eating behaviour (Study 4) and encouraging healthier eating (Study 5). However, approach bias modification for food may be particularly useful for some individuals, such as those with poor trait self-regulatory control (Study 5).

Theoretical Implications

The present thesis contributes to the relatively small amount of research that has been conducted on automatic processing in the context of unhealthy eating behaviour. The studies focused on examining approach bias for appetitive food cues. In particular, the current studies show that both normal weight (Study 1) and overweight individuals (Study 3) are faster to approach than avoid unhealthy food cues. Thus, appetitive food cues do appear to elicit fast, implicit responses by way of approaching (moving toward) such cues, which suggests that automatic approach tendencies may be a useful construct to examine in regard to unhealthy eating behaviour. Automatically approaching unhealthy food may be particularly problematic in the current environment, where appetitive, high-calorie food and related cues are abundant due to the ready availability of fast food and the prevalence of advertisements for such food.

Although approach bias toward unhealthy food cues alone was not associated with increased consumption, Studies 1, 2 and 3 also investigated when, and for whom, approach bias is likely to influence unhealthy eating behaviour. The findings from Study 1 provide empirical support for the suggestion that approach bias for unhealthy food cues only influences eating behaviour in combination with low inhibitory control over responses to such cues. A similar finding was demonstrated in one recently published study that found an interaction between an aspect of automatic processing (positive implicit evaluation) and self-regulatory control in a related domain, namely soft drink consumption (Eschenbeck, Heim-Dreger, Steinhilber, & Kohlmann, 2016). Taken together, these findings show that stronger automatic processing and weaker controlled processing are implicated in the consumption of appetitive substances. The results offer strong support for the main premise of dual-process models, which posit that our behaviour is guided by an interplay between these two different types of information processing (Strack & Deutsch, 2004).

An important point highlighted by the findings from Studies 2 and 3 is that automatic processing can also be influenced by other factors, such as trait eating style. Study 2 showed that the affective aspect of automatic processing (implicit evaluation of unhealthy food) was positively related to choosing an unhealthy snack food in low emotional eaters. While this might appear counterintuitive, it is not entirely surprising as implicit evaluation (increased liking) reflects an association between food and *positive* affect, while the emotional eating measure (DEBQ) assesses a tendency to eat in response to *negative* affect. Contrasting results were found in Study 3, which examined a different aspect of automatic processing, namely approach bias. For normal weight individuals, no combined effects were found. However, for overweight individuals, approach bias for unhealthy food cues was related to consumption of unhealthy snack food in high emotional eaters. The finding that the direction of the effect of an emotional eating style on behaviour varied across the two studies suggests that there are differences between the affective (as measured by implicit evaluation) and cognitive (as measured by approach bias) components of automatic processing of unhealthy food cues.

The results of Study 3 also showed that another eating style was important, namely an external eating style. Among overweight individuals, approach bias for unhealthy food cues interacted with external eating in predicting unhealthy snack food consumption. Although approach bias and external eating style are two distinct variables, it has been suggested that automatic approach bias and individual differences in the tendency to eat in response to external food-related cues might both involve aspects of the same underlying construct, namely a heightened sensitivity to reward (Brignell, Griffiths, Bradley, & Mogg, 2009). Future research could investigate whether approach bias for food and external eating are a function of sensitivity to reward in general to clarify the constructs underlying automatic processes and eating style that can lead to overeating and weight gain.

The above studies have demonstrated that aspects of automatic processing together with self-regulatory control or eating style interact in predicting unhealthy eating behaviour. However, it is important to remember that the scope of the studies presented in the current thesis was limited to investigating particular components of automatic processing and self-regulatory control as well as specific types of trait eating styles. In regards to automatic processing, the studies only examined cognitive bias (attentional and approach) and implicit evaluation. Other potential aspects of automatic processing include a bias in memory. Future studies could investigate the role of memory bias for food cues in eating behaviour. In terms of controlled processing, inhibitory control and trait impulsivity were examined in the current studies. Future research could determine whether other aspects of controlled processing, such as working memory capacity and sensation seeking, also predict unhealthy eating behaviour in combination with automatic processing. Finally, the eating styles considered in the current studies, namely, restrained, emotional and external eating as measured by the DEBQ, are the most commonly researched. Future studies could assess other eating styles (e.g., disinhibited eating) as measured by other scales (e.g., the Three-Factor Eating Questionnaire; Stunkard & Messick, 1985).

The findings of Studies 1, 2, and 3 highlight the importance of examining the combination of automatic and controlled processing on unhealthy eating behaviour. However, as the studies were correlational in nature, the causal direction of relationships cannot be established. The laboratory measure of snack food consumption provides only one behavioural incidence of unhealthy eating behaviour. So it is possible, for example, that approach bias for food and low inhibitory control may be correlates or consequences, rather than predictors (as is posited in the current studies), of unhealthy eating behaviour. Only experimental studies that actually manipulate these constructs can determine the causal direction of the relationship between cognitive processes and unhealthy eating behaviour. Indeed, in Studies 4 and 5, approach bias and inhibitory control were experimentally manipulated to assess subsequent effects on food consumption.

Practical Implications

Studies 4 and 5 were geared toward addressing the second aim of the thesis, which was to determine whether interventions targeting the modification of automatic processing and/or self-regulatory control are effective for reducing unhealthy eating, but also promoting healthier eating. Given the negative consequences of unhealthy eating behaviour, including weight gain, it is important to not only be able to predict, but also to modify such behaviour.

The literature review (Chapter 5) showed that the effect of approach bias modification was stronger in clinical samples (with higher levels of substance dependence) than in unselected samples. It seems likely that individuals in unselected samples are less motivated to change their appetitive consumption behaviour. The studies in the eating domain used mostly unselected samples and also showed greater variability than those in the alcohol domain in the effect of training on consumption. If the finding that training was most effective for alcohol dependent clinical samples generalises to the eating domain, then we might expect approach bias modification to be more effective for people with problematic eating, such as overweight or obese individuals.

Dual-process models suggest that one way to improve approach bias modification is to also modify self-regulatory control along with automatic processing. Study 4 tested this prediction experimentally and found that the effectiveness of the combined training depended upon the outcome measure that was considered. Specifically, combining the two training tasks induced a more negative implicit evaluation of unhealthy food, but did not influence food consumption. Approach-avoidance training reduced choice for unhealthy snack food. These findings can partly be explained by the suggestion that eating behaviour varies in terms of the degree of automatic and controlled processing involved. Specifically, single acts of eating behaviour may be more a function of automatic processing than continuous types of eating behaviour (Friese, Hofmann, & Wänke, 2008). In relation to the findings of Study 4, implicit evaluation of food is proposed to be an entirely automatic process. In contrast, choosing an unhealthy snack food represents a single act of eating behaviour under time pressure, and is likely to involve more automatic processing, but might also involve some degree of control. Finally, consumption of snack food during a taste test likely reflects a continuous measure of eating behaviour that involves both automatic and controlled processing (consistent with the results of Study 1).

Although the combined training did not have the predicted effect on consumption, it would be premature to conclude that the results of Study 4 do not support the key theoretical predictions of recent dual-process models. The major conclusion of the review on approach bias modification (Chapter 5) was that the mechanism underlying change in appetitive behaviour is a reduction in approach bias. Similarly, a recent review of attentional bias modification for anxiety emphasised the importance of distinguishing between the underlying process and the procedures aimed at modifying the process (MacLeod & Grafton, 2016). The main conclusion was that if the process has not been successfully modified, then a change in subsequent behaviour is not to be expected. The same principle applies to other types of cognitive modification tasks, such as inhibitory control training. Importantly, the go/no-go task that was used in Study 4 did not appear to effectively modify inhibitory control, as evidenced by the lack of difference in commission errors for food between conditions, and so no effect of the combined training on consumption could really be expected.

Study 5 aimed to address one of the suggestions made in the review on approach bias modification, namely to examine the possibility of not only training avoidance of unhealthy food, but also training approach toward healthy food. The study showed that simultaneously reducing approach bias for unhealthy food cues and increasing approach bias for healthy food resulted in a greater proportion of healthy food consumption, but only for individuals with higher trait impulsivity. Importantly, the finding that impulsivity moderates the effect of approach bias modification on the proportion of healthy food consumed suggests that interventions that aim to modify approach bias for food to improve eating behaviour might be most beneficial for individuals with poor trait self-regulatory control. Given the variable success of approach bias modification on consumption in the eating domain, as illustrated in the literature review, future research should examine whether such interventions are more effective when targeted at individuals with higher trait impulsivity.

In addition, Study 5 found that the most effective training protocol for modifying approach bias differed depending on the type of food stimuli used (healthy or unhealthy). Specifically, the effect of training on approach bias for unhealthy food was due to the 'avoid unhealthy' component, rather than the 'approach healthy' component. In contrast, the effect of training on approach bias for healthy food was due to a combination of both. Importantly, the finding that it is easier to train avoidance of unhealthy food than approach toward healthy food suggests that the 'avoid unhealthy' component may be the critical aspect of the training.

As a set, Studies 4 and 5 provide additional insight into the somewhat inconsistent findings for empirical studies using interventions aimed at modifying automatic processing underlying unhealthy consumption. Here approach bias modification was effective for re-training approach bias, but this did not translate to an effect on consumption across the whole sample (Study 4) or did so, but only for a particular sub-sample of the participants (Study 5). These findings are in contrast to the conclusion of the review that avoidance-training was effective at reducing consumption when approach bias for appetitive cues was successfully reduced. However, the findings are consistent with the logic of dual-process models (Strack & Deustch, 2004), which propose that approach bias should only translate to an effect on consumption behaviour when inhibitory control is low. In fact, the participants in the current intervention studies had relatively good inhibitory control. Study 5 showed that training had more positive effects on consumption in highly impulsive individuals, which suggests that approach bias re-training is more likely to be beneficial for individuals with poor trait self-regulatory control. Further investigation is warranted to determine whether individuals with deficits in other aspects of self-regulatory control, such as sensation seeking, are more likely to benefit from approach bias modification in the eating domain.

The studies presented here contribute to emerging evidence for the role of biased automatic processing in unhealthy eating behaviour. In particular, investigating the interplay between approach bias for food with self-regulatory control and trait eating style identified some of the boundary conditions and different types of individuals for which approach bias is likely to predict unhealthy eating behaviour. Importantly, the findings point toward promising interventions for reducing unhealthy food consumption.

Methodological Issues and Future Directions

The series of studies were all conducted in the laboratory using unselected samples of undergraduate students. While these studies provided a better understanding of the processes that contribute to unhealthy eating behaviour in mostly normal weight people, this limits the ability to generalise the findings to clinical samples, including individuals with problematic eating behaviour. While we did not specifically aim to recruit overweight and obese people, participants from three of these studies were pooled so that normal weight and overweight individuals could be compared in Study 3. Importantly, there were differences between the two weight groups in the combination of approach bias for food and trait eating styles on snack food consumption. Future studies could analyse sub-groups in unselected samples to determine whether the findings might differ depending on the weight status of participants.

Future research should aim to generalise the current findings to a clinical sample, such as overweight or obese individuals, given that they have a stronger approach bias for unhealthy food and lower inhibitory control, are more impulsive, and have higher levels of trait external and emotional eating. Elucidating the predictors of unhealthy eating behaviour in overweight and obese people is crucial given the importance of developing interventions to reduce overeating in this population. Another reason for using an overweight or obese sample is that these individuals might be more likely to have motivation or a desire to change their eating behaviour. The literature review on approach bias modification suggests that a change in consumption behaviour occurs more readily in clinical samples, particularly in the alcohol domain. It is likely that approach bias re-training will also be more effective for modifying behaviour in clinical samples in the eating domain. Future studies could recruit individuals who would be motivated to eat more healthily and/or lose weight due to health-related goals.

The studies (4 and 5) in the current thesis that modified automatic processing and/or self-regulatory control used a single-training session, which may not be sufficiently intensive for an immediate effect on consumption. It is likely that more training is necessary to change a complex behaviour such as unhealthy eating that has presumably developed over time. The studies in the alcohol domain that did find positive effects of training on behaviour, such as reduced relapse rates one year later, used multiple training sessions (e.g., Eberl et al., 2013; Wiers et al., 2011). Therefore, it is likely the case that utilising multiple sessions of approach bias re-training would also be more effective for modifying behaviour in the eating domain. Future studies should aim to determine how many training sessions are required to establish an immediate effect on consumption, but research could also usefully explore the longevity of these training effects following multiple sessions conducted over a longer period of time.

Another important issue to consider is the control condition chosen for comparison in training protocols. While some studies compare an ‘avoid unhealthy’ training condition with an ‘approach unhealthy’ training condition (an extreme comparison as these two conditions manipulate approach bias in opposite directions), others compare ‘avoid unhealthy’ training with a ‘sham-training’ control condition (a less extreme comparison). The latter comparison was used in Study 4, while Study 5 was the first study to compare all three conditions (‘avoid unhealthy’, ‘approach unhealthy’, ‘sham-training’). Study 5 found that an ‘avoid unhealthy’ condition was more likely to show a positive effect of training in comparison to an ‘approach unhealthy’ condition, but not the ‘sham-training’ condition, which suggests that the control comparison condition affected the evaluation of training effects. This finding is consistent with one recent study on inhibitory control training demonstrating that a ‘no-go unhealthy’ training condition was more likely to show a positive effect of training in comparison to ‘go unhealthy' training but not a control condition in which 'go' and 'no-go' responses were not manipulated (Adams, Lawrence, Verbruggen & Chambers, 2017). Taken together, the results suggest that studies using a more extreme control comparison condition might be more likely to demonstrate an effect of the intervention. Indeed, a recent review on a number of different cognitive modification tasks for food suggested that the type of control condition used might explain inconsistent findings in the eating domain (Stice, Lawrence, Kemps & Veling, 2016).

Another methodological issue relates to the timing of the measurement of approach bias in the training studies. Specifically, in Study 5 approach biases for healthy and unhealthy food cues were measured using an assessment version of the Approach-Avoidance task after the training phase. It is possible that this measurement might weaken the effect of training on subsequent behavioural measures, including the taste test. Study 4 addressed this issue by not measuring the bias after training, but this has the problem that approach bias is not measured. Other studies have assessed approach bias after the behavioural measure (Becker, Jostmann, Wiers, & Holland, 2015). However, it is possible that the behavioural measure may influence approach bias. Some other recent studies have included a booster session of training after the measurement of approach bias to reinforce learning of the trained contingencies and to ensure that the effectiveness of training was not weakened by the measurement (Becker et al., 2016; Lindgren et al., 2015; Mass, Jeijsers, Rinck, Tanis, & Becker, 2015), although these studies have produced mixed effects. Future intervention studies could aim to explicitly examine the timing of approach bias measurement.

A more general methodological issue is that all of the empirical studies in the current thesis (correlational and experimental) were conducted in a laboratory setting. Research done in the laboratory does enable control over several variables that are likely to influence eating behaviour. For example, food consumption was assessed with a standarised taste test across all of the studies. The snacks were presented in equal portion sizes and the participants were given the same instructions, questionnaires, and time to complete the taste test. Additionally, using an objective measure of eating behaviour, rather than relying on self-report, is likely to minimise several issues such as demand effects, social desirability, and inaccurate reporting of eating behaviour. However, a number of limitations can arise from conducting research in a standardised situation. For example, the taste test may not provide an accurate portrayal of how people usually eat. Indeed, research suggests that awareness of eating behaviour being monitored in a laboratory setting may reduce the amount of food that people eat (Robinson, Kersbergen, Brunstrom, & Field, 2014). In addition, food consumption in the current studies was assessed at only one specific time point. Measuring eating behaviour over different time points would allow for a more reliable representation of eating behaviour.

Despite the above limitations, the two experiments in the current thesis were able to manipulate automatic and controlled processing so that casual effects on eating behaviour could be established. Future research could usefully aim to determine whether approach bias modification has real-world benefits among individuals for whom unhealthy eating behaviour is a problem, such as overweight or obese people. In addition, future studies should examine the implementation of approach bias re-training tasks outside the laboratory setting through the use of novel delivery methods. Cognitive training tasks may be particularly suitable for development as online or mobile-based interventions given that they are computerised tasks with relatively simple instructions for participants (van Deursen, Salemink, Smit, Kramer & Wiers, 2013; Wiers, Gladwin, Hofmann, Salemink, & Ridderinkhof, 2013). Future research could endeavour to deliver approach bias re-training through an application designed for use with a smartphone so that training can be completed as it is required in real-world situations.

Conclusion

The current thesis addressed an important, but often overlooked, contributor to unhealthy eating behaviour, namely, automatic approach bias for unhealthy food cues. In particular, the empirical studies investigated the role of automatic processing in conjunction with self-regulatory control and trait eating style to foster a better understanding of unhealthy eating behaviour. The work presented here illustrates the complexity of the inter-relationships between these constructs. Theoretically, the findings support recent dual-process models by demonstrating that unhealthy eating behaviour is determined by a combination of automatic and controlled processing. In a practical sense, the findings suggest that interventions aimed at modifying approach bias for food cues may be effective for discouraging unhealthy eating and promoting healthier eating behaviour. Future research should usefully develop approach bias modification as a technique for reducing unhealthy eating behaviour in clinical samples.

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