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CAN WE BE TRAINED TO EAT HEALTHY?

THE EFFECTS OF AN ATTENTIONAL BIAS MODIFICATION PROGRAM

ON EATING BEHAVIOR

A DISSERTATION IN
Psychology

Presented to the Faculty of the University
of Missouri-Kansas City in partial fulfillment of
the requirements for the degree

DOCTOR OF PHILOSOPHY

by
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University of Missouri-Kansas City, 2018

ABSTRACT

The prevalence of overweight (OW) and obesity (OB) has significantly increased over the past four decades. OW and OB are complex in nature and arise from a multitude of factors and their interactive effects. Based on etiological models of OW and OB, interventions to reduce excess body weight have been developed, including population- and individual-level approaches. Current interventions are limited, however, in that they lack focus on how environmental factors (e.g., food cues) interact with biology (e.g., neural reward systems) to influence individual health-related behaviors (e.g., food consumption) through mechanisms such as attentional bias. Attentional bias modification (ABM) programs have been developed to train individuals to either attend to or avoid certain food cues in the environment, yet research in this area is underdeveloped. The purpose of this dissertation was to evaluate the effect of a single-session ABM training designed to promote healthy eating on eating behavior as a potential intervention that targets an individual's response to the obesogenic environment. This dissertation addressed the limitations of previous ABM studies in that it examined differential effects of the program on attention to food cues and eating behavior among individuals with varying body mass indices (i.e., healthy weight vs. OW/OB).

APPROVAL PAGE

The faculty listed below, appointed by the Dean of the College of Arts and Sciences, have examined a dissertation titled "Can We Be Trained to Eat Healthy? The Effects of an Attentional Bias Modification Program on Eating Behavior," presented by Ashleigh A. Pona, candidate for the Doctor of Philosophy degree, and certify that in their opinion it is worthy of acceptance.

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CONTENTS

ILLUSTRATIONS

Figure Page

TABLES

Table Page

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CHAPTER 1

INTRODUCTION

Definition of Overweight and Obesity

Overweight (OW) and obesity (OB) are characterized by an excess of adipose tissue. OW is defined as a body mass index (BMI) of 25 to 29.9 kg/m^2 and OB as a BMI of greater than or equal to 30 kg/m^2 (National Institutes of Health, 1998). Degree of OB can further be broken down into three classes: class I OB is defined as a BMI of 30 to 34.9 kg/m^2, class II OB as a BMI of 35 to 39.9 kg/m^2, and class III OB as a BMI of greater than or equal to 40 kg/m^2 (National Institutes of Health, 1998).

Morbidity and Mortality of OW and OB

OW and OB are associated with numerous health risks and are among the most significant contributors to poor health (Kopelman, 2007). For example, increasing BMI raises the risk of morbidity from health conditions including hypertension (Re, 2009), type 2 diabetes (Eckel et al., 2011), coronary artery disease (Eckel & Krauss, 1998), stroke (Guh et al., 2009), metabolic syndrome (Ginsberg & MacCallum, 2009), liver and gall bladder disease (Stinton & Shaffer, 2012), and cancer (Hursting, Nunez, Varticovski, & Vinson, 2007). Weight-related health comorbidities can also reduce the life expectancy of a person who is OW or OB, and these hazard rates can differ based on BMI category, age, sex, race, and tobacco use (Finkelstein, Brown, Wrage, Allaire, & Hoerger, 2009). For example, Finkelstein and colleagues (2009) reported the years of life lost among 18-year-olds in class II OB to range from 1 (for black females who never smoked) to 5 (for white females who currently smoke), and among 18-year-olds in class III OB to range from 5 (for black females who never smoked) to 12 (for white males who currently smoke). Weight-related health comorbidities that have been associated with premature deaths include heart disease, cancer, and type 2 diabetes (Finkelstein et al., 2009; Kitahara et al., 2014).

Prevalence and Prevalence Trends of OW and OB

The prevalence of OW and OB is also extremely high across stages of the lifespan, and tends to increase with age. Data from the National Health and Nutrition Examination Survey in 2011-2014 indicated that OB occurs among 8.9% of children aged 2-5 years, 17.5% of children aged 6-11 years, 20.5% of adolescents aged 12-19 years, and 36.3% of adults aged 20 years and older in the United States (US) (Ogden, Carroll, Fryar, & Flegal, 2015). Temporal trends have also been identified with regard to changes in OW and OB rates in the US. Between the years of 1960 and 1980, there was very little change in OB prevalence; however, significant changes started to appear after 1980. Flegal and colleagues (Flegal, Kuczmarski, & Johnson, 1998) reported increases in prevalence rates for all BMI categories between the years of 1980 and 1994, which included increases of 31.7% to 32.6% for OW, 10.2% to 14.4% for class I OB, 3.2% to 5.1% for class II OB, and 1.3% to 2.8% for class III OB. Kucsmarski and colleagues (Kuczmarski, Flegal, Campbell, & Johnson, 1994) also reported a significant increase in OW and OB among adult men and women between 1980 and 1994, which increased from 25.4% to 33.3%. Between 2000 and 2005, these trends continued to increase for men, but not for women (Flegal, Kruszon-Moran, Carroll, Fryar, & Ogden, 2016). Between 2005 and present, however, there have been significant linear increases in overall OB and class III OB for women, but no significant trends have been identified for men (Flegal et al., 2016).

Collectively, these findings show that there have been significant increases in OW and OB over the past four decades. Although further research is warranted to determine the exact reasons for these trends, we do know that there have been no documented biological population changes to account for the increase in OW and OB prevalence. As such, the environment and its interactive effects have been considered as a contributing factor that may be related to the temporal rise in OW and OB. Notwithstanding, given the numerous health risks associated with these conditions, targeting their increasing prevalence rates has become a public health priority (US Department of Health and Human Services, 2010). In order to work towards the prevention and treatment of OW and OB, it is important to understand what factors contribute to the development of these conditions.

Factors Contributing to the Development of OW and OB

On a fundamental level, the cause of OW and OB is linked to an imbalance of energy intake vs. energy expenditure. In other words, when a person takes in more calories than they lose via metabolic and physical activity, they are likely to gain weight (Wright & Aronne, 2012). It is now evident, however, that OW and OB are more complex in nature and arise from a multitude of factors and their interactive effects (US Department of Agriculture and US Department of Health and Human Services, 2010). Potential contributing factors in the development and maintenance of OW and OB are reviewed below.

Genetic and Hormonal Factors

Research on the behavioral genetics of OW and OB has examined the heritability of BMI through twin, adoption, and family studies. The behavioral genetic basis of OW and OB does not only apply to the heritability of body weight, but also to a number of genetically determined behaviors that can affect body weight, including ingestion, absorption, metabolism, and energy expenditure (Hinney, Vogel, & Hebebrand, 2010). Studies have shown that OW and OB run in families and are better determined by genetic vs. environmental factors (Maes, Neale, & Eaves, 1997). More specifically, the within-population variation in BMI at all ages can primarily be explained by genetic differences between individuals, which indicates that BMI has a strong hereditary component (Maes et al., 1997; Silventoinen & Kaprio, 2009). Studies have consistently reported heritability estimates for OW and OB in the 40% to 90% range (Faith, Johnson, & Allison, 1997; Hinney et al., 2010; Silventoinen & Kaprio, 2009). Longitudinal studies have also revealed a strong genetic continuity in BMI when it is tracked across stages of the lifespan, with reported heritability estimates ranging from 57% to 86% for the trend of BMI from early adulthood to late middle age (Silventoinen & Kaprio, 2009). Overall, twin, adoption, and family studies have provided sufficient evidence for moderate to high heritability of OW and OB.

Research on the molecular genetics of OB has identified either single genes (i.e., monogenic) or combinations of genes (i.e., polygenic) that explain intra-individual differences in OB (Chung, 2012; Hinney et al., 2010; Walley, Blakemore, & Froguel, 2006). Findings from monogenic OB studies suggest that mutations or deficiencies of single genes in the leptin-melanocortin pathway, which play a significant role in the regulation of appetite, account for about 5% of the variation in human OB (Albuquerque, Stice, Rodríguez-López, Manco, & Nóbrega, 2015; Frayling et al., 2007). Research on polygenic OB indicates there are over 100 genes that demonstrate a small effect on BMI, and the specific set of genetic variants related to OB in one individual is unlikely to be the same in another individual (Chung, 2012). The genes most commonly studied in polygenic OB research are those in the leptin-melanocortin pathway, proinflammatory cytokines, and uncoupling proteins. Furthermore, research on about 30 forms of syndromic OB, which are often associated with cognitive deficits, suggest that specific neuroanatomic or functional deficits in the hypothalamus may lead to increased energy intake (Hinney et al., 2010). Overall, findings from molecular genetic studies suggest that there is a multitude of genes that have been shown to be implicated in the development of OW and OB.

Over 30 hormones produced in the gut and adipose tissue, which help to regulate appetite, food intake, and metabolism, have also been found to be implicated in OW and OB (Lean & Malkova, 2015). Indeed, abnormalities in these hormones have been found in individuals with OB when compared to individuals of healthy weight (HW), as well as individuals with OB who have lost weight. For example, OB has been associated with a diminished response to hormones that stimulate feelings of satiety and suppress feelings of hunger after episodes of eating, which include glucagon-like peptide 1, peptide YY, and cholecystokinin (Lean & Malkova, 2015). OB has been associated with diminished suppression of ghrelin after eating episodes, which is a hormone that triggers hunger and increases preference for foods high in sugar and fat (Wright & Aronne, 2012). Resistance to leptin, a hormone that works to suppress appetite and regulate metabolism, has also been found in individuals with OB (Myers, Leibel, Seeley, & Schwartz, 2010). Moreover, research suggests that weight loss induced by caloric restriction results in changes in hormones that play a role in increased appetite and weight gain (Lean & Malkova, 2015).

Although this finding supports a causal relationship between calorie reduction-induced weight loss and hormone alterations, the extent to which implicated hormones cause OW and OB warrants further research. Nonetheless, these collective findings suggest that hormonal factors do, indeed, play an important part in OW and OB.

Obesogenic Environment

As mentioned earlier, the causes of OW and OB are multifactorial and the role of the environment in the rise of these conditions over the last four decades has been considered. There is evidence that indicates that the contemporary obesogenic environment has a significant effect on diet and physical activity (Popkin, Duffey, & Gordon-Larsen, 2005). The contemporary obesogenic environment refers to an environment that encompasses surroundings, opportunities, and conditions that promote OW and OB in individuals or populations, and is hypothesized to be a major influence in the rise of these conditions (Swinburn et al., 2011). Aspects of the obesogenic environment that are thought to drive the increasing OW and OB rates include an increased wealth of cheap, energy-dense, highly palatable foods; improved distribution systems that make food much more convenient and accessible; and more omnipresent, persuasive, and attractive food marketing (Swinburn et al., 2011).

Over the past four decades, unhealthy foods have become more readily available and their prices are much lower compared to healthy foods, such as fruits and vegetables (Cohen, 2008). In terms of accessibility, there are a plethora of fast food restaurants in the community, and vending machines that carry energy dense items are often found in schools and work settings. Highly palatable foods are often available in large portions, not only at commercial restaurants, but also in grocery and convenience stores (Rolls, 2003). Technological methods that can create cheaper, processed food items have also been developed (Cutler, Glaeser, & Shapiro, 2003). These less expensive, highly caloric and fat-laden foods have become heavily represented in the visual environment to which people are constantly exposed; for example, through advertising on television, billboards, and public transport, and in shops and magazines (Havermans, 2013). The fact that these foods are advertised as fast, inexpensive, and require little to no preparation give them appeal to millions of consumers, especially those who struggle with economic or time-related demands (Wright & Aronne, 2012).

The obesogenic environment is also thought to influence OW and OB rates by affecting the population's activity practices. Indeed, technological advances related to electronic communication, occupational work, and entertainment have influenced our engagement in physical activity and sedentary behavior, such that more time is now spent using smart phones, watching television, working on the computer, surfing the internet, and playing video games rather than being physically active (Wright & Aronne, 2012). Chapter 2 (Review of the Literature) provides a detailed review of the pathways through which environmental factors are associated with the development of OW and OB.

Other Individual Factors

OW and OB are multifactorial and there are numerous other individual factors bedsides biological and environmental factors that may contribute to the development and maintenance of these conditions. These include the role of sleep, stress, mood, and decision-making styles.

Research on the role of sleep in the development of OW and OB has shown that sleep restriction (i.e., sleeping just a few hours a night) may cause increases in hunger and appetite (Spiegel, Tasali, Penev, & Cauter, 2004). Cross-sectional studies in both children and adults have repeatedly found an association between reduced sleep and increased weight (Gangwisch, Malaspina, Boden-Albala, & Heymsfield, 2005; Sugimori et al., 2004). Furthermore, pooled odds ratios of 1.89 for children and 1.55 for adults have been reported for short sleep duration and its relationship with OB (Cappuccio et al., 2008).

Stress has also been proposed as a factor that can affect weight and weight-related behaviors. Research has shown that stress appears to both increase and decrease food intake (Torres & Nowson, 2007). When individuals respond to stress by eating more, evidence suggests the selected foods are usually high in sugar and fat (Torres & Nowson, 2007). However, anxiety may also alter eating behavior by decreasing energy intake in individuals who are responsive to their physiological state (Herman, Polivy, Lank, & Heatherton, 1987).

Mood has been shown to affect eating behavior, as well. Research suggests that individuals typically eat more food when they are in a positive or negative mood than when they are in a neutral mood (Patel & Schlundt, 2001). There is also consistent evidence of a bidirectional relationship between depression and OB, with a number of biopsychosocial factors having a role in this association (Preiss, Brennan, & Clarke, 2013). Level of education, body image, presence of binge eating, physical health status, psychological characteristics, and interpersonal effectiveness are variables that have been repeatedly linked to the relationship between depression and OB (Preiss et al., 2013).

Cognitive factors, such as the reinforcing value of food and delay discounting, have also been linked to OB. The reinforcing value of food refers to how much an individual will work towards gaining access to a given food (Temple, 2014). Research on this topic indicates that the reinforcing value of food is higher in individuals with OB vs. HW, whereby the former have been shown to work harder for food than their HW counterparts (C. Hill, Saxton, Webber, Blundell, & Wardle, 2009). The reinforcing value of food has also served as a significant predictor of weight gain over time (C. Hill et al., 2009).

Delay discounting, or the degree to which a person is driven by immediate gratification vs. the prospect of larger but delayed reward, has also been investigated with regards to OB (Epstein, Salvy, Carr, Dearing, & Bickel, 2010). Research suggests that youth with OB are more likely to choose smaller, immediate rewards, and have more difficulty with delayed gratification for food than for alternative items as compared to their peers without OB (Bonato & Boland, 1983). More recent research has also indicated that difficulty with delaying gratification in childhood can predict weight gain from ages 3 to 11 (Seeyave et al., 2010).

Summary

The research presented in this introduction demonstrates that OW and OB are complex in nature and arise from a multitude of factors and their interactive effects. The contributing factors of OW and OB can be conceptually grouped into a handful of overarching categories, including biological, environmental, and other individual-level factors. OW and OB typically occur as the result of a combination of these factors and their interactive effects, as opposed to the isolated effect of a single factor. Based on these etiological models of OB, interventions to reduce excess body weight have been developed. The purpose of this dissertation was to evaluate the effect of a single-session attentional bias modification paradigm on eating behavior as a potential intervention that targets an individual's response to the obesogenic environment. Chapter 2 (Review of the Literature) examines in detail the state of the non-biological OW/OB treatment outcome literature, as well as the literature on attentional bias modification as it relates to OW/OB and eating behavior.

CHAPTER 2

REVIEW OF THE LITERATURE

Status of Non-Biological OW/OB Treatment Outcome Research

A number of interventions have been implemented as a means of addressing the increasing and high rates of OW and OB by targeting specific contributing factors. These interventions can be further categorized based on the intervention target, either population-level interventions or individual-level interventions (Swinburn et al., 2011). For example, policy interventions, health promotion programs, and social marketing are population-level interventions that seek to change the larger environment. Individual-level interventions, such as lifestyle modification programs, seek to produce behavior change within an individual.

Population-Level Interventions for OW and OB

To address the high rates of OW and OB, population-level interventions seek to improve physical and social environmental contexts that may promote healthy eating and physical activity. These larger scale interventions compliment other treatment approaches, such as individual-level interventions for individuals with current OW and OB. The rationale behind population-based approaches, however, is that individual-level treatment alone cannot resolve the disturbingly high rates of OW and OB (Chan & Woo, 2010). Although individual-level interventions are of importance, they are limited in terms of long-term weight loss success, as well as the feasibility to deliver them to large amounts of people (Chan & Woo, 2010).

There are a number of population-level approaches to address OW and OB, which include policy interventions, health promotion programs, and social marketing. One of the main methods for changing the environment involves creating public policies at the federal, state, and local levels (Mayne, Auchincloss, & Michael, 2015; US Department of Health and Human Services, 2010). Aspects of the environment that may be targeted by policy and play a role in the high rates of OW and OB include transportation, nutrition standards, access to food, and advertising (Mayne et al., 2015; McKinnon, 2010; Popkin et al., 2005; Sallis & Glanz, 2009). McKinnon (2010) provides examples of effective policies, which include those that modify the environment in such a way that will make the most healthy diet and activity options easy for consumers to choose; generate short-term incentives that support people's long-term health goals; enhance the accessibility of relevant information that will facilitate informed and conscious decision making among consumers; and address disparities in the ability to engage in healthy diet and activity practices, such as limited availability and access to healthy foods in certain areas of the US

Research on the effectiveness of current policy interventions for addressing the high rates of OW and OB suggests that this approach appears to result in healthy behavior change. Greater improvements in nutritional intake have been found for policies that place bans/restrictions (e.g., tax) on unhealthy food items, mandate offering and provide subsidies for healthier foods, and modify rules regarding foods that can be purchased using low-income food vouchers (Mayne et al., 2015; Powell & Chaloupka, 2009; Thow, Downs, & Jan, 2014). Policies that have made improvements to active transportation infrastructure have demonstrated increases in physical activity engagement (Mayne et al., 2015). Although a limited number of studies have assessed change in BMI as a result of policy interventions, one study (MacDonald, Stokes, Cohen, Kofner, &

Ridgeway, 2010) found that installing a light-rail system resulted in significant reductions in BMI and risk of acquiring OB over time.

In addition to policy interventions, community-based health promotion programs and social marketing are approaches that also address OW and OB at a population level. One may conceptualize community-based health promotion programs as a step down from policy interventions, whereby the former is limited to geographic boundaries (e.g., neighborhoods) or small social units (e.g., schools or work places) (Atienza & King, 2002). Community-based health promotion approaches may include promoting physical activity practices through building playgrounds or recreational facilities in a neighborhood or requiring an additional physical education class at a school (Atienza & King, 2002). Other community-based approaches to promote healthy eating would be to make changes to a school menu (e.g., introducing new fruit and vegetable options) or by eliminating unhealthy high fat/high sugar foods and sugar sweetened beverages from a work place's vending machines (Moynihan, 2010).

Research on the effectiveness of current community-based health promotion programs indicates that this approach appears to result in healthy behavior change. For example, two studies (French et al., 2001; Jeffery, French, Raether, & Baxter, 1994) found that reducing the price of healthy foods, including fruits and vegetables in a school cafeteria and low-fat items in a vending machine, resulted in increased buying and consumption of these healthy foods. Other studies have found that access to nearby parks and recreational facilities in a neighborhood, as well as having sport-related amenities (e.g., basketball hoops) in a school, have consistently been associated with higher levels of physical activity in youth and adults (Chan & Woo, 2010; Sallis & Glanz, 2009).

Furthermore, building designs with more convenient access to stairs than elevators and using signs that encourage stair use has also resulted in higher levels of physical activity among youth and adults (Chan & Woo, 2010; Sallis & Glanz, 2009).

A third population-level approach to address OW and OB is social marketing, which involves implementing communication and marketing strategies to promote healthy behaviors (Carins & Rundle-Thiele, 2013; Evans, 2006). Health-related messages can be communicated to the public via a number of outlets, including mass media, healthcare providers and in clinics, interpersonally, and through community outreach (Evans, 2006). The theoretical basis of social marketing involves an integration of behavioral, persuasion, and exposure principles to target changes in risky health behaviors (Evans, 2006). The main goal is to identify behavioral causes of OW and OB that can be changed and, once identified, construct theoretical frameworks that model the multifaceted relationships from messages to behavior change (Evans, 2006).

Research on the effectiveness of social marketing indicates that this approach appears to result in healthy behavior change, as well. Findings from a recent review yielded six components of social marketing interventions that were related to better improvements in healthy eating, which included declaring a behavioral objective, defining a target audience, using research to inform the intervention, offering incentives for desired behavior, employing a multifaceted marketing approach, and considering the competition (Carins & Rundle-Thiele, 2013). Overall, the evidence suggests that social marketing is effective in encouraging a variety of healthy eating behaviors, including increasing fruit and vegetable consumption, as well as decreasing consumption of foods high in fat, carbohydrates, and calorie content (Carins & Rundle-Thiele, 2013).

Individual-Level Interventions for OW and OB

Interventions, such as comprehensive lifestyle modification programs, target OW and OB on an individual level; that is, they focus on individual behavior change by providing care services, education, and training to individuals (Wadden, Webb, Moran, & Bailer, Brooke, 2012). Comprehensive lifestyle modification programs are considered the first option for weight loss and consist of three primary components, including diet, physical activity, and behavior therapy. These programs are usually delivered in either an individual or group format, and involve weekly treatment sessions that focus on modifying eating and physical activity practices (Wadden et al., 2012).

Given that energy intake plays a significant role in OW and OB, lifestyle programs aim to prescribe a diet that will result in weight loss or weight maintenance. Such diets vary widely in macronutrient composition and can include those that are low in carbohydrates (e.g., Atkins diet) (Foster et al., 2003), fat (e.g., Ornish diet) (Dansinger, Gleason, Griffith, Selker, & Schaefer, 2005), or glycemic load (Ebbeling, Leidig, Feldman, Lovesky, & Ludwig, 2007); those that encourage consumption of unsaturated fats (e.g., Mediterranean diet) (Mendez et al., 2006); and those that encourage greater consumption of protein (e.g., Paleo diet) (Frassetto, Schloetter, Mietus-Synder, Morris, & Sebastian, 2009). Caloric restriction, as opposed to macronutrient composition, however, is the key determinant of weight loss in dietary interventions (Wadden et al., 2012). As such, in order to achieve long-term weight loss, most individuals with OW or OB must consciously restrict their energy intake through a number of approaches, including decreasing portion sizes, decreasing the caloric density of the diet, and/or counting calories or limiting intake of specific macronutrients (Wadden et al., 2012). There is evidence to suggest that the different macronutrient-based diets produce relatively equivalent amounts of short-term weight loss (Wadden et al., 2012).

Complimentary to the diet component of lifestyle modifications programs is the physical activity component. Individuals are encouraged to engage in some degree of exercise that will result in energy expenditure, mainly for the sake of improving their cardiovascular health. Oftentimes the recommendation is to engage in physical activity of moderate to vigorous intensity, which can be performed in multiple short bouts (e.g., 10 minutes) or a long bout (e.g., greater than 40 minutes) (Wadden et al., 2012). Low intensity exercise, such as walking, however, has also shown to be an effective method for weight control (Wadden et al., 2012). Overall, there is evidence to suggest that engaging in high levels of physical activity reduces the amount of weight that is regained following weight loss; however, it only slightly increases short-term weight loss when combined with caloric restriction (Wadden et al., 2012).

The set of recommendations and strategies that are taught to individuals participating in lifestyle modification programs to help them change their current diet and activity habits comprises the behavior therapy component of these interventions (Wadden et al., 2012). Behavioral strategies employed in such interventions include setting specific, measurable goals for behavior change, such that define the particular behaviors that an individual will engage in, as well as when, where, how, and the duration (Wadden et al., 2012). Another important behavioral strategy is self-monitoring of behavior, such as recording one's daily food intake, physical activity, and weight. This strategy helps to monitor changes in behavior and outcomes of behavior change, as well as identify barriers that may be hindering behavior change (Wadden et al., 2012).

Overall, comprehensive lifestyle modification programs have demonstrated short-term efficacy in that they produce an average weight loss of about 7 to 10 kilograms in six months, which is equivalent to a 7% to 10% reduction in initial weight, and this weight loss is often maintained for up to 12 months (Wadden et al., 2012). Evidence on the long-term efficacy of these programs, however, is less consistent, with some degree of weight regain often being reported in the year following weight loss (Wadden et al., 2012). Notwithstanding, the short-term reduction in weight is often associated with clinically meaningful improvements in OB-related comorbid health conditions, such as several cardiovascular disease risk factors and type 2 diabetes (Wadden et al., 2012).

Limitations of Current Non-Biological Interventions for OW and OB

It has been described here that various approaches have been taken to address the increasing prevalence of OW and OB, such as those that promote health behavior change on both a population and individual level. Population-level interventions, including policy interventions, health promotion programs, and social marketing, primarily seek to produce health behavior change through modifying the obesogenic environment. Individual-level interventions, including comprehensive lifestyle modification programs, primarily seek to produce weight loss by modifying person-level factors within an individual. Although there is evidence to suggest that the current interventions demonstrate some degree of effectiveness for the treatment of OW and OB, they are not without their limitations. Indeed, the prevalence of OW and OB in the US is still alarmingly high, which suggests that the OB problem has not been solved. This author proposes that the primary weakness of the current interventions is the lack of focus on and incorporation of the interactive effects of the environment with biological factors.

As described in Chapter 1 (Introduction), the obesogenic environment and its interactions with biological factors have been determined to be significant contributing factors in the development and maintenance of OW and OB. One aspect of the environment that promotes OB is the pervasive presence of visual food cues, through advertising on television, billboards, and public transport, and in shops and magazines (Havermans, 2013). Continual exposure to the omnipresence of visual food cues in the environment has the ability to interact with reward systems of the brain and trigger motivated behavior, which may play a significant role in excessive food intake and subsequent OW and OB (Castellanos et al., 2009). Determining the role of food cues in the development and maintenance of OW and OB is of practical and ecological significance; thus, it is important to understand exactly how food cues interact with reward systems in the brain to direct attention and impact resultant behavior (Castellanos et al., 2009).

The current individual-level interventions for OW and OB lack consideration of how the environment interacts with biology to influence individual health-related behaviors. For example, lifestyle modification programs provide education on the importance of diet and physical activity but do not into account individual differences in attention to visual food cues. An attentional bias to visual food cues, particularly unhealthy foods, may be strong enough to disregard dietary recommendations or disrupt a diet. As such, it may be advantageous for interventions to incorporate modification of attentional bias to food cues to enhance their effectiveness in treating OW and OB.

What is certain is that continued work that focuses on the development of new, or modification of current, treatment strategies is crucial to successfully combat OW and

OB, or at least to significantly reduce the current prevalence rates. Given that exposure to visual food cues is a potentially modifiable environmental variable, a better understanding of the effects of visual food cue exposure on attention may prove to be an important step in the development and modification of treatments for OW and OB.

Food Cue Exposure and Attentional Bias

One influential general theory that provides an explanation for the connection between cue exposure and its effects on attention is Robinson and Berridge's (1993) incentive sensitization model, which was originally developed to explain addiction. This model posits that repeated administration of substances of abuse (i.e., drugs) modifies the reward-related dopaminergic system in the brain, leading the brain to become hypersensitive to such substances. The sensitized dopaminergic response causes these substances to become highly desired and "wanted". Cues in the environment that are associated with these rewarding substances, such as visual stimuli or images of the substance, acquire motivational properties or incentive salience over time through a process known as classical conditioning, or the repeated association between the cues (i.e., images of drug) and intake of the rewarding substance (i.e., drug itself) (Robinson & Berridge, 1993). Consequently, the cues that are related to the rewarding substance also become highly salient, causing them to be perceived as attractive and "wanted". The brain begins to perceive these cues as predictive of reward; thus, the cues begin to automatically capture greater attention and, in turn, stimulate craving, which may potentially influence subsequent behavior (i.e., towards obtaining the rewarding substance). This process occurs outside of conscious awareness and is often referred to as attentional bias (Robinson & Berridge, 1993).

The ability of a substance to activate the dopaminergic system is the key component in determining its reward value (Wise, 1998). As such, the incentive sensitization model has been applied to numerous substances of addiction including drugs (Marhe, Luijten, van de Wetering, Smits, & Franken, 2013), alcohol (Weafer & Fillmore, 2009), tobacco (Chanon, Sours, & Boettiger, 2010), and caffeine (Yeomans, Javaherian, Tovey, & Stafford, 2005), and attentional biases to these substances, and their related cues, have been well-documented. In addition, research has shown that palatable foods, especially those high in sugar and/or fat, have the ability to activate the dopaminergic system in a similar manner to substances of addiction (Avena, Rada, & Hoebel, 2008; South & Huang, 2008). Thus, it has been suggested that food-related cues may have the ability to capture attention and activate the dopaminergic system as well, thus making visual food cues more salient and attractive to the observer (Volkow, Wang, & Baler, 2011; Volkow & Wise, 2005). However, it is important to note that not all individuals are equally susceptible to food cues in the environment.

Measurement of Attentional Bias to Food Cues

Attentional bias to food and other stimuli is thought to occur automatically and without necessary conscious awareness. Implicit processing measures, therefore, are needed to assess this construct and the most common are the Stroop task and dot probe task. The Stroop task (Stroop, 1935) was adapted from cognitive psychology to examine human attention and information processing. During this task there is a presentation of words that are displayed in different colors of ink; some words are control words, while the others are words related to the stimuli of interest (e.g., food). The participant is asked to name the color of ink that each word is printed in as quickly and accurately as possible, while attempting to ignore the meaning of the word (see Figure 1). A relative delay in correctly naming the color of the word is considered an interference effect and suggests that there is cognitive competition present; that is, it would suggest that the participant may have difficulty ignoring the meaning of the word because it takes them longer to focus on and correctly name the color of the word (Stroop, 1935). As such, attentional bias is determined from the length of time that it takes to color name a word related to the stimuli of interest (e.g., food) as compared with a control word (Stroop, 1935).

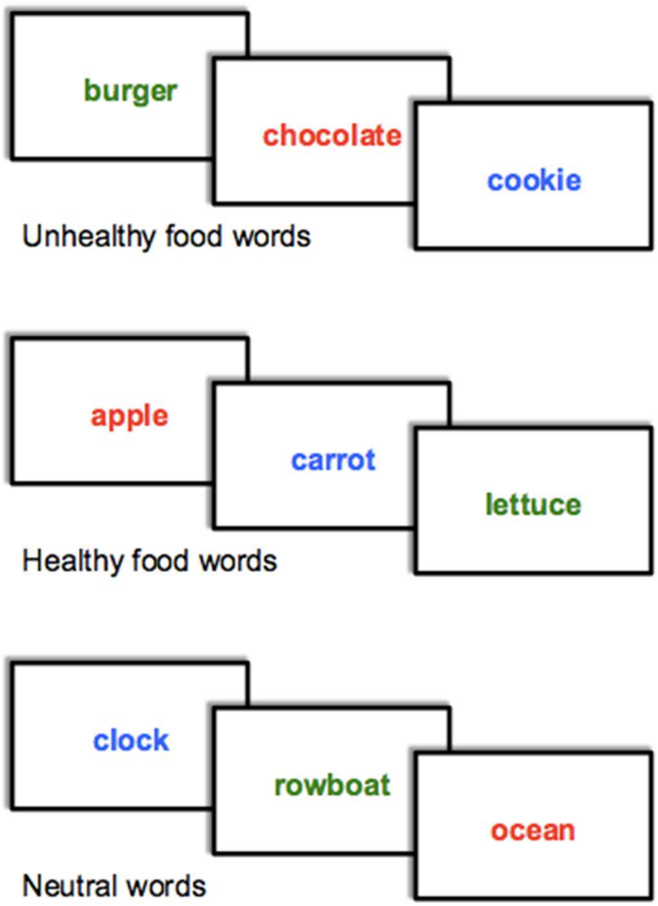

Figure 1. Visual illustration of stimulus words presented during the Stroop task.

Although the Stroop task has been widely used as a test of attentional bias, it has a number of disadvantages (Werthmann, 2014). First, the underlying attentional processes at work are unknown in that slower color-naming of a word could be caused both by an attentional bias towards the meaning of the word or by an avoidance of processing the word (Field & Cox, 2008). This leads to the problem of not being able to identify the direction (approach or avoidance) of the attentional processes. The time course of the attentional processes is unclear as well, such that the delay in color-naming has been argued to reflect an automatic semantic processing, which is an early attentional process (Cox & Pothos, 2006), or a slow disengagement, which is a later attentional process (Phaf & Kan, 2007).

Attentional bias research has continued to evolve in an attempt to measure how visual attention is allocated to a particular stimuli when there are two competing reward-related cues presented simultaneously. One such method is the dot probe task (see Figure 2) (MacLeod, Mathews, & Tata, 1986), which has been argued to be a superior, more direct, and more ecologically valid measure of attention than the Stroop task (Faunce, 2002; MacLeod et al., 1986; MacLeod & Mathews, 1991). In the dot probe task, participants are exposed to a word or image related to a stimulus of interest (e.g., food) that is matched to a control word or image that are presented simultaneously, side by side on a computer screen. The paired words or images disappear after a predetermined length of time (usually 50-2000 ms) and a dot probe replaces one of the previous stimuli. Participants are then asked to indicate the location of the probe as quickly and accurately as possible, and attentional bias is determined from the length of time that it takes to correctly identify the location of the probe. It has been suggested that participants will respond faster to probes that replace the location of a stimulus that they have already directed their attention towards, as compared to probes that appear in an area to which the participant has not attended (MacLeod et al., 1986).

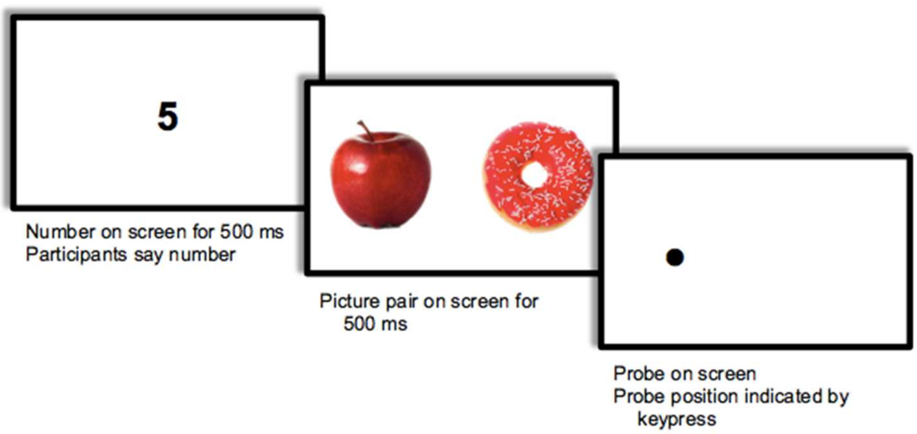

Figure 2. Visual illustration of stimulus pictures presented during the dot probe task.

An advantage of the dot probe task is that the calculation of response latencies provides information regarding the direction of attention. To calculate an attentional bias score, the mean response latency when probes replace food pictures is subtracted from the mean response latency when probes replace control pictures; thus, a positive number reflects attentional approach and a negative number reflects attentional avoidance (Mogg, Bradley, Miles, & Dixon, 2004). Additionally, this task can distinguish early and later attentional processes by varying the length of time that the stimulus is presented on the computer screen (Werthmann, 2014). It has been proposed that stimulus durations of 100-500 ms assess initial orientation of attention, whereas stimulus durations of 500 ms and above assess maintained attention (Mogg et al., 2004). The use of long stimulus durations, however, has been discouraged as it is not possible to measure shifts in attention between stimuli or disengagement from stimuli (Field, Mogg, Zetteler, & Bradley, 2004). As such, the dot probe task may be more suitable for assessing initial attention to visual food cues.

Studies on Attentional Bias to Food Cues

Not all individuals are equally susceptible to food cues in the environment. Individual differences in attentional biases for food-related cues relative to one's BMI category has been an area of interest because research suggests that greater attention to food cues may be associated with OB. Given this association, researchers have also studied the utility of attention to food cues in predicting change in BMI across time. The studies described below assessed attentional bias using the dot probe or Stroop task.

Comparing BMI categories with the dot probe task. Werthmann and colleagues (2011) examined whether OW and HW female college students differed on attentional bias measures towards unhealthy foods using both the dot probe task and eye-tracking methodology. The stimuli were pictures of highly palatable, unhealthy foods vs. non-food objects (i.e., musical instruments). Stimuli were presented for a duration of 2000 ms so that the researchers could use eye-tracking to assess the attentional mechanisms at play, including initial orientation vs. maintained attention, direction of attention, and duration of attention. Three attentional bias measures were yielded from the eye-tracking (i.e., gaze direction bias, initial fixation duration bias, and gaze dwell time bias) and one was yielded from the dot probe task (i.e., probe manual response latency bias). Compared to HW participants, OW participants (1) directed their first fixation more often to food images than to non-food images and (2) had a significantly shorter fixation duration when they attended to food pictures first than when they attended to non-food pictures first (Werthmann et al., 2011).

Nijs and colleagues (2010) investigated whether attentional biases to unhealthy food vs. non-food pictures differed between OW/OB and HW college women using a combination of the dot probe task (stimulus presentations of 100 ms and 500 ms), eye-tracking methodology, and electroencephalographic (EEG) recordings. The authors assessed different attentional mechanisms, such as gaze direction and duration. The eye-tracking data did not yield significant differences between BMI groups; rather, there was an initial orientation and maintained attention to unhealthy food pictures observed in all participants. The dot probe task revealed that initial orientation towards unhealthy food cues was observed in OW/OB vs. HW women, but there were no differences between BMI groups in terms of maintained attention (Nijs, Muris, Euser, & Franken, 2010).

Loeber and colleagues (2012) assessed whether attentional biases for food-related vs. non-food cues differed between community-dwelling adults who were either OB or HW using the dot probe task. The stimuli consisted of general food pictures and non-food object pictures, and were presented for a duration of 500 ms. The authors found no differences between OB and HW participants in attentional biases towards food or non-food related stimuli (Loeber et al., 2012).

Comparing BMI categories with the Stoop task. Nijs and colleagues (2010) assessed attentional bias to food-related words using a combination of the Stroop task and event related potentials as measured by simultaneous EEG recordings of brain activity. The stimuli presented during the Stroop task included words referring to highly palatable, unhealthy foods and neutral office-related control words, and were presented for a duration of 2000 ms. The researchers were interested in examining initial orientation of attention and maintained attention in a sample of community-dwelling, OB and HW adults. The two BMI groups did not differ in their attentional bias towards food-related content as measured by the Stroop-related reaction time; rather, a general bias towards food-related content was found for both BMI groups. The EEG data yielded differences between BMI groups, whereby OB individuals showed a greater initial orientation of attention towards food-related words than nonfood words, and this finding was not observed in the HW participants. The two BMI groups did not differ in maintained attention towards food-related words (Nijs, Franken, & Muris, 2010).

Phelan and colleagues (2011) examined differences in attentional bias towards high- and low-calorie food words among OB, HW, and weight loss maintaining adults in the community. There were no differences in attentional bias between the three groups towards the low-calorie food words; however, for the high-calorie food words, the weight loss maintainers showed a significantly greater attentional bias than both the HW and OB participants (Phelan et al., 2011).

Predicting change in BMI with attentional bias measures. Calitri (2010) and colleagues investigated whether attentional biases for food-related words could predict change in BMI over a 12-month period using both the Stroop and dot probe tasks. Stimuli included healthy and unhealthy food words, and presentation time was varied in the dot probe task to examine initial (500 ms) vs. sustained (1250 ms) attention. Participants included first-year college students residing on campus. Results from the Stroop task revealed that an attentional bias towards unhealthy foods predicted an increase in BMI over time, whereas an attentional bias towards healthy foods and stress (as measured by

Lovibond and Lovibond's [1995] Depression, Anxiety, and Stress Scale) predicted a decrease in BMI over time (Calitri, Pothos, Tapper, Brunstrom, & Rogers, 2010).

Pothos (2009) and colleagues examined cognitive correlates of BMI among male and female undergraduate students using three attentional measures, including the dot probe task as a measure of initial attention (500 ms), the dot probe task as a measure of sustained attention (1200 ms), and the Stroop task, all of which presented stimuli of healthy and unhealthy food words. The authors found none of the attentional measures to significantly correlate with or predict BMI, either for the sample as a whole or when analyzing males and females separately (Pothos, Tapper, & Calitri, 2009).

Other factors that may influence attention to food cues. Additional studies have indicated that attentional biases towards unhealthy food cues are common to an array of eating-related populations, such as individuals who restrict their food intake (Hollitt, Kemps, Tiggemann, Smeets, & Mills, 2010) or eat in response to external food cues (Hou et al., 2011). Both restrained eaters and external eaters have been found to respond faster to high calorie food cues relative to non-food cues. Nijs and colleagues (2010) investigated whether attentional biases to unhealthy food vs. non-food pictures differed depending on hungry vs. sated status in OW/OB and HW college women. Initial orientation towards unhealthy food cues was observed in hungry vs. sated women, regardless of BMI category, but there were no differences between hunger conditions in terms of maintained attention. Furthermore, conscious maintained attention to unhealthy food pictures was enhanced in the hunger vs. satiety condition only in HW females (Nijs, Muris, et al., 2010). Phelan and colleagues (2011) examined differences in attentional bias towards high- and low-calorie food words relative to levels of restraint and disinhibition. These variables were not significantly associated with attentional bias scores on the Stroop task before or after controlling for weight group status.

Summary of studies on attentional bias to food cues. The majority of findings from studies that have compared BMI groups with regards to attentional bias to food cues have been mixed. The evidence suggests that individuals with OW and OB sometimes demonstrate attentional biases to unhealthy food stimuli vs. non-food stimuli when compared to individuals of HW. It appears that the attentional bias findings observed in OW/OB individuals are driven by an initial orientation to unhealthy food stimuli as opposed to sustained attention, which has been assessed with shorter stimulus presentation times. Furthermore, there is some evidence to suggest that attentional measures may predict change in BMI over time, such that greater attention towards unhealthy foods is associated with increases in BMI and greater attention towards healthy foods is associated with decreases in BMI. Although further research is needed to adequately assess the relationship between BMI status and attentional bias to food-related stimuli, the limited research that is available suggests that attentional bias to food cues may play some role in the development and maintenance of OW and OB. Table 1 outlines the aforementioned studies that have examined individual differences in attentional bias to food cues.

Table 1

Studies on individual differences in attentional bias to food cues

Authors, year	Attentional bias measure(s), stimuli, and presentation duration	Sample and group comparisons	Results
Werthmann, Roefs, Mogg, Bradley, & Jansen, 2011	DP, ET Unhealthy vs. non-food pictures 2000 ms	Female college students OW vs. HW	OW participants directed first fixation more often to unhealthy food vs. non-food pictures OW participants had shorter fixation duration when attending to unhealthy food vs. non-food pictures first
Nijs, Muris, Euser, & Franken, 2010	DP, ET, EEG Unhealthy vs. non-food pictures 100 and 500 ms	Female college students OW/OB vs. HW	ET: all participants demonstrated initial orientation and maintained attention to unhealthy food pictures DP: initial orientation to unhealthy food pictures in OW/OB (vs. HW) DP: no differences between BMI groups in maintained attention to unhealthy food words
Loeber et al., 2012	DT Food vs. non-food pictures 500 ms	Community dwelling adults OB vs. HW	No differences between BMI groups in attention to food vs. non-food pictures

Note: DT = dot probe; ET = eye tracking, EEG = electroencephalography

table continues

Authors, year	Attentional bias measure(s), stimuli, and presentation duration	Sample and group comparisons	Results
Nijs, Franken, & Muris, 2010	Stroop, EEG Unhealthy vs. non-food words 2000 ms	Community dwelling adults OB vs. HW	Stroop: all participants demonstrated bias towards unhealthy vs. non-food words EEG: OB participants showed greater initial orientation towards unhealthy vs. non-food words, but HW participants did not show this bias EEG: no differences between BMI groups in maintained attention to unhealthy food words
Phelan et al., 2011	Stroop High- vs. low-calorie food words Unknown duration	Community dwelling adults OB vs. HW vs. weight loss maintainers	No differences between groups in attentional bias towards low-calorie food words Weight loss maintainers demonstrated greater attentional bias than HW and OB to high-calorie food words
Calitri, Pothos, Tapper, Brunstrom, & Rogers, 2010	Stroop, DT Healthy vs. unhealthy food words 500 and 1250 ms	First-year college students who reside on campus No group comparisons	Stroop: greater attentional bias towards unhealthy food words predicted increases in BMI Stroop: greater attentional bias towards healthy food words predicted decreases in BMI
Pothos, Tapper, & Calitri, 2009	Stroop, DT Healthy vs. unhealthy food words 500 and 1200 ms	College students No group comparisons	No attentional bias measures predicted BMI

Note: DT = dot probe; ET = eye tracking, EEG = electroencephalography

Attentional Bias and Consumption Behavior

Attentional biases for high calorie foods have been linked to subsequent consumption of these foods (Nijs, Muris, et al., 2010) as well as weight gain over a 12 month period (Calitri et al., 2010). One theory that seeks to explain this relationship is Berridge's (2009) model of food reward, which was adapted from the incentive sensitization model originally developed to explain addiction (Robinson & Berridge, 1993). The model of food reward posits that motivational value is attributed to food cues through classical conditioning. Food cues (e.g., the sight of food) in the environment become salient through constant association with a rewarding experience (e.g., eating) and, as a result, grab attention, which then prompts the consumption of that food. This process often occurs without conscious awareness (Berridge, 2009). Only a couple of studies have examined the relationship between baseline attentional bias and subsequent food consumption in a laboratory-based taste test.

Nijs and colleagues (2010) sought to determine if measures of attentional bias (e.g., eye-tracking methodology, dot probe task, EEG recordings) towards food pictures were correlated with food intake during a laboratory taste test in both OW/OB and HW college women. They found that maintained attention to food pictures as measured by EEG recordings was significantly and positively associated with food intake in only the HW group, but not in the OW/OB group. No other measures of attention were associated with food intake during the taste test (Nijs, Muris, et al., 2010).

Wethmann and colleagues (2011) also investigated whether attentional bias towards food pictures was related to food intake during a laboratory-based taste task in both OW/OB and HW female students using the dot probe task in conjunction with eye-tracking. The authors failed to find any significant correlations between the attentional bias measures and food consumption (Werthmann et al., 2011).

Calitri and colleagues (2010) conducted a study that differs from the previous two in that it measured BMI over time rather than direct food consumption. The authors investigated whether attentional biases for food-related words could predict change in BMI over a 12 month period using both the Stroop and dot probe tasks. Stimuli included healthy and unhealthy food words, and presentation time was varied in the dot probe task to examine initial (500 ms) vs. sustained (1250 ms) attention. Participants included first-year college students residing on campus. Results from the Stroop task revealed that an attentional bias towards unhealthy foods predicted an increase in BMI over time, whereas an attentional bias towards healthy foods and stress (as measured by Lovibond and Lovibond's [1995] Depression, Anxiety, and Stress Scale) predicted a decrease in BMI over time (Calitri et al., 2010).

Collectively, there has been very limited research that has examined the relationship between attentional bias to food cues and food consumption or change in BMI over time. Nonetheless, the available evidence suggests that attentional bias to unhealthy food stimuli may have a role in the development and maintenance of OW and OB.

Attentional Bias Modification for Unhealthy Food Cues

It is important to change unhealthy eating behavior in order to improve health. Berridge's (2009) model of food reward suggests one way to counteract unhealthy eating is to change the underlying cognitive process, that is, the attentional bias. Decreases in attentional biases for unhealthy food should, theoretically, lead to decreases in the consumption of unhealthy food according to this model.

In order to experimentally manipulate attentional bias, researchers have utilized the visual dot probe task. The first attentional bias modification (ABM) program was developed to train alcohol users to either attend to or avoid alcohol-related cues (Field & Eastwood, 2005). During this program, the dot probe task attempts to retrain an individual's automatic attentional process by having the probe replace a given stimuli during all or most (i.e., ≥ 90%) of the trials of the dot probe task. In Field and Eastwood's (2005) study, for example, the probe always replaced the alcohol-related picture in the 'attend alcohol' condition, whereas the probe always replaced the neutral control picture in the 'avoid alcohol' condition. Thus, the objective of the ABM dot probe task is for the participant to learn an implicit rule in that if two competing stimuli are present simultaneously, then attend preferentially to the stimuli that you are being trained towards (Mathews & MacLeod, 2002).

This ABM paradigm has since been applied to other research areas, including the food domain. In a study conducted by Kemps and colleagues (2014), female college students, aged 18 to 26 years, with unknown weights/BMI categories (these variables were not reported by the authors), were trained to direct their attention towards ('attend chocolate' group) or away from ('avoid chocolate' group) chocolate cues in an ABM task that utilized a dot probe paradigm. Participants in the 'attend chocolate' group demonstrated an increased attentional bias towards chocolate cues, whereas those in the 'avoid chocolate' group demonstrated a reduced attentional bias towards such cues and ate less of a chocolate muffin than those in the 'attend chocolate' group (Kemps, Tiggemann, Orr, & Grear, 2014).

In a similar study, female college students with an average age of 19.5 years and average BMI of 22.1 kg/m^2 were trained to direct their attention towards either chocolate stimuli or non-food stimuli in an ABM task that utilized an antisaccade paradigm that records eye movements rather than key presses (Werthmann, Field, Roefs, Nederkoorn, & Jansen, 2014). Eye movements during the task were also examined to assess for accuracy and its possible moderating effects. There were no differences between ABM training groups in chocolate consumption. However, a significant interaction between ABM training and accuracy was revealed, whereby participants who demonstrated high accuracy ate more chocolate when they had to attend to chocolate and ate less chocolate when they had to attend to non-food stimuli. Participants who demonstrated low accuracy, however, showed reverse results (Werthmann et al., 2014).

In a later study, Kakoschke and colleagues (2014) attempted to train participants to attend to healthy food cues, rather than simply avoid unhealthy food cues utilizing a dot probe task. Female college students, aged 18 to 25 years, most of whom were in the normal weight range (average BMI was 22.2 kg/m^2), were asked to direct their attention towards either healthy food cues ('attend healthy' group) or unhealthy food cues ('attend unhealthy' group). Participants in the 'attend healthy' group demonstrated an increased attentional bias towards healthy food cues and ate more healthy snacks (i.e., strawberries and mixed unsalted nuts) relative to unhealthy snacks (i.e., M&Ms and potato chips) compared to the 'attend unhealthy' group during a taste test that occurred immediately following the ABM training. This study is novel in that it was the first to attempt to train participants to attend to healthy food cues; however, the sample was limited to female college students of HW. Although the 'attend healthy' condition did result in greater consumption of healthy vs. unhealthy foods in a taste test, it is imperative that these results be replicated in other samples (Kakoschke, Kemps, & Tiggemann, 2014).

In their most recent study, Kemps and colleagues (2014) examined ABM in a sample of community-dwelling OB adult women (average BMI was 36.63 kg/m^2). Participants were between the ages of 24 and 67 with an average age of 48.88. They were trained to either attend to ('attend food' group) or avoid ('avoid food' group) food pictures, which consisted of a combination of high-calorie and low-calorie food items, during a dot probe task. Consistent with previous findings, the 'attend food' group demonstrated an increase in attentional bias towards food, while the avoid group demonstrated a decrease in attentional bias towards food, as measured by responses on the dot probe task (Kemps, Tiggemann, & Hollitt, 2014). Food consumption following the modification program was not measured in this study, as it was in the others, which is considered as a limitation. Thus, it is unknown if a decrease in attentional bias towards food results in decreased food consumption in OB individuals.

Boutelle and colleagues (2014) assessed the efficacy of a dot probe ABM paradigm on overeating in OW and OB children, aged 8 to 12 years old, who demonstrated eating in the absence of hunger at baseline. Attention was either trained away from food words to neutral words 100% of the time ('attention modification' condition) or 50% of the time ('attention control' condition). Children were then introduced to a free access eating session immediately following the attentional task, and their caloric consumption was measured. The 'attention modification' condition resulted in decreases in the number of calories consumed, as well as the percent of daily caloric needs consumed, in the eating in the absence of hunger free access session following the task. Furthermore, children in the 'attentional control' condition demonstrated a significant increase over time in number of calories consumed, as well as the percent of daily caloric needs consumed, in the eating in the absence of hunger free access session following the task (Boutelle, Kuckertz, Carlson, & Amir, 2014).

Limitations of Studies on ABM for Unhealthy Food Cues

Although these findings support the efficacy of ABM paradigms for modifying eating behaviors as well as the hypothesized link between biased attentional processing and food consumption, they are subject to limitations which have been briefly described above. The four adult studies have used all-female samples, so it is unknown if the findings will generalize to males. Additionally, while there is adequate evidence to suggest that these programs can train unhealthy eating, by either attending to or avoiding it, their ability to train healthy eating warrants further investigation, as only one study (Kakoschke et al., 2014) to date has examined this aspect and was limited in terms of an all-female, HW sample. It is also important to extend these findings to individuals who are OW or OB, and might have a stronger pre-existing attentional bias towards unhealthy food.

Summary

In summary, the prevalence of OW and OB is extremely high across stages of the lifespan and temporal trends indicate significant increases in these conditions over the past four decades. Given the numerous health risks associated with OW and OB, targeting their increasing prevalence rates has become a public health priority. There is evidence to suggest that OW and OB are very complex in nature and arise from a multitude of factors and their interactive effects. The contributing factors of OW and OB can be conceptually grouped into a handful of overarching categories, including biological, environmental, and other individual-level factors.

Based on etiological models of OW and OB, interventions to reduce adiposity have been developed. These interventions target specific contributing factors of OW and OB and include population-level (e.g., policy interventions, health promotion programs, social marketing) as well as individual-level (e.g. lifestyle modification programs) approaches. Although there is evidence to suggest that the current interventions demonstrate some degree of effectiveness for the treatment of OW and OB, they are limited in that they lack focus on how environmental factors (e.g., food cues) interact with biology (e.g., reward systems in brain) to influence individual health-related behaviors (e.g., food consumption) through pathways such as attentional bias.

There is evidence to suggest that attentional bias to food cues may play some role in the development and maintenance of OW and OB, whereby individuals with OW and OB have sometimes demonstrated greater biases for unhealthy foods than their HW counterparts, and greater biases for unhealthy foods have been associated with increases in BMI over time. ABM paradigms have been developed to train individuals to either attend to or avoid certain food cues in the environment. Overall, findings from these studies support the efficacy of ABM paradigms in modifying eating behaviors as well as the hypothesized link between biased attentional processing and food consumption. Nonetheless, the restricted number of studies that have examined the outcomes of ABM for unhealthy food cues have been limited in the following ways: (1) the majority have used all-female samples, and (2) the majority have mainly focused on training unhealthy eating, with limited evidence on the ability to train healthy eating.

As such, the purpose of this dissertation was to evaluate the effect of a single-session ABM training designed to promote healthy eating on eating behavior as a potential intervention that targets an individual's response to the obesogenic environment. The current dissertation addresses the limitations of previous ABM studies in that it examines differential effects of the program on attention to food cues and eating behavior based on BMI category (i.e., HW vs. OW/OB).

Dissertation Aims

This dissertation sought to determine whether a single-session ABM training designed to promote healthy eating could induce an attentional bias towards healthy food cues as measured by a dot probe task and, subsequently, increase consumption of healthy foods during a laboratory-based eating behavior assessment. Participants were randomly assigned to either the ABM condition or an attentional control (AC) condition. In the ABM condition, participants were trained to attend to healthy food; in the AC condition, participants were not trained to attend to any food group. Subsequent measures of attentional bias towards and consumption of healthy foods were administered to assess the effects of the ABM condition compared to the AC condition. To extend the existent literature on food-related ABM, this study recruited participants of both HW and OW/OB status and examined BMI category as a potential moderating factor in the relationship between the intervention and both attentional bias towards and consumption of healthy foods.

This study had two aims:

Specific Aim 1: To assess the effect of an ABM intervention for healthy eating on attentional bias towards healthy food using a dot probe paradigm. A 2 (training condition: ABM, AC) × 2 (time: pre-training, post-training) mixed analysis of variance (ANOVA) was conducted to determine whether any change in attentional bias score was the result of the interaction between the training condition and time.

Hypothesis 1: Participants in the ABM condition would show a significant increase in attentional bias towards healthy food from pre-training to post-training, and participants in the AC condition would show no change in attentional bias towards healthy food from pre-training to post-training.

Sub-Aim 1.1: To assess whether the effect of an ABM intervention for healthy eating on attentional bias towards healthy food would hold across BMI groups (HW, OW/OB). A 2 (training condition: ABM, AC) × 2 (time: pre-training, post-training) × 2 (BMI group: HW, OW/OB) mixed ANOVA was conducted to determine whether any change in attentional bias score from pre-training to post-training was the result of the training condition, and if this effect would be the same across BMI groups.

Hypothesis 1.1: Both HW and OW/OB participants in the ABM condition would show a significant increase in attentional bias towards healthy food from pre-training to post-training, and both HW and OW/OB participants in the AC condition would show no change in attentional bias score from pre-training to post-training. Overall, it was hypothesized that BMI group would not have a significant moderating effect on the relationship between training condition and attentional bias change.

Specific Aim 2: To assess the effect of an ABM intervention for healthy eating on healthy food consumption during a laboratory-based taste test, controlling for participant ratings of liking for the healthy food and their hunger level. Two analyses of covariance (ANCOVAs) were conducted to compare the amount of calories consumed from healthy snack food, and amount of calories consumed from unhealthy snack food, between the ABM and AC training conditions. Participant ratings of overall liking for the healthy snack food and the unhealthy snack food, and hunger level, were controlled for in analyses.

Hypothesis 2: Participants in the ABM condition would consume significantly more calories from healthy snack food, and significantly less calories from unhealthy snack food, as compared to participants in the AC group, controlling for participant ratings of liking for the healthy and unhealthy foods and their hunger level.

Sub-Aim 2.1: To assess whether the effect of an ABM intervention for healthy eating on healthy food consumption during a laboratory-based taste test would hold across BMI groups (HW, OW/OB), while controlling for participant ratings of liking for the healthy food and their hunger level. Two ANCOVAs were conducted to compare the amount of calories consumed from healthy snack food, and amount of calories consumed from unhealthy snack food, between training conditions (ABM vs. AC) and BMI groups (HW vs. OW/OB), as well as the interaction between training condition and BMI group by entering the following term into the model: training condition*BMI group. Participant ratings of overall liking for the healthy snack food and the unhealthy snack food, and hunger level, were controlled for in analyses.

Hypothesis 2.1: Both HW and OW/OB participants in the ABM condition would consume significantly more calories from healthy snack food, and significantly less calories from unhealthy snack food, as compared to HW and OW/OB participants in the

AC group, controlling for participant ratings of liking for the healthy and unhealthy foods and their hunger level. Overall, it was hypothesized that BMI group would not have a significant moderating effect on the relationship between training condition and caloric consumption of the healthy and unhealthy snack foods.

CHAPTER 3

METHODOLOGY

Participants

After obtaining approval from the University of Missouri-Kansas City's Social Sciences Institutional Review Board, participants were recruited by the principal investigator (PI) from a sample of students at universities in the Kansas City metropolitan area. Individuals were eligible to participate in the study if they were female, at least 18 years of age, enrolled as a student at a university in the Kansas City metropolitan area, proficient in English as their first language, and had a BMI of greater than or equal to 18.5 kg/m^2. In addition, individuals had to report that they had no food allergies or dietary requirements, deny current or recent dieting, and had no past or current eating disorder to be eligible to partake in the study.

Recruitment and Screening Procedures

Participants were recruited via two methods: the UMKC Psychology Department online research participant recruitment system (Psych Pool) and campus flyers. Students were asked to complete an online screening questionnaire (Appendix A) prior to enrolling in the study to determine their eligibility. Students recruited via Psych Pool accessed the screener by following a link listed on the study page, and those recruited via flyers accessed the screener via a link indicated on the flyer. Screening data were collected using REDCap (described in Overview of Experimental Procedures).

Students who met eligibility criteria for the study received a link at the end of the online screener that redirected them to a site (www.SignUpGenius.com) to sign up for a day and time to complete the study. Through this site, the PI listed available days and times in which the participants could meet with the PI or a research assistant on campus to complete the main study. Once a participant signed up for the study online, a confirmation email was immediately sent to them with instructions to eat something 2 hours before their testing session to ensure that they were not hungry. A reminder email with these same instructions was sent to the participant one day before their testing session was to occur.

Screening Measures

Demographics questionnaire. A demographic questionnaire developed by the PI was administered to assess participant characteristics related to eligibility requirements, including age, sex, enrollment status, and language proficiency. Individuals were asked to report their current height and weight and, with this information, BMI was calculated automatically. Recruitment was balanced to acquire equal numbers of HW and OW/OB participants.

Eating questionnaire. An eating questionnaire developed by the PI was administered to assess participant eating characteristics related to eligibility requirements. Individuals were asked if they had any food allergies or dietary requirements or had been on a diet for the purposes of weight loss within the last 3 months. Participants were also asked to rate their liking of the four foods used in the bogus taste test of the study using visual analogue scales ranging from 0 (extremely dislike) to 100 (extremely like). Participants were required to rate one out of the two healthy foods, and one out of the two unhealthy foods, as at least a 25 out of 100 in order to be eligible for the study.

SCOFF eating disorder screener. The SCOFF (Morgan, Reid, & Lacey, 1999), a five-item questionnaire, was used to assess current or past eating disorder behavior. Individuals who endorsed two or more items were excluded from the study. This cut-off score has been established in previous research to provide 100% sensitivity for anorexia nervosa and bulimia nervosa, with a specificity of 87.5% for controls (Morgan et al., 1999).

Pre-Experiment Procedures

Participants were tested individually in a quiet room in the UMKC Psychology Department in a single session of 60-minute duration. All participants were tested in the afternoon because food cravings occur more frequently after midday (Hill, Weaver, & Blundell, 1991). Upon arrival for testing, the PI or research assistant discussed with the participant the study information sheet/consent form (Appendix B), which outlined the purpose, procedures, possible risks and benefits of participating, and data confidentiality, and participants were asked to give their written consent to participate. All participants were provided a copy of the consent form after reviewing it with the PI or research assistant. Participants were told that they could discontinue their participation at any time without penalty. Participants received a $15 American Express gift card or 3 Psych Pool credits for participating in this study.

After providing informed consent, participants were seated approximately 50 cm in front of a computer with a 21.5-inch monitor. They completed self-report measures (see Measures below) of demographic characteristics and eating behaviors and cognitions. Self-report data were collected and managed using REDCap, which is a secure, web-based application designed to support data capture for research studies, providing an intuitive interface for validated data entry, audit trails for tracking data manipulation and export procedures, automated export procedures for seamless data downloads to common statistical packages, and procedures for importing data from external sources (Harris et al., 2009).

Pre-Experiment Measures

The following measures have been administered as part of a standard assessment battery in previous food-related ABM studies (Hollitt et al., 2010; Hou et al., 2011; Phelan et al., 2011) to characterize the samples. Given the expectation/limitation of lower power in this dissertation, the majority of the these measures were only used to characterize the sample, descriptively compare groups, and aid in future hypothesis generation; thus, they were not included in statistical analyses. The measures primarily assessed demographic characteristics and eating behaviors and cognitions.

Demographics questionnaire. A demographics questionnaire (Appendix C) developed by the PI was administered to assess participant characteristics, including year in school, age, and racial identification. This information was used to describe the sample. Participants were also asked when the last time they ate was to ensure that they complied with the 2-hour eating instruction and rated their hunger using a 100-mm visual analogue scale ranging from “not hungry at all” to “extremely hungry”. This variable was used as a covariate in statistical analyses as a way to ensure that hunger levels across participants were standardized/approximately equal.

Three-Factor Eating Questionnaire (TFEQ). The TFEQ (Stunkard & Messick, 1985) (Appendix D) is a 51-item self-report questionnaire designed to measure cognitive and behavioral components of eating. The original factor structure of the TFEQ included three specific dimensions: cognitive restraint of eating (restraint), disinhibition, and hunger. The restraint scale measures conscious control over food intake in order to influence body weight and/or body shape. The disinhibition scale is designed to measure episodes of loss of control over eating, while the hunger scale assesses subjective feelings of hunger and food cravings and their behavioral consequences. Each of the three scales of the TFEQ demonstrates acceptable internal consistency (Cronbach's alphas = .70-.90) (Karlsson, Persson, Sjöström, & Sullivan, 2000). These subscales of TFEQ were used to describe the sample and were not used in the planned statistical analyses.

Experiment Procedures

After completing the self-report measures, participants were randomly assigned to either the ABM condition or the AC condition. An online random number generator was used to generate a random allocation sequence with 1:1 block randomization for the two experimental conditions, and an Excel database indicated the condition assignment for each participant. The PI or research assistant consulted the Excel database prior to the experimental procedures to determine the participant's condition assignment, which the participant was blind to.

Participants completed a visual dot probe task procedure described below (Field & Eastwood, 2005; Macleod, Rutherford, Campbell, Ebsworthy, & Holker, 2002). This procedure consisted of three phases: a pre-training baseline assessment of participants' attentional bias towards healthy and unhealthy food (pretest); a training phase where half of the participants were trained to attend to healthy food (ABM condition), and the other half was not trained to attend to any food group (AC condition); and a post-training assessment of participants' attentional bias towards healthy and unhealthy food, identical to the pretest (posttest).

Stimuli

Stimuli were selected from a normed food picture database (https://sites.google.com/site/eatingandanxietylab/resources/food-pics) that featured food images with simple figure ground compositions for experimental research (Blechert, Meule, Busch, & Ohla, 2014) and included pictures of unhealthy (i.e., high-calorie) and healthy (i.e., low-calorie) foods. Unhealthy food pictures included both sweet (e.g., chocolate, cake) and savory (e.g., pizza, chips) foods, while healthy food pictures included fruits and vegetables. All pictures had the same resolution and color depth and were standardized with regard to background color and camera distance. Further, the healthy and unhealthy food pictures did not differ in color (RGB), brightness, spatial frequencies or contrast, visual complexity, or subjective palatability ratings. The unhealthy food pictures displayed foods with a higher caloric density as compared with the healthy food pictures (Blechert et al., 2014). A total of 16 healthy food pictures and 16 unhealthy food pictures were selected from the database for the visual dot probe task procedure. In addition, 32 non-food (e.g., animals) pictures were selected from the database.

Visual Dot Probe Task Procedure

Pretest. At pretest, participants completed a visual dot probe task. At the start of each trial, participants focused on a black number (3 cm in height) between 1 and 9 positioned in the center of the screen and presented for 500 ms. To ensure that they were centrally fixated, participants were asked to say the number aloud. After the number disappeared, a picture pair appeared on the screen for 500 ms. All pictures were color JPEG files and fit a square measuring 10 cm; the pictures were displayed on the right- and left-hand sides of the screen and were an equal distance (4 cm) from the center.

Immediately after a picture pair disappeared, a probe stimulus (small dot with a 1 cm diameter) was displayed on the screen in a location corresponding to the center of one of the preceding two pictures. Participants were asked to indicate, as quickly and accurately as possible, the position of the probe by pressing one of two buttons on the computer keyboard ("Z" for left and "/" for right). The probe remained displayed until a response was made. Accuracy and reaction time were recorded. There was an interval of 500 ms between trials, which consisted of a black screen.

For the pretest, 10 practice trials preceded the 128 experimental trials. There were 16 critical picture pairs (healthy-unhealthy food) and 16 control picture pairs (animal-animal). Presentation of picture pairs was randomized for each participant. Each picture pair was presented a total of four times, once for each of the picture (left, right) and probe location (left, right) replacement variations. For the pretest, the probe replaced the pictures in each pair with equal frequency (50/50).

Training. In the attentional retraining phase, patients completed a modified version of the visual dot probe task with only the 16 critical picture pairs (healthy-unhealthy food) presented. Each pair was presented 16 times, with each picture presented eight times on each side of the screen, for a total of 256 trials. Following previous research (Schoenmakers, Wiers, Jones, Bruce, & Jansen, 2007), attentional bias was manipulated by following a 90/10 contingency. That is, for participants who were in the ABM condition, the probe replaced the healthy food picture in 90% of the trials, while replaced the unhealthy food picture in only 10% of the trials, to direct their attention to the healthy food. For participants in the AC condition, the probe replaced the unhealthy food picture 50% of the time and the healthy food 50% of the time.

Posttest. The posttest was identical to the pretest, except there were no practice trials, only the 128 experimental trials.

Measurement of Attentional Bias

Reaction time data from the critical trials of the pretest and posttest phases of the visual dot probe task procedure were used to measure attentional bias. Following previous studies (Kakoschke et al., 2014; Nijs, Muris, et al., 2010), incorrect responses were removed, as well as reaction times less than 100 ms and greater than 1000 ms, which are indicative of responses due to anticipation or a lapse in concentration, as well as reaction times more than three standard deviations above or below each participant's mean (Kemps & Tiggemann, 2009). An attentional bias score was calculated for the pretest and posttest phases, separately, by subtracting the median reaction time to the dot probes replacing healthy food pictures from the median reaction time to the dot probes replacing unhealthy food pictures. As such, positive scores were indicative of an attentional bias towards healthy food pictures, while negative scores were indicative of an attentional bias towards unhealthy food pictures. Median reaction time was used as a measure of central tendency to reduce the influence of reaction time outliers (Whelan, 2008) because the reaction time data from the visual dot probe were positively skewed.

Post-Experiment Procedures

Following the visual dot probe task procedure, participants completed a laboratory-based taste test, which assessed participant eating behavior. They then had their height and weight measured by the PI or research assistant using standardized equipment and procedures. Total estimated time to complete the study was one hour.

Laboratory-Based Taste Test

Eating behavior was measured using a laboratory-based taste test. After the visual dot probe procedure, each participant was presented with a tray of four individual bowls equally filled with snack foods along with a bottle of water. There were two healthy snacks (i.e., grapes, baby carrots) and two unhealthy snacks (i.e., mini Oreos, potato chips). These snack foods were chosen as they are commonly eaten and are bite-sized to facilitate eating. Large bowls were used so that participants were unaware of how much they consumed, and 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 four dimensions (i.e., appearance, taste/flavor, texture/mouthfeel, overall liking) using a 9-point hedonic scale (Peryam & Pilgrim, 1957) (Appendix E) while their questionnaire and dot probe data were being "scored and processed" by the study coordinator. Participant ratings of overall liking for the two healthy snack foods were averaged, as well as the two unhealthy snack foods. The ratings of overall liking for the healthy snack food and the unhealthy snack food were entered as covariates in statistical analyses that examined consumption. The purpose of the other three rating dimensions, however, were only to simulate actual taste test procedures. Moreover, participants were told that the food could not be saved or used with other participants due to sanitary concerns, so they could eat as much as they wanted. After 10 minutes, the experimenter returned to the room to continue post-experiment procedures.

Measurement of consumption. To calculate the total amount of each food consumed, the weight (in grams) of the snacks after the taste test was subtracted from the weight of the snacks before the taste test. The weight in grams was then converted into the number of calories consumed for each food. The two healthy snack foods were summed, as well as the two unhealthy snack foods. The dependent variables of interest in the current study were calories consumed from the healthy foods and calories consumed from the unhealthy foods during the bogus taste test.

Height and Weight

Participant height and weight were measured by the PI or research assistant using a commercial grade digital scale and stadiometer. Body mass index (BMI) was calculated using the following equation: $BMI = \frac{Weight\ (kg)}{(Height\ (m))^2}$. BMI group (i.e., HW vs. OW/OB) was examined as a potential moderating variable in statistical analyses.

Debriefing

After all study procedures had been completed, the PI or research assistant informed the participants that their consumption of food during the laboratory-based taste test was measured as an outcome variable.

Statistical Analysis

Specific Aim 1

The first specific aim of this dissertation was to assess the effect of an ABM intervention for healthy eating on attentional bias towards healthy food using a dot probe paradigm. A 2 (training condition: ABM, AC) × 2 (time: pre-training, post-training) mixed analysis of variance (ANOVA) was conducted to determine whether any change in attentional bias score was the result of the interaction between the training condition and time. It was hypothesized that participants in the ABM condition would show a significant increase in attentional bias towards healthy food from pre-training to post-training, and participants in the AC condition would show no change in attentional bias towards healthy food from pre-training to post-training.

Sub-Aim 1.1. The first sub-aim of this dissertation was to assess whether the effect of an ABM intervention for healthy eating on attentional bias towards healthy food would hold across BMI groups (HW, OW/OB). A 2 (training condition: ABM, AC) × 2 (time: pre-training, post-training) × 2 (BMI group: HW, OW/OB) mixed ANOVA was conducted to determine whether any change in attentional bias score from pre-training to post-training was the result of the training condition, and if this effect would be the same across BMI groups. It was hypothesized that both HW and OW/OB participants in the ABM condition would show a significant increase in attentional bias towards healthy food from pre-training to post-training, and both HW and OW/OB participants in the AC condition would show no change in attentional bias score from pre-training to post-training. Overall, it was hypothesized that BMI group would not have a significant moderating effect on the relationship between training condition and attentional bias change.

Specific Aim 2

The second specific aim of this dissertation was to assess the effect of an ABM intervention for healthy eating on healthy food consumption during a laboratory-based taste test, controlling for participant ratings of liking for the healthy food and their hunger level. Two analyses of covariance (ANCOVAs) were conducted to compare the amount of calories consumed from healthy snack food, and amount of calories consumed from unhealthy snack food, between the ABM and AC training conditions. Participant ratings of overall liking for the healthy snack food and the unhealthy snack food, and hunger level, were controlled for in analyses. It was hypothesized that participants in the ABM condition would consume significantly more calories from healthy snack food, and significantly less calories from unhealthy snack food, as compared to participants in the AC group, controlling for participant ratings of liking for the healthy and unhealthy foods and their hunger level.

Sub-Aim 2.1. The second sub-aim of this dissertation was to assess whether the effect of an ABM intervention for healthy eating on healthy food consumption during a laboratory-based taste test would hold across BMI groups (HW, OW/OB), while controlling for participant ratings of liking for the healthy food and their hunger level. Two ANCOVAs were conducted to compare the amount of calories consumed from healthy snack food, and amount of calories consumed from unhealthy snack food, between training conditions (ABM vs. AC) and BMI groups (HW vs. OW/OB), as well as the interaction between training condition and BMI group by entering the following term into the model: training condition*BMI group. Participant ratings of overall liking for the healthy snack food and the unhealthy snack food, and hunger level, were controlled for in analyses. It was hypothesized that both HW and OW/OB participants in the ABM condition would consume significantly more calories from healthy snack food, and significantly less calories from unhealthy snack food, as compared to HW and OW/OB participants in the AC group, controlling for participant ratings of liking for the healthy and unhealthy foods and their hunger level. Overall, it was hypothesized that BMI group would not have a significant moderating effect on the relationship between training condition and caloric consumption of the healthy and unhealthy snack foods.

Power Analysis

Given that the main outcome variable of interest in this dissertation was eating behavior, the following power analysis was conducted based on the parameters needed to carry out the statistical analysis for Sub-Aim 2. As such, the sample size for this dissertation was determined based on an *a priori* power analysis using the following criteria: test family = F tests; statistical test = ANCOVA (fixed effects, main effects, and interactions); nominal alpha level = 0.05; desired power level = 0.80; numerator degrees of freedom = 1 (for powering interaction, [2-1] * [2-1] = 1); number of groups = 4 (2 training conditions * 2 BMI groups = 4); and number of covariates = 2. Additionally, an estimated previous effect size of $f = 0.18$ was inputted based on a similar study that attempted to train healthy eating using an ABM paradigm (Kakoschke et al., 2014). This previous study yielded an effect size of $d = 0.36$ for consumption of healthy food, which was transformed into an f effect size for the current power analysis. Using G*Power software to conduct a power analysis, the analysis yielded a total sample size of 245 participants in order to detect our desired effect. However, given the time and financial restrictions for the current dissertation, obtaining a sample size of 245 was deemed unfeasible. Thus, sample sizes and effect sizes from previous similar studies (see Table 2) were examined and a total sample size of 120 participants was considered to be appropriate.

Table 2

Studies on attentional bias modification for food cues

Authors, year	Sample size	Design	Results	*d*
Kemps, Tiggemann, Orr, & Grear, 2014	88 female college students Unknown BMI	ABM training: ‘attend’ chocolate vs. ‘avoid’ chocolate Consumption DVs = chocolate muffin, blueberry muffin	Training × accuracy interaction: $F(1,86)=29.48$, $p<.001$ ‘Avoid’ group ate less of chocolate muffin than ‘attend’ group, $t(86)=3.32$, $p<.01$ ‘Avoid’ group ate more of blueberry muffin than ‘attend’ group, $t(86)=2.16$, $p<.05$	1.18 .72 .46
Werthmann, Field, Roefs, Nederkoorn, & Jansen, 2014	56 female college students Majority HW	ABM training: attend ‘shoes’ vs. attend ‘chocolate’ Consumption DV: chocolate Additional variable: accuracy (low vs. high)	No differences between ABM training groups in chocolate consumption, $t(49)=.05$, $p=.96$ Training × accuracy interaction: Of participants with high accuracy, those in ‘chocolate’ ate more chocolate than those in ‘shoes’, $t(47)=1.80$, $p=.08$ Of participants with low accuracy, results were reversed, $t(47)=1.72$, $p=.09$	.01 $\beta=.47$ .53 .50
Kakoschke, Kemps, & Tiggemann, 2014	146 female college students Majority HW	ABM training: ‘attend healthy’ food vs. ‘attend unhealthy’ food Consumption DV: healthy snack food consumed as a proportion of total snack food consumption	‘Attend healthy’ group consumed more healthy snack food relative to unhealthy snack food than ‘attend unhealthy’ group, $t(144)=2.23$, $p=.03$	.36

Note: DV = dependent variable

table continues

Authors, year	Sample size	Design	Results	*d*
Boutelle, Kuckertz, Carlson, & Amir, 2014	29 children who eat in the absence of hunger Ages: 8-12 years All OW/OB	ABM training: away from food ('modification') vs. neutral ('control') Consumption DVs: change in % daily caloric needs and kcal consumed during an eating in the absence of hunger (EAH) free access session from pre- to post-training visit	'Control' group showed an increase in EAH% from pre- to post-training visit, whereas 'modification' group showed no change, $F(24)=6.48$, $p=.02$	1.04
			'Control' group showed an increase in EAH kcal from pre- to post-training visit, whereas 'modification' group showed no change, $F(24)=6.02$, $p=.02$	1.00

CHAPTER 4

RESULTS

Demographics and Baseline Measurements

In response to internet and posted advertisements, 324 individuals were screened for participation in the current study. Of the individuals who completed the screening questionnaire, 218 were eligible and 114 completed the study. Reasons for exclusion included: being male, not currently enrolled as a student in the Kansas City metropolitan area, not proficient in English, BMI below 18.5 kg/m^2, allergy to food used in taste test, being on a diet for the purpose of weight loss over the last 3 months, and a score of greater than or equal to 2 on the SCOFF eating disorder screener. Participants were compensated with a $15 American Express gift card or 3 Psych Pool credits for their time. The distribution of the sample between the ABM and AC training conditions was almost equal, with 49.1% of participants assigned to the ABM condition and 50.9% of participants assigned to the AC condition. Further, there was a fairly equal distribution of HW and OW/OB participants amongst the two training conditions: of the total sample, 26.3% of the sample was HW-ABM, 25.4% of the sample was HW-AC, 22.8% of the sample was OW/OB-ABM, and 25.4% of the sample was OW/OB-AC.

Demographics

Demographics for the entire sample and separated by BMI group and training condition are presented in Table 3. Participants had a mean age of 21.13 years (*SD* = 3.77, range 18 – 41), a mean weight of 157.65 pounds (*SD* = 39.66), and a mean BMI of 26.19 kg/m^2 (*SD* = 6.11). The distribution of BMI groups was almost equal, with 51.8% of the sample having a BMI in the HW range and 48.2% of the sample having a BMI in the OW/OB range. The mean BMI of the HW group was 21.65 (*SD* = 1.61) and the mean BMI of the OW/OB group was 31.06 (*SD* = 5.36), with the BMIs of the two groups being statistically significantly different from one another, $t(63.06) = -12.50$, $p < 0.001$. Nearly half of the participants were White (47.8%), 20.4% Black, 16.8% Asian, 9.7% Hispanic, and 5.3% other. The participants were distributed fairly evenly across academic levels: 18.6% freshmen, 19.5% sophomores, 20.4% juniors, 23.9% seniors, and 17.7% other, which included graduate students or students in the 6-year medical school program.

The two BMI groups and two training conditions were very similar in terms of demographic makeup. The two BMI groups did not differ in terms of age, race, or academic level distribution. The two training conditions did not differ in terms of age, BMI, race, or academic level distribution.

Baseline Measurements

Baseline measurement values for the entire sample and separated by BMI group and training condition are also presented in Table 3.

TFEQ. The TFEQ measures three components of eating behavior: dietary restraint, disinhibition of control over eating, and perceived hunger. Mean scores on the three components for the entire sample were: Restraint 8.71 (*SD* = 4.49), Disinhibition 6.21 (*SD* = 3.21), and Hunger 5.40 (*SD* = 2.73). For comparison purposes, normative data for a sample of unrestrained eaters used in the original study validating the TFEQ were Restraint 6.0 (SD = 5.5), Disinhibition 5.6 (SD = 4.3), and Hunger 7.0 (SD = 4.3) (Stunkard & Messick, 1985). The two training conditions did not differ from one another on any of the three TFEQ subscales. The two BMI groups also did not differ from one another on any of the three TFEQ subscales, although there was a trend for OW/OB

Table 3

Participant demographics and baseline measurements

	Entire Sample (N = 114)	Training Conditions			BMI Groups		
		ABM (n = 56)	AC (n = 58)	*p*	HW (n = 59)	OW/OB (n = 55)	*p*
Age (years)	21.13 (3.77)	21.36 (3.41)	20.91 (4.10)	.532	20.93 (3.60)	21.35 (3.96)	.561
Height (inches)	65.01 (2.67)	64.93 (2.60)	65.08 (2.75)	.772	65.43 (2.81)	64.55 (2.45)	.077
Weight (lbs)	157.65 (39.66)	152.87 (34.46)	162.26 (43.92)	.209	132.17 (16.12)	184.97 (39.31)	**<.001**
BMI (kg/m^2)	26.19 (6.11)	25.46 (5.29)	26.89 (6.79)	.213	21.65 (1.61)	31.06 (5.36)	**<.001**
Race				.364			.216
White	54 (47.8%)	30 (53.6%)	24 (42.1%)		29 (50.0%)	25 (45.5%)	
Black	23 (20.4%)	8 (14.3%)	15 (26.3%)		11 (19.0%)	12 (21.8%)	
Asian	19 (16.8%)	9 (16.1%)	10 (17.5%)		13 (22.4%)	6 (10.9%)	
Hispanic	11 (9.7%)	7 (12.5%)	4 (7.0%)		3 (5.2%)	8 (14.5%)	
Other	6 (5.3%)	2 (3.6%)	4 (7.0%)		2 (3.4%)	4 (7.3%)	
Grade Level				.072			.116
Freshman	21 (18.6%)	6 (10.7%)	15 (26.3%)		14 (24.1%)	7 (12.7%)	
Sophomore	22 (19.5%)	8 (14.3%)	14 (24.6%)		7 (12.1%)	15 (27.3%)	
Junior	23 (20.4%)	14 (25.0%)	9 (15.8%)		10 (17.2%)	13 (23.6%)	
Senior	27 (23.9%)	17 (30.4%)	10 (17.5%)		14 (24.1%)	13 (23.6%)	
Other	20 (17.7%)	11 (19.6%)	9 (15.8%)		13 (22.4%)	7 12.7%)	
TFEQ							
Restraint	8.71 (4.49)	9.25 (4.27)	8.18 (4.67)	.205	8.24 (4.37)	9.20 (4.60)	.258
Disinhibition	6.21 (3.21)	6.29 (3.40)	6.14 (3.03)	.811	5.66 (3.04)	6.80 (3.30)	.057
Hunger	5.40 (2.73)	5.39 (2.47)	5.40 (2.98)	.984	5.59 (2.61)	5.20 (2.86)	.454
Hunger Level	53.51 (23.23)	51.89 (24.28)	55.11 (22.24)	.393	57.95 (21.14)	48.84 (24.58)	**.034**
Liking Healthy	2.31 (1.33)	2.44 (1.25)	2.18 (1.40)	.312	2.31 (1.02)	2.31 (1.61)	.961
Liking Unhealthy	2.40 (1.26)	2.47 (1.13)	2.34 (1.39)	.595	2.61 (0.92)	2.18 (1.53)	.077

participants to have higher Disinhibition scores than their HW counterparts (*M* = 6.80, *SD* = 3.30, compared to *M* = 5.66, *SD* = 3.04, respectively), $t(111) = -1.92$, $p = 0.057$.

Further, scores on the three TFEQ subscales were correlated with pre-training attentional bias scores to examine the possible relationship between a measure of eating behavior and attentional bias to food cues. Restraint was the only subscale that was significantly correlated with pre-training attentional bias, and this relationship was only significant amongst the OW/OB group ($r = 0.34$, $p = 0.018$), whereby greater Restraint scores were associated with greater attentional bias towards healthy foods.

Hunger level. Participants were asked to rate their hunger on a 100 mm visual analogue scale ranging from “not hungry at all” (0) to “extremely hungry” (100) prior to completing the experimental procedures. This variable was assessed in order to control for hunger levels in statistical analyses examining food consumption during the laboratory taste test.

Hunger level ratings were compared by means of univariate analysis of variance (ANOVA) to check for differences between training conditions and BMI groups. Hunger level rating was entered as the dependent variable and training condition (ABM vs. AC) and BMI group (HW vs. OW/OB) were entered as between-subjects factors. There was a significant difference in hunger level rating between BMI groups, with HW participants reporting greater hunger levels (*M* = 57.95, SD = 21.14) compared to OW/OB participants (*M* = 48.84, SD = 24.58), $F(1,109) = 4.63$, $p = 0.034$. There were no significant differences in hunger level rating between training conditions and no significant training condition × BMI group interaction. Further, hunger level was not correlated with healthy calories consumed, unhealthy calories consumed, or total calories consumed during the laboratory taste test for the entire sample nor within BMI groups.

Food ratings. To assess food preferences and determine if individuals consume the types of foods they report liking, ratings of liking (ranging from “dislike extremely” [-4] to “like extremely” [4]) were acquired for all four snack foods presented during the laboratory taste test. Liking ratings for healthy and unhealthy foods were averaged and controlled for in statistical analyses that examined food consumption.

Liking ratings were compared by means of two univariate ANOVAs to check for differences between training conditions and BMI groups. Liking ratings for the healthy foods and unhealthy foods were entered separately in each model as the dependent variable and training condition (ABM vs. AC) and BMI group (HW vs. OW/OB) were entered as between-subjects factors. There were no significant differences in liking ratings of the healthy or unhealthy foods between the training conditions or BMI groups, and there was no significant training condition × BMI group interaction. Further, liking of the unhealthy foods was positively correlated with amount of calories consumed from the unhealthy foods ($r = 0.26$, $p = 0.005$); however, liking of the healthy foods was not correlated with amount of calories consumed from the healthy foods ($r = 0.11$, $p = 0.238$).

Pre-training attentional bias scores. Pre-training (baseline) differences in attentional bias scores between training conditions and BMI groups were compared by means of univariate ANOVA. Pre-training attentional bias score was entered as the dependent variable and training condition (ABM vs. AC) and BMI group (HW vs. OW/OB) were entered as between-subjects factors. Please note that attentional bias score data from four participants were excluded from this analysis, as well as from remaining analyses that examine attentional bias score as a dependent variable, as they were diagnosed as extreme outliers compared to the rest of the sample based on their attentional bias scores via examination of boxplots.

The mean pre-training attentional bias score for the entire sample was -0.15 (SE = 1.42), which indicates a slight attentional bias towards unhealthy food, but this was not statistically different from zero when analyzed via a subsequent one-sample t-test, $t(104) = -0.15$, $p = 0.884$. Results from the ANOVA indicated no significant differences in pre-training attentional bias scores between the training conditions or BMI groups, and there was no significant training condition × BMI group interaction, $F(1,101) = 1.08$, $p = 0.301$. The mean pre-training attentional bias scores for the two training conditions were as follows: ABM -0.64 (SE = 2.04) and AC 0.34 (SE = 1.98), $F(1,101) = 0.12$, $p = 0.732$. The mean pre-training attentional bias scores for the two BMI groups were as follows: HW -1.08 (SE = 1.92) and OW/OB 0.77 (SE = 2.10), $F(1,101) = 0.42$, $p = 0.516$.

In order to determine if the experimental training conditions had differential effects on persons who had demonstrated baseline attentional biases towards healthy or unhealthy foods in *post hoc* exploratory analyses, pre-training attentional bias scores were dichotomized as either "healthy" or "unhealthy" depending on the sign of the attentional bias score, with positive scores indicating a healthy attentional bias and negative scores indicating an unhealthy attentional bias. The proportion of participants who demonstrated a healthy vs. unhealthy pre-training attentional bias was fairly equal, with 47.6% demonstrating a healthy attentional bias and 52.4% demonstrating an unhealthy attentional bias at baseline. Per chi-square analyses, the proportion of participants with healthy vs. unhealthy attentional bias scores at baseline was equal across training groups, X^2 (1, N = 105) = 0.45, p = 0.503, but not across BMI groups, X^2 (1, N = 105) = 4.07, p = 0.044, such that more HW participants demonstrated unhealthy (61.4%) vs. healthy (38.6%) attentional bias scores, and more OW/OB participants demonstrated healthy (58.3%) vs. unhealthy (41.7%) attentional bias scores.

Pre-training reaction times. Pre-training (baseline) differences in reaction times to probes replacing healthy vs. unhealthy food pictures between training conditions and BMI groups were compared by means of multivariate ANOVA. Pre-training reaction times for healthy and unhealthy foods were entered as the dependent variables, and training condition (ABM vs. AC) and BMI group (HW vs. OW/OB) were entered as between-subjects factors.

The mean pre-training reaction times to healthy and unhealthy foods for the entire sample were 322.65 (*SE* = 5.35) ms and 322.48 (*SE* = 5.41) ms, respectively. Results from the ANOVA indicated no significant differences in pre-training reaction times to healthy and unhealthy foods between the training conditions, and there were no significant training condition × BMI group interactions for neither healthy nor unhealthy foods. There was a significant main effect of BMI group whereby the HW participants demonstrated faster reaction times overall to both healthy foods, $F(1,101) = 6.94$, p = 0.010, and unhealthy foods, $F(1,101) = 7.72$, p = 0.007, compared to their OW/OB counterparts. The mean pre-training reaction times to healthy and unhealthy foods, respectively, for the two BMI groups were as follows: HW 308.54 (*SE* = 7.23) ms and 307.46 (*SE* = 7.31) ms; OW/OB 336.73 (*SE* = 7.88) ms and 337.50 (*SE* = 7.97) ms.

Aims and Hypotheses Results

Specific Aim 1

The first specific aim of this study was to assess the effect of an ABM intervention for healthy eating on attentional bias towards healthy food using a dot probe paradigm.

Hypothesis 1. It was hypothesized that participants in the ABM condition would show a significant increase in attentional bias towards healthy food from pre-training to post-training, and participants in the AC condition would show no change in attentional bias towards healthy food from pre-training to post-training. Thus, results that support this hypothesis would indicate a significant training condition × time interaction.

As a reminder, attentional bias scores from the visual dot probe task were calculated from the critical trials that displayed picture pairs consisting of a healthy food and an unhealthy food. Attentional bias scores were calculated by subtracting reaction times (all reaction times were in milliseconds) to identify probes that replaced healthy food pictures from reaction times to identify probes that replaced unhealthy food pictures. In the current sample, attentional bias scores ranged from -52.0 to 40.0 at pre-training, and from -52.0 to 58.5 at post-training. Positive attentional bias scores represent a bias in attention towards healthy food (because the reaction times to these pictures were faster than the reaction times to unhealthy foods), whereas negative attentional bias scores represent a bias in attention towards unhealthy foods (because the reaction times to these pictures were faster than the reaction times to healthy foods).

Statistical Analysis 1. A 2 (training condition: ABM, AC) × 2 (time: pre-training, post-training) mixed ANOVA was conducted to determine whether any change in attentional bias score was the result of the interaction between the training condition and time. Time was entered as the within-subjects factor and training condition was entered as the between-subjects factor. As a reminder, four participants were excluded from this analysis as they were diagnosed as extreme outliers compared to the rest of the sample based on their pre-training or post-training attentional bias scores via examination of boxplots.

Results 1. In contrast to the hypothesis, there was no significant training condition × time interaction, $F(1,102) = 1.639$, $p = 0.203$, $\eta^2 = 0.016$. Given that the two training conditions did not differ at baseline with regards to attentional bias scores, this lack of a significant interaction effect implies that the ABM training did not work in terms of modifying attentional biases to be healthier. Attentional bias scores are depicted by training condition in Table 4. Further, there was no significant main effect of time, $F(1,102) = 0.257$, $p = 0.613$, $\eta^2 = 0.003$, or condition, $F(1,102) = 0.691$, $p = 0.408$, $\eta^2 = 0.007$.

Table 4

Attentional bias scores by training condition, with F-test values for training condition × time interaction effect

AB Score	N = 104		ABM (n = 51)		AC (n = 53)		*F*	*p*	η^2
	M	SE	M	SE	M	SE			
Pre	-0.14	1.42	-0.59	2.03	0.30	2.00	1.639	0.203	0.016
Post	0.98	1.76	3.35	2.52	-1.40	2.47			

Note: + AB scores = AB towards healthy foods
– AB scores = AB towards unhealthy foods

Exploratory Post Hoc Analysis 1. Given that the theory behind ABM interventions lies within the addictions, whereby an attentional bias towards unhealthy food cues may predict future consumption of unhealthy foods and ultimately play a role in the development and maintenance of OW/OB, it was of particular interest to determine whether the ABM intervention in the current study had an effect on participants who demonstrated baseline attentional bias scores towards unhealthy food. To examine this, a *post hoc* 2 (training condition: ABM, AC) × 2 (time: pre-training, post-training) mixed ANOVA was conducted on a subset (n = 54) of the sample who had negative pre-training attentional bias scores (which represented a bias in attention towards unhealthy foods) to determine whether any change in attentional bias score was the result of the interaction between the training condition and time.

Results from the mixed ANOVA revealed that while there was no significant training condition × time interaction, $F(1,52) = 1.365$, $p = 0.248$, $\eta^2 = 0.026$, nor main effect of condition, $F(1,52) = 0.125$, $p = 0.726$, $\eta^2 = 0.002$, there was a significant main effect of time, $F(1,52) = 11.308$, $p = 0.001$, $\eta^2 = 0.179$. The main effect of time showed that, on average, participants with attentional biases towards unhealthy foods (represented as negative attentional bias scores) at baseline demonstrated an increase in attentional bias score from pre-training to post-training, which means that their attentional bias became "healthier" with time and closer to zero. The mean attentional bias score at pre-training for this subset of the sample was -10.33 (*SD* = 10.28) and, at post-training, was --1.57 (*SD* = 16.22). It is likely that this main effect of time on attentional bias score depicts a regression to the mean, as the opposite main effect of time was observed for the subset (n = 50) of the sample who had positive attentional bias scores (which represented a bias in attention towards healthy foods) at baseline, whereby their mean attentional bias score at pre-training was 10.88 (*SD* = 9.31) and, at post-training, was 3.63 (*SD* = 19.63), $F(1,48) = 5.313$, $p = 0.026$, $\eta^2 = 0.100$, thus suggesting that their attentional bias became "unhealthier" with time and closer to zero.

Exploratory Post Hoc Analysis 2. The ABM intervention utilized in this study attempted to retrain participants' automatic attentional processes by having the probe replace healthy food pictures during most (i.e., 90%) of the trials of the dot probe task. Even if attentional bias scores (which take into account reaction time to healthy foods *as compared to* reaction time to unhealthy foods) did not change from pre-training to post-training for neither the ABM or AC groups, it might still be expected that participants in the ABM group would demonstrate a greater decrease in reaction time to healthy food pictures *alone* from pre-training to post-training as compared to participants in the AC group (whom were not trained to preferentially attend to either healthy or unhealthy food pictures). To examine this, a *post hoc* 2 (training condition: ABM, AC) × 2 (time: pre-training, post-training) × 2 (food type: healthy, unhealthy) mixed ANOVA was conducted to determine whether any change in reaction time was the result of an interaction between training condition, time, and type of food stimuli. If the ABM group demonstrated a greater decrease in reaction time to healthy food pictures only (and not to unhealthy food pictures) as compared to the AC group, then a significant three-way interaction would be expected.

Results from the mixed ANOVA revealed that there was no significant training condition × time × food type interaction, $F(1,102) = 1.639$, $p = 0.203$, $\eta^2 = 0.016$, on reaction times. Reaction times to healthy and unhealthy food pictures at pre-training and post-training are depicted by training condition in Table 5.

Table 5

Reaction times (ms) to healthy and unhealthy food pictures at pre-training and post-training, depicted by training group

Reaction Time (ms)	ABM (n = 51)				AC (n = 53)			
	Pre		Post		Pre		Post	
	M	SE	M	SE	M	SE	M	SE
Healthy	325.65	7.94	303.64	6.50	317.84	7.79	312.45	6.37
Unhealthy	325.06	8.01	306.99	6.08	318.14	7.86	311.05	5.97

Exploratory Post Hoc Analysis 3. Given the findings that the ABM intervention used in this study did not have an effect on change in attentional bias towards healthy foods, nor reaction time to healthy foods, from pre-training to post-training, an important question to ask is whether or not the ABM intervention used in this study "worked". It is possible that any effects of the ABM intervention, which was administered during the training phase of the study, could have been diluted or weakened during the posttest. This could be expected because, during the training phase of the ABM condition, the probe replaced healthy food pictures during 90% of the trials of the dot probe task and then, during the posttest phase, the probe returned to replacing healthy and unhealthy food pictures equally (50%). As such, it is possible that an "extinction" effect could have occurred once the probe was no longer replacing the healthy food pictures most of the time.

To determine whether the ABM intervention actually "worked" but its effects were just diluted from the posttest, both attentional bias scores and reaction times to healthy and unhealthy food pictures were examined separately for the first half and second half of the training phase of the dot probe task. If the ABM intervention "worked", it would be expected that attentional bias scores would become "healthier", and reaction time to healthy food pictures would become faster, from the first to the second half of the training phase only for participants in the ABM condition.

A *post hoc* 2 (training condition: ABM, AC) × 2 (training phase time: first half, second half) mixed ANOVA was conducted to determine whether *attentional bias scores* changed from the first half to the second half of the training phase of the dot probe task. Although there was no significant training condition × training phase time interaction, $F(1,53) = 0.028$, $p = 0.868$, $\eta^2 = 0.001$, there was a significant main effect of training condition, $F(1,53) = 5.495$, $p = 0.023$, $\eta^2 = 0.094$. This main effect revealed that participants in the ABM condition demonstrated overall healthier attentional bias scores ($M = 12.87$, $SE = 4.34$) than participants in the AC condition ($M = -1.16$, $SE = 4.11$) during the training phase of the dot probe task.

A *post hoc* 2 (training condition: ABM, AC) × 2 (training phase time: first half, second half) × 2 (food type: healthy, unhealthy) mixed ANOVA was conducted to determine whether *reaction times* to healthy and unhealthy food pictures changed from the first half to the second half of the training phase of the dot probe task. Although there was no significant training condition × training phase time × food type interaction, $F(1,53) = 0.028$, $p = 0.868$, $\eta^2 = 0.001$, there was a significant training condition × food type interaction, $F(1,53) = 5.495$, $p = 0.023$, $\eta^2 = 0.094$. This interaction showed that participants in the ABM condition responded much faster to healthy food pictures ($M = 301.49$, $SE = 9.41$) than to unhealthy food pictures ($M = 314.36$, $SE = 10.53$), whereas participants in the AC condition responded at a similar speed to both healthy (*M* = 326.82, *SE* = 8.91) and unhealthy food pictures (*M* = 325.66, *SE* = 9.97).

Sub-Aim 1.1

The first sub-aim of this study was to assess whether the effect of an ABM intervention for healthy eating on attentional bias towards healthy food would hold across BMI groups (HW, OW/OB).

Hypothesis 1.1. It was hypothesized that both HW and OW/OB participants in the ABM condition would show a significant increase in attentional bias towards healthy food from pre-training to post-training, and both HW and OW/OB participants in the AC condition would show no change in attentional bias score from pre-training to post-training. Overall, it was hypothesized that BMI group would not have a significant moderating effect on the relationship between training condition and attentional bias change. Thus, results that support this hypothesis would indicate a significant training condition × time interaction, and an absence of a significant training condition × time × BMI group interaction.

Statistical Analysis 1.1. A 2 (training condition: ABM, AC) × 2 (time: pre-training, post-training) × 2 (BMI group: HW, OW/OB) mixed ANOVA was conducted to determine whether any change in attentional bias score from pre-training to post-training was the result of the training condition, and if this effect would be the same across BMI groups. Time was entered as the within-subjects factor and training condition and BMI group were entered as the between-subjects factors. As a reminder, four participants were excluded from this analysis as they were diagnosed as extreme outliers compared to the rest of the sample based on their pre-training or post-training attentional bias scores via examination of boxplots.

Results 1.1. In contrast to the hypothesis, there was no significant training condition × time interaction, $F(1,100) = 1.657$, $p = 0.201$, $\eta^2 = 0.016$. Consistent with the hypothesis, however, there was also no significant training condition × time × BMI group interaction, $F(1,100) = 0.070$, $p = 0.792$, $\eta^2 = 0.001$. Again, given that there were no significant differences in pre-training attentional bias scores between the training conditions or BMI groups, and there was no significant training condition × BMI group interaction, the lack of a significant interaction effect between training condition × time implies that the ABM training was unsuccessful in modifying attentional biases to be healthier, for both the HW and OW/OB groups. Attentional bias scores are depicted by training condition within HW and OW/OB BMI groups in Table 6.

Table 6

Attentional bias scores by training condition within HW and OW/OB BMI groups, with F-test values for training condition × time interaction effect

AB Score	HW-ABM (n = 28)		HW-AC (n = 29)		OW/OB-ABM (n = 23)		OW/OB-AC (n = 24)		*F*	*p*	η^2
	M	SE	M	SE	M	SE	M	SE			
Pre	-0.09	2.75	-2.07	2.70	-1.20	3.03	3.17	2.97	1.657	0.201	0.016
Post	3.75	3.42	-2.80	3.36	2.87	3.78	0.29	3.70			

Note: + AB scores = AB towards healthy foods
– AB scores = AB towards unhealthy foods

Specific Aim 2

The second specific aim of this study was to assess the effect of an ABM intervention for healthy eating on healthy food consumption during a laboratory-based taste test, controlling for participant ratings of liking for the healthy food and their hunger level.

Hypothesis 2. It was hypothesized that participants in the ABM condition would consume significantly more calories from healthy snack food, and significantly less calories from unhealthy snack food, as compared to participants in the AC group, controlling for participant ratings of liking for the healthy and unhealthy foods and their hunger level. Thus, results that support this hypothesis would indicate a significant main effect of training condition.

Statistical Analysis 2. Two analyses of covariance (ANCOVAs) were conducted to compare the amount of calories consumed from healthy snack food, and amount of calories consumed from unhealthy snack food, between the ABM and AC training conditions. Calories consumed from the healthy foods and unhealthy foods were entered separately in each model as the dependent variable, training condition (ABM vs. AC) was entered as the between-subjects factor, and participant rating of their hunger level was entered as a covariate. Participant ratings of liking for the healthy snack food and the unhealthy snack food were entered separately in each model as additional covariates. One participant was excluded from this analysis as her consumption data (specifically, the amount of calories she consumed from unhealthy snack foods) was diagnosed as an extreme outlier compared to the rest of the sample based on examination of boxplots.

Results 2. In contrast to the hypothesis, there was no significant main effect of training condition on amount of calories consumed from healthy snack food, $F(1,108) = 1.387$, $p = 0.242$, $\eta^2 = 0.013$, or unhealthy snack food, $F(1,108) = 0.401$, $p = 0.528$, $\eta^2 = 0.004$. Amount of calories consumed from healthy snack food and unhealthy snack food are depicted by training condition in Table 7.

Table 7

Amount of calories consumed from healthy snack food and unhealthy snack food by training condition, with F-test values for main effect of training condition

Calories Consumed	N = 112		ABM (n = 55)		AC (n = 57)		*F*	*p*	η^2
	M	SE	M	SE	M	SE			
Healthy	79.82	8.70	74.69	10.06	84.96	9.39	1.387	0.242	0.013
Unhealthy	120.46	23.60	113.47	26.54	127.45	25.56	0.401	0.528	0.004

Note: Covariates in the model were evaluated at the following values: hunger level = 50 ("moderately hungry"), liking for the healthy/unhealthy snack foods = 0 ("neither like nor dislike").

Exploratory Post Hoc Analysis 1. Consumption of each of the four snack foods, as measured in grams (instead of calories), was also compared between training conditions. An ANCOVA was conducted for each of the four snack foods, with consumption in grams as the dependent variable, and hunger level and rating of liking entered as covariates. Results from the ANCOVAs revealed that there were no differences between training conditions with regards to grams consumed for each of the four snack foods, including grapes, $F(1,108) = 2.059$, $p = 0.154$, carrots, $F(1,108) = 1.379$, $p = 0.243$, chips, $F(1,108) = 1.673$, $p = 0.199$, and mini Oreos, $F(1,108) = 0.017$, $p = 0.896$.

Exploratory Post Hoc Analysis 2. Research on the role of contingency awareness in ABM training is mixed – some studies show that training only affects those with awareness (Field & Duka, 2002), whereas others show that awareness does not impact training effects (Field & Eastwood, 2005). In the current study, contingency awareness during the training phase was assessed with two items: the first was an open-ended question asking participants to describe the relationship between the food picture type and dot probe location, and the second was a multiple-choice question asking participants to select the correct option from five statements describing possible relationships. A participant was considered to have contingency awareness if she responded correctly to at least one of the two questions.

To examine the effect of contingency awareness on consumption behavior in the ABM group, two ANCOVAs were conducted to compare the amount of calories consumed from healthy snack food, and amount of calories consumed from unhealthy snack food, between participants who were aware vs. unaware of the contingency during the ABM training, with hunger level and ratings of liking entered as covariates. Results from the ANCOVAs yielded no significant main effects for contingency awareness on calories consumed from healthy, $F(1,52) = 0.506$, $p = 0.480$, or unhealthy, $F(1,52) = 0.466$, $p = 0.498$, snack food.

Sub-Aim 2.1

The second sub-aim of this study was to assess whether the effect of an ABM intervention for healthy eating on healthy food consumption during a laboratory-based taste test would hold across BMI groups (HW, OW/OB), while controlling for participant ratings of liking for the healthy food and their hunger level.

Hypothesis 2.1. It was hypothesized that HW and OW/OB participants in the ABM condition would consume significantly more calories from healthy snack food, and significantly less calories from unhealthy snack food, as compared to HW and OW/OB participants in the AC group, controlling for participant ratings of liking for the healthy and unhealthy foods and their hunger level. Overall, it was hypothesized that BMI group would not have a significant moderating effect on the relationship between training condition and caloric consumption of the healthy and unhealthy snack foods. Thus, results that support this hypothesis would indicate a significant main effect of training condition, and an absence of a significant training condition × BMI group interaction.

Statistical Analysis 2.1. Two ANCOVAs were conducted to compare the amount of calories consumed from healthy snack food, and amount of calories consumed from unhealthy snack food, between training conditions (ABM vs. AC) and BMI groups (HW vs. OW/OB), as well as the interaction between training condition and BMI group by entering the following term into the model: training condition*BMI group. Calories consumed from the healthy foods and unhealthy foods were entered separately in each model as the dependent variable, training condition (ABM vs. AC) and BMI group (HW vs. OW/OB) were entered as the between-subjects factors, and participant rating of their hunger level was entered as a covariate. Participant ratings of liking for the healthy snack food and the unhealthy snack food were entered separately in each model as additional covariates. As a reminder, one participant was excluded from this analysis as her consumption data (specifically, the amount of calories she consumed from unhealthy snack foods) was diagnosed as an extreme outlier compared to the rest of the sample based on examination of boxplots.

Results 2.1. In contrast to the hypothesis, there was no significant main effect of training condition on amount of calories consumed from healthy snack food, $F(1,106) =$

1.277, $p = 0.261$, $\eta^2 = 0.012$, or unhealthy snack food, $F(1,106) = 0.349$, $p = 0.556$, $\eta^2 = 0.003$. Consistent with the hypothesis, however, there was also no significant training condition × BMI group interaction for either healthy food consumption, $F(1,106) = 0.298$, $p = 0.586$, $\eta^2 = 0.003$, or unhealthy food consumption, $F(1,106) = 2.008$, $p = 0.159$, $\eta^2 = 0.019$. Further, there was no significant main effect of BMI group on amount of calories consumed from healthy snack food, $F(1,106) = 0.249$, $p = 0.619$, $\eta^2 = 0.002$, or unhealthy snack food, $F(1,106) = 0.013$, $p = 0.910$, $\eta^2 = 0.000$. Amount of calories consumed from healthy snack food and unhealthy snack food are depicted by training condition within HW and OW/OB BMI groups in Table 8.

Table 8

Amount of calories consumed from healthy snack food and unhealthy snack food by training condition within HW and OW/OB BMI groups, with F-test values for main effect of training condition

Calories Consumed	HW-ABM (n = 29)		HW-AC (n = 28)		OW/OB-ABM (n = 26)		OW/OB-AC (n = 29)		*F*	*p*	η^2
	M	SE	M	SE	M	SE	M	SE			
Healthy	70.26	11.82	84.99	11.33	79.49	12.10	84.65	11.22	1.277	0.261	0.012
Unhealthy	98.73	31.70	143.10	32.12	132.61	30.72	114.35	28.30	0.349	0.556	0.003

Note: Covariates in the model were evaluated at the following values: hunger level = 50 (“moderately hungry”), liking for the healthy/unhealthy snack foods = 0 (“neither like nor dislike”).

CHAPTER 5

DISCUSSION

Summary of Aims and Overall Findings

The purpose of the present study was two-fold in that it sought to determine whether a single-session ABM training designed to promote healthy eating could 1) induce an attentional bias towards healthy food cues as measured by a dot probe task and, subsequently, 2) increase consumption of healthy foods during a laboratory-based eating behavior assessment. The concept of the ABM training, specifically with regards to modifying human attention towards food cues in the environment, has been derived from an adapted addiction model to explain the development and maintenance of OB. The visual dot probe task used in this study had been modified from studies of addiction to assess attentional bias specific to food stimuli (pictures of healthy foods and unhealthy foods) in HW and OW/OB females. An ABM task training attention towards healthy food stimuli was randomly assigned to half of the participants in each BMI group.

Pre-training and post-training attentional bias to the food stimuli was compared between women who completed the ABM training condition and an attentional control (AC) condition. BMI group was also examined as a possible moderating factor in the relationship between the ABM training and change in attentional bias from pre-training to post-training. Further, caloric consumption from healthy snack foods and unhealthy snack foods presented during a bogus taste test were also compared between women who complete the ABM training condition and AC condition, and BMI group was again examined as a possible moderating factor in the relationship between the ABM training and eating behavior.

The overarching conclusion from this study is that no straightforward answer can yet be provided to the main questions of 1) whether or not attention to food stimuli can be manipulated using a computer-based attentional bias modification strategy adapted from the addictions, or 2) whether or not this type of attentional bias modification strategy can influence eating behavior. Furthermore, the findings from this study also add to the mixed literature regarding the relationship between attentional bias to food stimuli and weight status, whereby there was a lack of BMI group differences in attentional bias scores at baseline.

Discussion of Baseline Attentional Bias Findings

The foundation on which food-related ABM trainings have been developed has focused on the evidence that individuals with OW/OB have sometimes demonstrated greater biases for unhealthy foods than their HW counterparts, and greater biases for unhealthy foods have been associated with increases in BMI over time. Findings from the current study do not support these findings, in that the HW and OW/OB participants in the current sample did not differ from one another on baseline attentional bias scores. That is, this study does not provide evidence that individuals with OW/OB demonstrate greater biases for unhealthy foods than their HW counterparts, as some previous studies (Wethmann et al., 2011; Nijs, Franken, et al., 2010; Nijs, Muris, et al., 2010) have found.

A systematic review (Hendriskse et al., 2015) of the literature on differences in attentional biases to food cues among HW and OW/OB individuals reported that 15 out of 19 studies analyzed yielded results supporting the notion of enhanced reactivity to food stimuli (compared to non-food stimuli) in individuals with OW/OB. However, the authors qualified this by stating that supportive findings were primarily observed in studies that employed psychophysiological techniques to measure attentional bias, including EEG, eye-tracking, and fMRI methodologies. In fact, the majority of the studies using dot probe methodology did not find group differences in attentional bias to food stimuli between OW/OB and HW individuals.

Specifically within dot probe studies, it is important to consider the stimuli presented during the task. In Hendriskse (2015) et al.'s review, most of the dot probe studies included picture pairs consisting of either high- or low-calorie foods paired with a non-food picture, and conclusions were based on group differences in attentional bias to food-related stimuli compared to non-food stimuli overall, vs. comparing high- to low-calorie food. It is possible that group differences would be more likely to be observed in studies where the "control" stimuli is non-food, vs. in the current study whereby attentional bias is compared between unhealthy food and healthy food. It is hypothesized that effect sizes would be larger in the former case.

In addition to methodological considerations, another reason for the current study's lack of significant findings regarding BMI group differences in baseline attentional bias towards food stimuli could be due to variable hunger levels across the participants. Some research (Nijs, Muris, et al., 2010; Loeber, Grosshans, Herpertz, Kiefer, & Herpertz, 2013) has found hunger level to have differential effects on attentional bias to unhealthy food pictures in HW compared to OW/OB women. Specifically, greater attentional bias has been demonstrated in HW females when they are hungry vs. sated, and this relationship was not demonstrated in OW/OB females. While the current study attempted to standardize hunger level by requiring all participants to refrain from eating or drinking anything besides water two hours prior to testing, selfrated hunger levels were still variable across participants in the sample and ranged from 0 to 100. However, in *post hoc* investigations of hunger level as a covariate in analyses that examined BMI group differences in attentional bias to food cues, the addition of hunger level as a covariate did not change the results nor reveal group differences. Still, hunger level perhaps could have been more standardized if patients were asked to consume a standardized meal in the laboratory prior to experimental procedures. In addition, the findings from the current study also urge the need for continued research in this area and replication of findings, especially across studies with the same methodology.

Discussion of ABM Training on Attentional Bias Findings

Contrary to predictions, the current study did not find evidence for the notion that attention to food stimuli can be manipulated using a computer-based attentional bias modification strategy adapted from the addictions. Pre-training and post-training attentional bias to food stimuli was compared between women who completed an ABM training condition and an AC condition, and BMI group was also examined as a possible moderating factor in this relationship. Overall, it was hypothesized that there would be a significant time × training condition interaction, whereby participants in the ABM condition (regardless of BMI group status) would show a significant increase in attentional bias towards healthy food from pre-training to post-training, and participants in the AC condition would show no change in attentional bias. Contrary to predictions, we did not find any significant time × training condition interaction for the entire sample.

An exploratory analysis that examined the possibility of a time × training condition interaction only in participants who had a baseline attentional bias towards healthy foods also did not reveal a significant interaction effect. The only significant finding from this exploratory analysis was a main effect of time which showed that participants with unhealthy attentional biases at baseline demonstrated an increase in attentional bias score from pre-training to post-training, which means that their attentional bias became “healthier” with time and closer to zero. It is likely that this main effect of time depicted a regression to the mean, as the opposite main effect of time was observed for a subset of the sample who had healthy attentional bias scores at baseline.

One explanation for the lack of training condition group differences in attentional bias to healthy and unhealthy food pictures during the visual dot probe task could be the stimulus presentation duration. In the current study, picture pairs were displayed on the computer screen for a total of 500 ms and participants were asked to indicate the position of the probe when the picture pair disappeared. Although the majority of dot probe studies have used a stimulus presentation duration of 500 ms, this duration has been criticized because eye saccades can be made within less than half of this time (200 ms). Thus, attention could have already shifted between the healthy and unhealthy food pictures before the probe appeared (van Rooijen, Ploeger, & Kret, 2017).

As such, the reaction time data obtained from this study likely does not provide information about initial orientation to healthy and unhealthy food pictures (Bradley, Mogg, & Millar, 2000), but possibly rather a maintained attention or even a coincident direction of the eyes to one of the pictures at a particular moment (Field & Cox, 2008). This might also explain the absence of significant BMI group differences in studies examining maintained attention to food-related stimuli using the dot probe task (Castellanos, Charboneau, Dietrich, et al., 2009; Wethmann, Roefs, Nederkoorn, et al., 2011; Nijs, Muris, Euser, & Franken, 2010). Further, previous research has shown that the effect sizes in studies that utilized shorter, subliminal presentation times were twice as large as those that utilized longer, supraliminal presentation times (Bar-Haim et al., 2007).

Future research studies examining group differences in attentional bias to healthy and unhealthy food cues should consider using shorter stimulus presentation durations such as 200-300 ms to prevent eye movements and obtain a purer measure of initial orientation of attention. In addition, given the infancy of the field of how attentional bias to food cues may impact eating behavior, it would be interesting to determine the differential predictive validity of initial vs. maintained attention in predicting future eating behavior. If one measure of attention has more predictive validity than the other, then this information could better inform future clinical interventions that might incorporate an attentional retraining component to modify eating behavior.

A second explanation for the lack of training condition group differences in attentional bias to healthy and unhealthy food pictures during the visual dot probe task could be the stimulus content of the picture pairs. In the current study, attentional bias to food cues was derived from critical trials that displayed pictures pairs depicting a healthy food picture paired with an unhealthy food picture. In most studies examining attentional biases to food cues using the dot probe task, the stimulus content has typically consisted of a food picture paired with a non-food control picture (Nijs, Muris, Euser, et al., 2010; Castellanos, Charboneau, Dietrich, et al., 2009; Nathan, O'Neill, Mogg, et al., 2012; Wethmann, Roefs, Nederkoorn, et al., 2011; Loeber, Grosshans, Korucuoglu, et al., 2012; Pothos, Tapper, & Calitri, 2009; Calitri, Pothos, Tapper, et al., 2010). It is possible that the distractor picture (i.e., the picture in the pair that the probe does not replace) could influence the context in which the target picture (i.e., the picture in the pair that the probe does replace) is automatically evaluated. For example, the combined presentation of unhealthy food with healthy food might prime the concept of “health”, whereas the combination of unhealthy food with a neutral non-food object would likely fail to activate this association (Wethmann, Jansenm & Roefs, 2015). As such, the methodological difference in stimulus content in the current study compared to previous studies limits the ability to compare the current results to past findings, but also highlights the need for replication to evaluate the reliability of applied methodology across studies.

Another explanation for the lack of training condition and BMI group differences in attentional bias to healthy and unhealthy food pictures during the visual dot probe task could be that there are other individual-level variables that influence attentional bias to food cues that were not accounted for in the current study. For example, there is some evidence to suggest that persons with binge eating disorder (Svaldi, Tuschen-Caffier, Peyk, & Blechert, 2010), external eaters (Nijs, Franken, & Muris, 2009), and successful and unsuccessful dieters (Veenstra, de Jong, Koster, & Roefs, 2010; Tapper, Pothos, Fadari, & Ziori, 2008) demonstrate greater attentional bias to food stimuli as compared to persons without these eating styles. Indeed, descriptive analyses did reveal a significant positive correlation between scores on the TFEQ subscale of Restraint and baseline attentional bias scores only in the OW/OB BMI group, whereby greater restraint was associated with “healthier” attentional bias. Previous research has also yielded some evidence to suggest that there is a positive association between early attentional processes and self-report ratings of subjective craving and hunger (Nijs, Muris, Euser, et al., 2010; Castellanos, Charboneau, Dietrich, et al., 2009; Wethmann, Roefs, Nederkoorn, et al., 2011). There may also be certain circumstances, or interactions of circumstances, in which an enhanced attention to food might be particularly present and problematic, such as in situations where stress or negative emotionality levels are elevated or when there is a high availability of unhealthy foods, such as during social gatherings or at the grocery store (Adam & Epel, 2007; Nijs & Franken, 2012).

Finally, it is important to note that additional exploratory analyses were conducted to determine whether the ABM intervention actually "worked" with regards to the attentional bias scores and reaction times during the training phase of the dot probe task. These exploratory analyses were conducted because there is a possibility that any effects of the ABM intervention, which was administered during the training phase of the dot probe task, could have been diluted or weakened during the posttest. This could be expected because, during the training phase of the ABM condition, the probe replaced healthy food pictures during 90% of the trials of the dot probe task and then, during the posttest phase, the probe returned to replacing healthy and unhealthy food pictures equally (50%). As such, it is possible that an "extinction" effect could have occurred once the probe was no longer replacing the healthy food pictures most of the time.

The results from exploratory analyses revealed that, while attentional bias scores and reaction times did not change from the first part of the training phase to the second part of the training phase, participants in the ABM group did demonstrate healthier attentional bias scores overall than participants in the AC group during the training phase, which means that they responded much faster to healthy food pictures than to unhealthy food pictures compared to the AC participants who responded at a similar speed to both healthy and unhealthy food pictures. These findings support the notion that the ABM intervention actually "worked" during the training phase, but that the effects might have been diluted or weakened during the posttest.

Discussion of ABM Training on Eating Behavior Findings

With regards to the effect of the ABM intervention for healthy eating on food consumption during the laboratory-based taste test, the current study did not find evidence to support the hypothesis that participants in the ABM condition consumed more calories from healthy snack foods, and less calories from unhealthy snack foods, as compared to the participants in the AC condition. There were also no differences between BMI groups with regards to healthy and unhealthy food consumption, nor any significant training condition × BMI group interaction effect. Again, it is important to keep in mind methodological considerations of the dot probe paradigm when evaluating the lack of significant group differences in the current study, which are detailed below. *A fortiori*, it is important to note that the ABM training in the current study appeared to be unsuccessful in modifying attentional biases to become healthier. Thus, consequently, it cannot be expected that the ABM training would influence healthier eating behavior in the laboratory taste test. In other words, the ABM training was hypothesized to influence eating behavior indirectly through change in attentional bias and, because it did not modify attentional bias, it cannot be expected to impact eating behavior. However, combined with the findings from exploratory analyses that revealed that the ABM group did demonstrate healthier attentional bias during the training phase of the dot probe task compared to the AC group, it is possible that the ABM intervention effects might have been diluted or weakened during the posttest and, thus, did not translate into healthier eating behavior during the taste test. As such, if the taste test were administered immediately after the training phase of the dot probe task (rather than after the posttest), it is possible that training group differences might have been more likely to be observed with regards to eating behavior.

In terms of recognizing methodological considerations, first, given the infancy of the field of attentional bias modification for food cues and its effect on subsequent eating behavior, there are only a limited number of studies to which these results can be compared. Of the few known studies examining this relationship, two studies trained females to attend to (or avoid) chocolate cues and measured their subsequent consumption of chocolate; one of these studies (Kemps, Tiggemann, Orr, & Grear, 2014) found the attend chocolate training to increase chocolate consumption whereas the other study (Werthmann, Field, Roefs, Nederkoorn, & Jansen, 2014) did not find any differences in chocolate consumption between training groups. The current study differed in that it attempted to train a desirable outcome (eat healthy food) rather than train an undesirable outcome (eat chocolate), which could be argued is more difficult to do given that foods high in sugar and fat, such as chocolate, have a greater reward value and are more desirable amongst the general population, and in animal models, than fruits and vegetables (Avena, Rada, & Hoebel, 2008; Hoebel, Avena, Bocarsly, & Rada, 2009; Avena, Bocarsly, & Hoebel, 2011).

A study (Kakoschke et al., 2014) very similar to the current one trained females to either attend to healthy foods or attend to unhealthy foods and found that females in the attend healthy group consumed more healthy food relative to unhealthy food as compared to counterparts in the attend unhealthy group. Again, an important methodological difference here is that, in the current study, the “control” group was a true attentional control and was not trained to attend to unhealthy food as was the case in the Kakoschke et al. (2014) study. A true control group such as the one in the current study might result in smaller effect sizes between training conditions given that our control condition was not the complete reverse of the healthy training condition as it was in the Kakoschke et al. (2014) study. Thus, this might be a reason for our lack of training group differences with regards to food consumption during the bogus taste test.

Another important factor to keep in mind is that the food consumption findings from the current study are limited in that we do not have data regarding participants' food consumption at baseline/pre-training. As such, it is unknown how or whether participant food consumption would be different if they had not been exposed to the ABM intervention or if they had not been exposed to multiple trials of pictures depicting food, which may have also impacted their hunger or craving levels, which then may have impacted their food consumption during the taste test.

Further, the laboratory setting and "taste test" set-up may have also impacted the amount of snacks consumed by the participants. Although participants were told that the food used in the taste test could not be saved or used with other participants due to sanitary concerns, thus they could eat as much as they want, it is still possible that the participants thought they needed to eat smaller amounts. It is also possible that participants restrained the amount that they ate because they thought that their consumption would be measured by the experimenter. Participants did not provide verbal debriefing data regarding why they consumed the amount that they did, but this would be a helpful variable to collect in future research.

Conceptual Implications

As noted in the literature review, food-related ABM paradigms were originally developed on the basis that individuals with OW/OB have sometimes demonstrated greater biases for unhealthy foods than their HW counterparts, and greater biases for unhealthy foods have been associated with increases in BMI over time. The data from the current study inform the food addiction model of OB in that our findings do not support the idea that OW/OB participants demonstrate stronger attentional biases towards unhealthy foods as compared to HW participants. In the current study, OW/OB and HW participants did not differ from one another with regards to pre-training (baseline) or post-training attentional bias scores.

Again, there are a number of methodological reasons for why this study may not have found significant differences in attentional bias between BMI groups, such as the stimulus presentation duration and stimuli content. However, these considerations are important when determining how our findings inform the food addiction model of OB in that perhaps group differences could have been detected with more sensitive measures of cognitive reactivity. For example, measures that assess direct eye movement (eye tracking) or assess attention allocation at an earlier point in time (<300 ms) may be more predictive of, or better distinguish between, BMI group status as opposed to a measure of maintained attention. Further, perhaps the food addiction model of OB is more general in that increased cognitive reactivity might be observed when choosing between food and non-food pictures in a computer task, but might not be detected when choosing between two food pictures, one being healthy and one being unhealthy. These considerations highlight the need for further standardization of attentional bias measurement in the addictions.

Along the same lines, the findings from this study also highlight the need to critically evaluate the food addiction model of OB, which posits that overeating and OB may be the result of a neurobiological addiction specifically to energy-dense, hyperpalatable foods high in sugar and fat (Davis et al., 2011). Food is necessary to survive and it is commonsensical that people show attentional bias towards food when compared to a neutral stimulus with less survival value (e.g., non-food pictures), as has been demonstrated in previous studies (Nijs, Muris, Euser, et al., 2010; Wethmann, Roefs, Nederkoorn, et al., 2011). When the findings from the current study (i.e., lack of BMI group differences in attentional bias towards healthy vs. unhealthy foods) are coupled with previous literature demonstrating BMI group differences in attentional bias towards food vs. non-food stimuli, it appears that what may be being observed with attentional bias paradigms is an attentional bias towards food in general because of its survival value, but not necessarily support for an addiction hypothesis specifically related to hyperpalatable foods.

Clinical Implications

Given the lack of BMI group differences in attentional bias towards healthy vs. unhealthy foods at baseline, an important clinical implication is the understanding that attentional bias (at least maintained attention) to healthy vs. unhealthy foods does not appear to predict nor differentiate BMI group status. As such, it is important for clinicians to acknowledge that there are a number of factors, as well as their interactive effects, that contribute to weight status and the development and maintenance of OW/OB. As noted in the literature review, on a basic level weight status is related to the balance between energy intake vs. energy expenditure, but there are also a number of other factors that influence and interact with this balance to impact weight. For example, factors such as genetics and hormones, the obesogenic environment, sleep, stress, mood, and decision-making styles, to name a few.

It is, therefore, important for clinicians to conduct thorough, comprehensive assessments to better understand the factors that might be related to individual patients' development and maintenance of OW/OB. Comprehensive assessment of these factors can then better inform treatment and help to tailor interventions that address weight loss for individual patients. Depending on what factors are most relevant to individual patients, treatment options could include lifestyle interventions, pharmacological treatments, and surgical procedures, as well as a combination of these options.

Future Directions and Limitations

This study has a number of limitations, aside from the number of methodological considerations discussed throughout this chapter. First, measuring attentional bias with computer-based reaction time tasks, such as the visual dot probe task used in the current study, is less accurate than employing more direct and sensitive measures of cognitive reactivity assessment, such as EEG, eye-tracking, and fMRI methodologies. Indeed, it has been the latter methodologies that have detected group differences in attentional bias to food stimuli between OW/OB and HW individuals in previous research.

As such, if ABM trainings, such as the one used in the current study, do not result in pre-post changes in attention using more direct and sensitive measures, then there is little need to replicate ABM studies in a natural setting (vs. laboratory), with different populations (such as males instead of only females, children vs. only adults), etc. Overall, there is limited evidence that the ABM paradigm using the visual dot probe task effects cognitive or behavioral change, which is a potential methodological limitation. However, it is also important to consider that the food addiction model of OB might be flawed and the findings from the current study, as well as the larger mixed literature, aid in the identification of these flaws.

A second limitation, as well as future direction, is the fact that the current study utilized only a single session of the ABM training as the main intervention. It is possible that an increased number of sessions of the ABM training, that is, repeated administration, could increase its effect on attentional bias. Along similar lines, it would be interesting to determine the longitudinal vs. cross-sectional effects of the ABM training on attentional bias.

A third limitation is the method of measuring eating behavior/food consumption. Overall, the participants consumed a small amount of calories during the taste test and this could be suggestive of limitations with the taste test methods. As noted earlier, it is possible that the taste test set-up led participants to think that they needed to eat smaller amounts or that their consumption would be measured by the experimenter, which could have then impacted the amount they consumed. Participants did not provide verbal debriefing data regarding why they consumed the amount that they did, but this would be a helpful variable to collect in future research. Overall, it is possible that the taste test paradigm is limited in its ability to allow participants to eat freely.

Summary

The findings from the current study did not support the main predictions that a single-session ABM training designed to promote healthy eating could 1) induce an attentional bias towards healthy food cues as measured by a dot probe task and, subsequently, 2) increase consumption of healthy foods during a laboratory-based eating behavior assessment. Furthermore, the findings from this study add to the mixed literature regarding the relationship between attentional bias to food stimuli and weight status in that there was a lack of BMI group differences in attentional bias towards healthy vs. unhealthy foods at baseline.

The findings from the present study highlight the need not only for further standardization of attentional bias measurement in the addictions so that data can be compared across studies, but also for critical evaluation of the food addiction model of obesity given the absence of BMI group differences in attentional bias to healthy vs. unhealthy foods.

APPENDIX A

SCREENING QUESTIONNAIRE

1. What is your current age (in years)?

2. What is your biological sex?
   Choose: male, female, intersex, not listed

3. Are you currently enrolled as a student at a university in the Kansas City metropolitan area?
   Choose: yes, no

4. Are you proficient in English?
   Choose: yes, no

5. What is your current height (in inches)?

6. What is your current weight (in pounds)?

   BMI will be calculated automatically with the following equation:

$$BMI = \frac{\big(Weight\ (lb)\big) * 703}{(Height\ (in))^2}$$

7. Do you have allergies to or experience discomfort with any foods (e.g., eggs, milk, peanuts/tree nuts, fruits/vegetables, wheat/gluten, etc.)?
   Choose: yes, no

8. Within the last 3 months including today, have you been on a special diet (i.e., intentionally avoided certain foods or reduced your amount of food intake for the purpose of weight loss)?
   Choose: yes, no

9. Do you make yourself sick because you feel uncomfortably full?
   Choose: yes, no

10. Do you worry you have lost control over how much you eat?
    Choose: yes, no

11. Have you recently lost more than 14 pounds in the last 3 months?
    Choose: yes, no

12. Do you believe yourself to be fat when others say you are too thin?
    Choose: yes, no

13. Would you say that food dominates your life? Choose: yes, no

14. Please rate your liking of the following foods using the sliding scale provided, which ranges from 0 (extremely dislike) to 100 (extremely like).
    - Oreos
    - Potato chips
    - Seedless grapes
    - Raw carrots

APPENDIX B

STUDY INFORMATION SHEET/CONSENT FORM

Consent for Participation in a Research Study
Food Preferences of University Students

Jennifer Lundgren, PhD
Ashleigh Pona, MA

Request to Participate
You are being asked to take part in a research study. This study is being conducted at the University of Missouri-Kansas City (UMKC).

The researcher in charge of this study is Jennifer Lundgren, PhD. While the study will be run by her, other qualified persons who work with her may act for her.

The study team is asking you to take part in this research study because you are female, at least 18 years of age, enrolled as a student at a university in the Kansas City metropolitan area, speak English as your first language, and have a BMI of greater than or equal to 18.5 kg/m^2. Research studies only include people who choose to take part. This document is called a consent form. Please read this consent form carefully and take your time making your decision. The researcher or study staff will go over this consent form with you. Ask him/her to explain anything that you do not understand. Think about it before you decide if you want to take part in this research study. This consent form explains what to expect: the risks, discomforts, and benefits, if any, if you consent to be in the study.

Background
The prevalence of obesity is high and associated with health risks. Reducing the rate of obesity has become a public health priority. University is an important time when young adults have more independence over food choices and preferences. However, it is unknown whether or not individual characteristics are associated with food choices and preferences in university students.

You are being asked to participate in this study to learn more about food preferences of university students. You will be one of about 120 individuals enrolled in this study at UMKC.

Purpose
The purpose of the study is to assess the food preferences of university students.

Procedures
If you agree to take part in this study, you will be involved in this study for approximately 90 minutes. After completing a screening to make sure you are eligible to be in this study, you will be able to enroll in the study. Your involvement will include

completing a set of questionnaires without identifying information (such as your name) as well as a computer task. The questionnaires will ask you information such as your age, racial identification, education level, and food preferences. The computer task will measure your food preferences. You will then be asked to complete a taste test for four different snack foods.

Your participation in this study is voluntary at all times. You may choose to not participate, not answer certain questions, or withdraw your participation at any time without penalty by informing the principal investigator.

Risks and Inconveniences

This research is considered to be minimal risk. That means that the risks of taking part in this research study are not expected to be more than the risks in your daily life. Although it is highly unlikely that completion of the questionnaires and computer task will be distressing, in the unlikely event that emotional concerns arise, please let the researcher know and she can provide you with a list of psychological counseling resources available to you. An additional risk of this study is the possible loss of privacy or breach of confidentiality. We will take measures to reduce this risk, such as assigning a study number to your data that is collected for the study. There may be other risks that have not yet been identified.

Benefits

There are no benefits to you for taking part in this study. Other people may benefit in the future from the information about food preferences of university students that comes from this study.

Fees and Expenses

There are no monetary costs associated with participating in this study.

Compensation

You will be compensated $15.00 in the form of an American Express gift card or 3 research participation credits through Psych Pool contingent upon completion of the study.

Alternatives to Study Participation

The alternative is not to take part in the study.

Confidentiality

While we will do our best to keep the information you share with us confidential, it cannot be absolutely guaranteed. Individuals from the University of Missouri-Kansas City Institutional Review Board (a committee that reviews and approves research studies), Research Protections Program, and Federal regulatory agencies may look at records related to this study to make sure we are doing proper, safe research and protecting human subjects. The results of this research may be published or presented to others. You will not be named in any reports of the results.

In Case of Injury

The University of Missouri-Kansas City appreciates people who help it gain knowledge by being in research studies. It is not the University's policy to pay for or provide medical treatment for persons who are in studies. If you think you have been harmed because you were in this study, please call the researcher, Dr. Jennifer Lundgren at (816) 235-5384.

Contacts for Questions about the Study

You should contact the Office of UMKC's Institutional Review Board at 816-235-5927 if you have any questions, concerns or complaints about your rights as a research subject. You may call the co-investigator, Ashleigh Pona, at 816-235-6601 if you have any questions about this study. You may also call her if any problems come up.

Voluntary Participation

Taking part in this research study is voluntary. If you choose to be in the study, you are free to stop participating at any time and for any reason. If you choose not to be in the study or decide to stop participating, you will not be penalized in any way. If the researchers find that you no longer meet study criteria, they will stop the study. You will be told of any important findings developed during the course of this research.

You have read this Consent Form or it has been read to you. You have been told why this research is being done and what will happen if you take part in the study, including the risks and benefits. You have had the chance to ask questions, and you may ask questions at any time in the future by calling Ashleigh Pona at 816-235-6601. By signing this consent form, you volunteer and consent to take part in this research study. Study staff will give you a copy of this consent form

______________________________ ________________

Signature (Volunteer Subject) **Date**

____

Printed Name (Volunteer Subject)

______________________________ ________________

Signature of Person Obtaining Consent **Date**

____

Printed Name of Person Obtaining Consent

APPENDIX C

DEMOGRAPHICS QUESTIONNAIRE

1. What is your current age (in years)?

2. What is your current grade level at UMKC?
   Choose: freshman, sophomore, junior, senior, graduate student, student in the 6-year medical program

3. Although the categories listed below may not represent your full identity or use the language you prefer, for the purpose of this survey, please indicate which group below most accurately describes your racial identification.
   Choose: Native American/American Indian/Alaska Native/Indigenous, Asian, Black, Latinx/Hispanic (non-White), Middle Eastern/North African (non-White), Pacific Islander/Native Hawaiian, White, Multiracial (specify), not listed (specify)

4. When was the last time that you ate?

5. Please rate your hunger on the visual analogue scale below ranging from “not hungry at all” to “extremely hungry”.

APPENDIX D

THREE-FACTOR EATING QUESTIONNAIRE

Part I

1.	When I smell a sizzling steak or see a juicy piece of meat, I find it very difficult to keep from eating, even if I have just Finished a meal.	T	F
2.	I usually eat too much at social occasions, like parties and picnics.	T	F
3.	I am usually so hungry that I eat more than three meals a day.	T	F
4.	When I have eaten my quota of calories, I am usually good about not eating anymore.	T	F
5.	Dieting is so hard for me because I just get too hungry.	T	F
6.	I deliberately take small helpings as a means of controlling my weight	T	F
7.	Sometimes things just taste so good that I keep on eating even when I am no longer hungry.	T	F
8.	Since I am often hungry, I sometimes wish that while I am eating, an expert would tell me that I have had enough or that I can have something more to eat.	T	F
9.	When I feel anxious, I find myself eating.	T	F
10.	Life is too short to worry about dieting.	T	F
11.	Since my weight goes up and down, I have gone on reducing diets more then once.	T	F
12.	I often feel so hungry that I just have to eat something.	T	F
13.	When I am with someone who is overeating, I usually overeat too.	T	F
14.	I have a pretty good idea of the number of calories in common food.	T	F
15.	Sometimes when I start eating, I just can't seem to stop.	T	F
16.	It is not difficult for me tot leave something on my plate.	T	F
17.	At certain times of the day, I get hungry because I have gotten used to eating then.	T	F
18.	While on a diet, if I eat food that is not allowed, I consciously eat less for a period of time to make up for it.	T	F

19. Being with someone who is eating often makes me hungry to eat also. T F

20. When I feel blue, I often overeat. T F

21. I enjoy eating too much to spoil it by counting calories or watching my weight. T F

22. When I see a real delicacy, I often get so hungry that I have to eat right away. T F

23. I often stop eating when I am not really full as a conscious means of limiting the amount that I eat T F

24. I get so hungry that my stomach often seems like a bottomless pit. T F

25. My weight has hardly changed at all in the last ten years. T F

26. I am always hungry so it is hard for me to stop eating before I finish the food on my plate T F

27. When I feel lonely, I console myself by eating. T F

28. I consciously hold back at meals in order not to gain weight. T F

29. I sometimes get very hungry late in the evening or at night. T F

30. I eat anything I want, any time I want. T F

31. Without even thinking about it, I take a long time to eat. T F

32. I count calories as a conscious means of controlling my weight. T F

33. I do not eat some foods because they make me fat. T F

34. I am always hungry enough to eat at any time. T F

35. I pay a great deal of attention to changes in my figure. T F

36. While on a diet, if I eat a food that is not allowed, I often splurge and eat other high calorie foods. T F

Part II

Directions: Please answer the following questions by circling the number above the response that is appropriate to you.

37. How often are you dieting in a conscious effort to control your weight?

1 2 3 4

rarely	sometime	usually	always

38. Would a weight fluctuation of 5 lbs. affect the way you live your life?

1	2	3	4
rarely	sometime	usually	always

39. How often do you feel hungry?

1	2	3	4
rarely	sometime	usually	always

40. Do your feelings of guilt about overeating help you to control your food intake?

1	2	3	4
rarely	sometime	usually	always

41. How difficult would it be for you to stop eating halfway through dinner and not eat for the next four hours?

1	2	3	4
easy	slightly difficult	moderately difficult	very difficult

42. How conscious re you of what you are eating?

1	2	3	4
easy	slightly	moderately	extremely

43. How frequently do you avoid "stocking up" on tempting food?

1	2	3	4
almost never	seldom	usually	almost always

44. How likely are you to shop for low calorie foods?

1	2	3	4
unlikely	slightly unlikely	moderately likely	very likely

45. Do you eat sensibly in front of others and splurge alone?

1	2	3	4
never	rarely	often	always

46. How likely are you to consciously eat slowly in order to cut down on how much you eat?

1	2	3	4
unlikely	slightly unlikely	moderately likely	very likely

47. How frequently do you skip dessert because you are no longer hungry?

1 almost never always | 2 seldom | 3 usually | 4 almost

1	2	3	4
almost never always	seldom	usually	almost

48. How likely are you to consciously eat less than you want?

1	2	3	4
unlikely	slightly unlikely	moderately likely	very likely

49. Do you go on eating binges though you are not hungry?

1	2	3	4
never	rarely	often	always

50. On a scale of 0 to 5, where 0 means no restraint in eating (eating whatever you want, whenever you want it) and 5 means total restraint (constantly limiting food intake and never "giving in"), what number would you give yourself?

0 eating whatever you want, whenever you want it
1 usually eat whatever you want, whenever you want it
2 often eat whatever you want, whenever you want it
3 often limit food intake, but often "give-in"
4 usually limit food intake, rarely "give-in"
5 constantly limiting food intake, never "giving-in"

51. To what extent does this statement describe your eating behavior?

"I start dieting in the morning, but because of any number of things that happen during the day, by evening I have given up and eat what I want, promising myself to start dieting again tomorrow."

1	2	3	4
not like me	little like me	pretty good description of me	describes me perfectly

APPENDIX E

FOOD RATING SCALE

Please taste and rate the following foods by placing a ✓ to indicate how much you like or dislike them on the following dimensions. You can eat as much of the foods as you would like.

Grapes

	Appearance	Taste/Flavor	Texture	Overall Liking
Like extremely				
Like very much				
Like moderately				
Like slightly				
Neither like nor dislike				
Dislike slightly				
Dislike moderately				
Dislike very much				
Dislike extremely				

Mini Oreos

	Appearance	Taste/Flavor	Texture	Overall Liking
Like extremely				
Like very much				
Like moderately				
Like slightly				
Neither like nor dislike				
Dislike slightly				
Dislike moderately				
Dislike very much				
Dislike extremely				

Baby Carrots

	Appearance	Taste/Flavor	Texture	Overall Liking
Like extremely				
Like very much				
Like moderately				
Like slightly				
Neither like nor dislike				
Dislike slightly				
Dislike moderately				
Dislike very much				
Dislike extremely				

Potato Chips

	Appearance	Taste/Flavor	Texture	Overall Liking
Like extremely				
Like very much				
Like moderately				
Like slightly				
Neither like nor dislike				
Dislike slightly				
Dislike moderately				
Dislike very much				
Dislike extremely				

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