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Resisting Temptation:
The Effects of Mindfulness Training in Overcoming the Food Approach Bias

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Margaret Ann Martinez
B.S. Yale University, 2010

Advisor: Linda W. Craighead, Ph.D.

A abstract of a thesis submitted to the faculty of the
James T. Laney School of Graduate Studies of Emory University
in partial fulfillment of the requirements for the degree of
Master of Arts in Psychology
2014

Abstract

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Maintaining a healthy weight is a chronic struggle for many individuals in the context of our current obseogenic environment. It has been suggested that an approach bias towards food stimuli – defined as a tendency to have a faster reaction time in response to attractive stimuli – may contribute to instances of overeating and mindless eating that interfere with successful weight loss and maintenance. A recent study by Papies and colleagues (2012) demonstrated the efficacy of a brief training in mindful attention (MA) in eliminating the approach bias towards attractive food stimuli, which is consistent with the growing popularity of mindfulness-based interventions in clinical eating disordered populations. The present study aimed to replicate the findings of Papies and colleagues (2012) and to systematically investigate the effects of dietary restraint on response to MA training. Participants were college-aged women with varying levels of dietary restraint who completed either MA training or one of two control trainings followed by an approach-avoidance task. Contrary to predictions, the current findings indicated that in the absence of specific training individuals lower in dietary restraint demonstrate an approach bias to neutral (i.e. less attractive) foods rather than to more attractive/tasty foods. However, MA training did successfully eliminate this approach bias, which supports prior research indicating that MA can reduce an approach bias (in that study the bias was toward attractive foods). Individuals higher in dietary restraint did not demonstrate a significant approach bias towards either type of food. These findings suggest that in the absence of MA training, individuals low in dietary restraint exhibit a tendency to approach healthier-looking foods; therefore MA training is not needed. By contrast, individuals high in dietary restraint were not differentially drawn to attractive versus neutral foods and the brief MA training provided was not beneficial. Further research is needed to understand the way highly restrained individuals respond to food stimuli. Mindful eating has significant clinical support as a therapeutic intervention for individuals who binge or overeat so it will be important to understand how highly restrained individuals may be benefiting from those longer, more intensive mindful eating interventions.

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Introduction

In today's society, food cues are everywhere. Whether watching TV, window shopping, or enjoying an afternoon in the park, it is hard to escape the sight or smell of food. Given the vast number of food cues we encounter on a daily basis, it is no wonder that Americans are gaining weight at an unprecedented rate. Multiple scholars have credited this "toxic environment" with the increasing rates of obesity and dieting in the United States (Hill & Peters, 1998; Wadden, Brownell, & Foster, 2002). Recent data suggest that the rates of obesity in the United States have increased substantially in the last several decades, to the point where 35.7% percent of U.S. adults were obese in 2010 (Ogden, Carroll, Kit, & Flegal, 2012).

Concurrent with the increase in obesity is an increase in the frequency of dieting behaviors among those individuals who are normal weight, as well as among overweight or obese individuals (Andreyeva, Long, Henderson, & Grode, 2010): one study reported rates of dieting as high as 24% in men and 38% in women (Kruger, Galuska, Serdula, & Jones, 2004). Dieting is a particular concern on college campuses, where the incidence of dieting behaviors and attitudes and disordered eating among young women is substantial (Berg, Frazier, & Sherr, 2009). Although clinical eating disorders are relatively rare (lifetime prevalence of Anorexia Nervosa [AN] 0.6%, Bulimia Nervosa [BN] 1.0%, and Binge Eating Disorder [BED] 2.8%; Hudson, Hiripi, Pope, & Kessler, 2007), the incidence of eating pathology is much higher. For example, data from a large epidemiological survey suggest that approximately 4.9% of women and 4.0% of men will experience some binge eating during their lifetime (Hudson et al., 2007). Rates of subclinical disordered eating are even higher among adolescent and college-aged women (Eisenberg, Nicklett, Roeder, & Kirz, 2011; Krahn, Kurth, Gomberg, & Drewnowski, 2005; Luce, Crowther, & Pole, 2008; Samman, Fayet, & Petocz, 2012; Welch, Birgegård, Parling, & Ghaderi, 2011), with recent data suggesting that of the approximately 55% of adolescent girls who are dieting 10% engage in extreme methods of weight control and 12% binge eat and will continue to do so into adulthood (Neumark-Sztainer, Wall, Larson, Eisenberg, & Loth, 2011). In another study, 49% of college women surveyed reported that they engage in eating disordered behaviors such as self-induced vomiting or excessive exercise at least once a week (Berg, Frazier, & Sherr, 2009).

These high rates of dieting and disordered eating behaviors suggest that even normal weight individuals find it difficult to regulate their weight in today's society. Indeed, data suggest that humans have an innate tendency to approach attractive stimuli, a tendency that likely evolved to keep our ancestors fed in times of scarcity (Zheng, Lenard, Shin, & Berthoud, 2009). This tendency to approach attractive stimuli is referred to in the research literature as an approach bias. From the perspective of grounded cognition theory, this approach bias likely involves the mental simulation of eating craved foods (Barsalou, 2008); indeed, research has demonstrated that food cravings consist of elaborate mental imagery, and that more elaborate imaginings produce more intense cravings (Tiggemann & Kemps, 2005).

Although the approach bias may have once served to ensure the survival of our species by predisposing our ancestors towards calorically dense foods, this bias appears to have become problematic in our current obesogenic food environment. When surrounded by enticing foods, the approach bias often overwhelms biological mechanisms of energy regulation (i.e. internal hunger/satiety cues). In short, we have become "external," rather than "internal," eaters.

Externality Theory and Dietary Restraint

The distinction between "external" and "internal" eaters was first made by Schachter over forty years ago (1968). Schachter viewed his externality theory as a way to distinguish the eating behavior of normal weight individuals from that of obese individuals. He reasoned that normal weight individuals rely on internal hunger and satiety cues to regulate food intake, whereas obese individuals rely more heavily on external cues such as portion size or the eating behavior of those around the individual. Although Schachter's hypothesis was initially supported (Goldman, Jaffa, & Schachter, 1968; Nisbett, 1968; Richard, 1968; Schachter, 1971; Schachter & Gross, 1968), later work suggested that both normal weight and obese individuals alter their eating behavior in response to certain external cues (Goldman, Herman, & Polivy, 1991; Kauffman, Herman, & Polivy, 1995; Nisbett & Storms, 1974). Individuals who are within in the normal weight range but attempting to suppress their weight by dieting and who are below their biological set-point weight (i.e. "restrained eaters;" Herman & Mack, 1975; Herman & Polivy, 1975) may be particularly susceptible to the effects of external cues (Fedoroff, Polivy, & Herman, 1997; Fedoroff, Polivy, & Peter Herman, 2003; Jansen & Van den Hout, 1991; LeGoff & Spigelman, 1987; Polivy, 1996; Rogers & Hill, 1989). The eating behaviors of restrained eaters differ consistently from those of non-restrained eaters (for a review, see Polivy, Herman, & Coelho, 2008). For example, restrained eaters are more likely than unrestrained eaters to experience increased thoughts of food, eating, weight, and shape in response to verbal food cues (e.g. a list of food words; Boon, Stroebe, Schut, & Jansen, 1998); additionally, restrained eaters eat more than unrestrained eaters in response to olfactory and cognitive food cues (e.g. the smell of pizza cooking and thoughts of pizza; Fedoroff et al., 1997; Fedoroff et al., 2003).

Thus, a large body of literature suggests that while all individuals are affected by external cues, some individuals are affected to a greater extant than others. What, then, accounts for this differential response? Herman and Polivy (2008) propose a distinction between normative and sensory external cues: normative cues, such as portion size, function as "environmental indicators of what or how much one should eat," whereas sensory cues, such as the palatability of a food, are "properties of the food itself that make one more (or less) likely to eat it" (p. 725). The authors suggest that while all individuals respond to normative cues, obese, restrained and/or dieting individuals are more likely to respond to sensory cues.

The mechanism by which restrained eaters are particularly influenced by external cues is not yet understood. One suggestion is that the differential influence of external cues on restrained versus unrestrained eaters may be a function of higher levels of arousal caused by the stress of dieting (Herman, Polivy, Pliner, & Threlkeld, 1978) or the state of weight suppression (Nisbett, 1972). A more recent suggestion is that dietary restriction may activate psychological hunger (Polivy et al., 2008), also referred to as hedonic hunger, (Lowe & Butryn, 2007), which stands in contrast to homeostatic hunger that reflects a biological need for fuel. Restrained individuals, who are psychologically hungry, may be more prone to approach attractive food items (Polivy, 1996; Polivy et al., 2008); alternatively, restrained eaters could show a decreased approach bias (Fishbach & Shah, 2006; Fishbach, Friedman, & Kruglanski, 2003), a tendency which may reflect years of practice resisting tempting food and which may facilitate successful dietary restraint. Presently, no study has systematically assessed approach bias in restrained versus unrestrained eaters.

Combating External Eating and the Approach Bias

The approach bias in response to external cues poses a particular challenge to our weight-conscious society. Individuals with eating disorders represent a population particularly vulnerable to the approach bias as they are, by definition, often dieting and typically score high on measures of dietary restraint (e.g. Cooper, Cooper, & Fairburn, 1989; Wardle, 1987). In these individuals, the approach bias may take the form of binge eating, that is eating an objectively large amount of food while experiencing a sense of loss of control over one's behavior.

Few interventions designed to specifically combat the approach bias in dieting or restrained eaters exist. Standard therapeutic interventions for clinical eating disorders typically focus on restructuring the environment as a way to minimize binge eating. Empirically-supported treatments for binge eating, including Fairburn's transdiagnostic Cognitive Behavioral Therapy for Eating Disorders (CBT-E; Fairburn, 2008) and Appetite Awareness Training (AAT; Craighead, 2006) instruct individuals struggling with binge eating to normalize eating patterns as the primary method to decrease the frequency of binge eating. AAT also offers a concrete strategy to cope with residual urges to binge eat: urge surfing (Marlatt & Gordon, 1985). Urge surfing, which has its roots in mindfulness meditation, is a strategy employed in cognitive behavioral treatments of addiction and other high-risk behaviors. While urge surfing, the individual is taught to "treat urges as though they were like waves in the ocean…[they] come on, grow in intensity, and eventually subside" (Lloyd, 2008, p. 571). Clients are taught that resisting the urges, rather than succumbing to them, gradually diminishes the strength of the urges over time. Urge surfing is also taught in Dialectical Behavioral Therapy (DBT; Linehan, 1993) as well as the adaptation of DBT for the treatment of binge eating and bulimia (Safer, Telch, & Chen, 2009). Within DBT, urge surfing is taught as a mindfulness skill over an extended course of treatment.

As indicated by the aforementioned adaptations of DBT for binge eating and bulimia, mindfulness-based interventions for binge eating and disordered eating more broadly have received increasing attention in recent years. In addition to DBT, which includes a heavy emphasis on mindfulness, several other mindfulness-based therapies have been adapted for the treatment of disordered eating, including Mindfulness-Based Cognitive Therapy (MBCT; Segal, Williams, & Teasdale, 2002), Mindfulness-Based Eating Awareness Training (MB-EAT; Kristeller & Wolever, 2010), and Acceptance and Commitment Therapy (ACT) for the treatment of Anorexia and Bulimia Nervosa (Sandoz, Wilson, & DuFrene, 2011) and body image dissatisfaction more broadly (Follette, Heffner, & Pearson, 2010). All of these treatments have been shown in empirical studies to decrease the frequency of disordered eating behaviors such as binge eating and are becoming viable alternatives to standard Cognitive Behavioral Therapy for the treatment of disordered eating (for a review, see Baer, Fischer, & Huss, 2006; Masuda & Hill, 2013; Wanden-Berghe, Sanz-Valero, & Wanden-Berghe, 2010). In addition, mindfulness-based approaches have also been found to reduce behaviors known to be precursors to binge eating, including food cravings, dichotomous thinking, and body image dissatisfaction (Alberts, Mulkens, Smeets, & Thewissen, 2010; Alberts, Thewissen, & Raes, 2012).

Trait-level mindfulness may also be a construct relevant to disordered eating: Lavendar and colleagues (Lavender, Gratz, & Tull, 2011) found a significant association between eating pathology and the acting with awareness, nonreactivity, and nonjudgmental dimensions of mindfulness (as measured by the Five Facet Mindfulness Questionnaire [FFMQ]; Baer, 2006) above and beyond symptoms of anxiety and depression. Additionally, Masuda and Wendell (2010) found that mindfulness partially mediated the relationship between disordered eating and both psychological ill-health and emotional distress related to interpersonal interactions. In total, this work suggests that mindfulness is a construct relevant to our understanding and treatment of disordered eating.

Proponents of mindfulness-based treatment approaches for disordered eating argue that, unlike cognitive behavioral approaches, these therapies promote distancing oneself from problematic cognitions rather than challenging them, a process that can be difficult for many eating disordered patients who experience their disordered cognitions as ego-syntonic (Baer et al., 2006). Furthermore, mindful awareness of emotions promotes exposure to uncomfortable or unpleasant emotions, which eradicates the emotional avoidance typical of many eating disordered individuals (Hayes, 2004). However, all of the interventions described above utilize an extended treatment protocol, wherein mindfulness skills are taught over several weeks or months. The time-consuming nature of these treatments renders their dissemination difficult and as a result the vast majority of individuals who struggle to regulate their food intake in the presence of external food cues are not able to benefit from these interventions.

Recent work by Papies and colleagues (Papies, Barsalou, & Custers, 2012) demonstrates that basic mindfulness skills can be taught in mere minutes. Using a computer-based mindful attention training, participants were taught to consider their thoughts mindfully while viewing images of food and non-food stimuli. Participants were instructed to view their thoughts as "constructions of the mind, which appear and disappear" (Papies et al., 2012, p. 293). Upon completing mindful attention training or one of two control trainings in which participants were either instructed to fully immerse themselves in their thoughts or to simply view the images in a relaxed manner, participants completed a computerized approach-avoidance task. In the approach-avoidance task, participants viewed a series of images encompassed by either a blue border or a purple border. They were instructed to press one key when the border was purple and another key when the border was blue, as quickly and accurately as possible. The image would then move towards the participant and appear to grow larger ("approach") or move away from the participant and appear to grow smaller ("avoid"). The color of the border and subsequent movement of the image was counterbalanced between participants. In this task, an approach bias is demonstrated by a relatively shorter reaction time when images of attractive food are bordered by the color indicating that the picture will move towards the participant.

Papies and colleagues (2012) found that participants who received the mindful attention training did not exhibit an approach bias towards pictures of attractive food on the approach-avoidance task, in contrast to participants who received either of the control trainings. That is, this brief training in mindful attention successfully eradicated the approach bias and allowed participants to resist the lure of tempting food. These results suggest that mindfulness skills can be learned in minutes, rather than weeks or months, and can effectively reduce the approach bias towards attractive food.

The Present Study

Given the empirical support for mindfulness-based treatments for eating disorders, as well as data suggesting that mindfulness skills can be taught more quickly than it is taught in traditional mindfulness-based psychotherapies, the present study aimed to examine the efficacy of brief mindful attention training in a sample of college women. Specifically, this study aimed to replicate the findings of Papies and colleagues (2012) using a sample of women with varying levels of concern about their weight, shape, and/or eating behaviors. To assess the effects of mindful attention training on approach bias in this population, this study compared performance on an approach-avoidance task across participants who received one of the three cognitive trainings employed in Papies et al., 2012. Participants in the experimental condition received training in mindful attention, as described above ("mindful attention" condition, or MA). Participants in the first control condition received instructions in cognitive immersion, in which they were asked to fully immerse themselves in an image and the thoughts they have while viewing it (cognitive immersion condition, or CI). Participants in the second control condition were asked to simply view the images in a relaxed manner ("relaxed viewing" condition, or RV). We hypothesized that individuals who receive MA training will show a greater decrease in approach bias as compared to individuals who receive either CI or RV training, as was previously observed by Papies and colleagues.

As a secondary aim, this study intended to examine the influence of dietary restraint on response to MA training. As suggested by externality theory, individuals high in restraint are greatly influenced by external eating cues. However, they also possess the ability to resist tempting food at least occasionally. The literature offers no suggestion as to how they are able to combat their own tendency towards external eating. It is possible that these individuals naturally assume a distanced stance towards food cues – similar to that taught in MA training – which allows them to resist the temptation of attractive foods. If this were the case, we would expect little to no approach bias towards attractive foods in these individuals. Consequently, we hypothesized that MA training would be less effective with these individuals; that is, individuals high in restraint who receive MA training would show a smaller decrease in approach bias relative to those individuals low in restraint.

Methods

Participants

Participants were forty-four women between the ages of 18-25. Individuals participated for course credit in Introductory Psychology (n=31) or for $10 in response to a flyer soliciting eating/weight concerned individuals (n=13). The use of flyers to supplement recruitment from the Intro Psych subject pool was intended to ensure that individuals specifically concerned about eating/weight were included in the sample, as the flyers specifically targeted eating/weight concerned individuals. Participants recruited via flyers completed a brief phone screening prior to participation to confirm their eligibility and to inform them of the study procedures; the eligibility of participants recruited via the Introductory Psychology subject pool was confirmed upon their arrival to the laboratory for their study visit. Individuals were excluded from study participation if they reported a current or past regular meditation practice or a severe medical or psychiatric condition that would prohibit study participation (e.g. schizophrenia or epilepsy). Only two individuals were excluded from study participation, both on the basis of their regular meditation practice.

Procedure

All studies took place in either an individual office or cubicle during the hours of 3-5pm. This standardized testing time was selected to attempt to control for the confounding effects of level of hunger and time since last meal on performance. Participants were informed that the study was interested in the relationship between attentional style, or the way a person attends to certain stimuli, and subsequent food preferences and choices. They were not informed that the study was interested in mindfulness or meditation, although they were asked about their history of mediation practice.

Upon arriving at the laboratory, all participants completed an informed consent discussion and signed the consent form. Participants were then randomly assigned to receive either Mindful Attention (MA) training (n=24), Cognitive Immersion (CI) training (n=9), or Relaxed Viewing (RV) training (n=10), as adapted from Papies et al., 2012. This study utilized a 2:1:1 randomization ratio, such that twice as many participants were randomized to the MA group than either the CI or the RV groups to maximize power to detect an effect in a relatively small sample.

Participants completed the training, as well as the subsequent tasks and questionnaires, on one of two laboratory computers. Each training consisted of two phases: a practice phase, in which participants were exposed to the particular attentional style and asked to practice on a set of food and non-food images; and a second phase, in which participants were again asked to practice the particular attentional style on a second set of food and non-food images. Participants completed a manipulation check in between phases of the training, in which they were asked to describe the particular strategy they were taught to practice. Both phases consisted of a total of 20 images: 5 attractive food stimuli (e.g. pizza, cookies), 5 neutral food stimuli (e.g. carrots, rice cakes), and 10 filler images taken from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008) database. This study utilized the same filler images as those used in Papies et al. (2012) but used unique food images deemed more appropriate for an American sample. All food stimuli were presented on a uniform white background and were pilot tested to determine whether female undergraduates considered them “attractive” or “neutral.”

After completing the computerized training, participants completed a series of computerized tasks including the approach-avoidance task. The approach-avoidance task utilized in this study was again modeled after Papies et al., 2012. Participants were presented with food and non-food images surrounded by either a blue or purple border and asked to press either the “A” or the “L” key depending on the color of the border. Participants were instructed that pressing one key would make the image grow and pressing the other key would make the image shrink. Both border color and keys were counterbalanced across participants. Participants first received 20 practice trials that used the same images from the practice phase of the training; the practice trials were followed by 40 critical trials using the same images as the second phase of the training. Each image was presented as both an approach and an avoid trail during the critical phase of the task.

Finally, after completing the all computerized tasks (including two additional tasks assessing food desire and preference not reported here), participants completed a series of questionnaire measures on the computer. These measures were administered after the completion of the experimental training and tasks so as not to prime for food, eating, weight, or dieting. In total, the completion of the computer training, tasks, and questionnaires took approximately one hour.

Measures

Participants completed the following measures (as well as other measures of eating attitudes and behaviors, not reported here) after completing the cognitive training and the approach-avoidance task.

Participant History Questionnaire. This measure, designed for use in this study, assessed demographic variables including ethnicity/race, self-reported height and weight, current level of hunger and time since last meal, self-reported adult lifetime highest/lowest weights, and previous psychiatric diagnoses and treatment.

Revised Restraint Scale (RS; Herman, Polivy, Pliner, Threlkeld, Munic, 1978). The RS is a self-report measure that consists of 9 items that assess the frequency and intensity of dieting behaviors and attitudes, preoccupation with eating, and past weight fluctuations.

Three-Factor Eating Questionnaire (TFEQ; Stunkard & Messick, 1985). The TFEQ is a 51-item self-report measure designed to assess three aspects of human eating behavior: cognitive restraint of eating, disinhibition, and hunger.

Dietary Intent Scale (DIS; Stice, 1998). The DIS is a 9-item self-report measure of intentional efforts to restrict food intake and control weight.

Eating Disorders Examination – Questionnaire (EDE-Q; Fairburn & Beglin, 1994). The EDE-Q is a self-report questionnaire form of the Eating Disorders Examination, widely considered the gold standard of eating disorders assessments. The questionnaire consists of 28 items that assess the frequency of disordered behaviors as well as the intensity of pathological attitudes towards eating, weight, and shape over the last month.

Results

Data Analyses

All analyses were conducted using SPSS version 20. We utilized a 3 (condition: MA vs. CI vs. RV training) x 2 (food type: attractive vs. neutral; within subjects) x 2 (response: approach vs. avoid; within subjects) analysis of variance (ANOVA) design with response latencies (or reaction times, measured in milliseconds) on the approach-avoidance task as the dependent variables. In accordance with the data analytic strategy of the creators of the approach-avoidance task (Rinck & Becker, 2007), median response latencies were calculated for each participant for each of the 4 combinations of response type (approach or avoid) and picture type (attractive or neutral food). In subsequent analyses of covariance (ANCOVAs), a composite measure combining scores on self-report measures of dietary restraint (RS; TFEQ restraint subscale; DIS; and EDE-Q restraint subscale) and weight suppression were used as continuous covariates (as suggested by Stein, 1988). Preliminary analyses indicated that 1) the experimental conditions did not differ on any of the demographic characteristics (age, ethnicity/race, BMI, hunger, or recruitment method), 2) no significant effects stemmed from demographic characteristics, and 3) the measures of restraint (RS, TFEQ restraint score, DIS, EDE-Q restraint score, weight suppression, time since last ate) did not differ between experimental groups. Contrary to our expectations, participants did not differ on measures of restraint as a function of their method of recruitment (from intro psych versus from a flyer). Furthermore, there were no significant differences in the reaction time measures based on which laboratory computer was used by the participant.

Data from one participant was not used due to experimenter error; thus, the present analyses utilize data from 43 participants. Response latencies on incorrect trials on the approach-avoidance task and trials with response latencies greater than 2 standard deviations from that participant's mean were excluded from analyses; this resulted in the removal of 97 trials across all participants (65 incorrect trials, 35 outlying trials; 5.6% of all trials). Error rates were also calculated for each participant. All error rates were below 18%. Due to the relatively small number of trials utilized in this task, an error rate of 18% equaled only 7 incorrect responses. Given the generally low error rates, no participants were excluded on the basis of high error rates in an attempt to maximize power.

Participant Demographics

Participants had a mean age of 19.9 (SD=1.2). Eight participants (18.6%) identified their ethnicity as Hispanic or Latino and 34 participants (79.1%) described themselves as Not Hispanic or Latino; one participant did not provide her ethnicity. The majority of participants identified as Asian/Other Pacific Islander (n=20, 46.5%). Thirteen participants (30.2%) identified as Non-Hispanic White and 4 participants (9.3%) identified as Black or African American. Six participants (14%) listed their race as "other." This ethnic/racial breakdown is generally consistent with the demographics of Emory University's undergraduate student body, which has a large Asian population. At the time of testing, the majority of participants described their current level of hunger as neutral (mean=4.2, SD=1.5). On average, participants had eaten 3.4 hours prior to study participation (SD=4.4, range 0.17-19.92).

Based on their self-reported height and weight, participants had a mean body mass index (BMI) of 21.3 (SD=2.8, range=17.74-30.34). The majority described themselves as normal weight (n=23, 53.5%) or slightly overweight (n=13, 30.2%); relatively few participants identified as slightly underweight (n=5, 11.6%) or very overweight (n=1, 2.3%). By contrast, 74.4% of participants (n=32) stated that a physician would describe them as normal weight and only 2.3% (n=1) stated that a physician would consider her slightly overweight; 16.3% (n=7) responded that a physician would consider them slightly underweight and 4.7% (n=2) responded that a physician would consider them very overweight. Participants' weight status as observed by the experimenter was also recorded; the experimenters described the majority of participants as normal weight (n=26, 60.5%), with smaller percentages being described as slightly underweight (n=9, 20.9%), slightly overweight (n=6, 14.0%), and very underweight (n=2, 4.7%).

The amount of weight suppression at the time of study participation was calculated by subtracting the participant's self-reported current weight from her self-reported highest lifetime adult weight (Lowe & Kleifield, 1988). Participants reported a mean amount of weight suppression of 6.6 pounds (SD=6.7, range 0.0-30.0). Participants' adult lifetime weight range was also calculated by subtracting their lowest lifetime weight from their highest lifetime weight; on average, participants reported a weight range of 18.6 pounds (SD=17.6, range 2.0-108.0).

With regard to previous psychiatric history, 5 participants (11.6%) reported that they had previously been diagnosed with a psychiatric disorder. Of these five, two participants reported a past diagnosis of Anorexia Nervosa; the remaining three participants listed other psychiatric diagnoses not related to eating or weight. Eight participants (18.6%) reported having received mental health treatment in the past and 4 participants (9.3%) reported being currently in mental health treatment.

Dietary restraint was measured via four self-report measures (TFEQ restraint subscale, DIS, RS, and EDE-Q restraint subscale) as well as by two implicit measures of dietary restraint (weight suppression and the time since the subject last ate). This sample demonstrated substantial variability on all measures of dietary restraint (see table 1). Self-report measures demonstrated good internal consistency as measured by Cronbach's alpha (see table 1). Furthermore, significant relationships existed between all of the self-reported measures of dietary restraint; Pearson's correlations between the four self-report measures of dietary restraint ranged between r=0.529-0.850 (see table 1). Weight suppression was also highly correlated with three of the four self-report measures of dietary restraint (see table 1). Because the participant's time since last meal was not significantly correlated with any of the other measures of restraint, it was not used in subsequent analyses.

Approach-Avoidance Task

An initial 2 (control condition: CI vs. RV) x 2 (food type: attractive vs. neutral) x 2 (response type: approach vs. avoid) analysis of variance (ANOVA) revealed no significant differences between control conditions, $F(1, 18)=.001$, $p=.978$. Given the lack of significant differences between control groups, both control conditions were combined in subsequent analyses to maximize power.

To evaluate the effects of the experimental manipulation on subsequent performance on the approach-avoidance task, we conducted a second 2 (condition: MA training vs. control training) x 2 (food type: attractive vs. neutral) x 2 (response type: approach vs. avoid) ANOVA (see Figure 1). These results demonstrated a significant main effect of response type, F(1, 42)=6.45, $p=.015$, $\eta^2_p=.136$ such that all participants were faster to make food images move towards rather than away from them. Furthermore, the three-way interaction between condition, food type, and response type was marginally significant, $F(1, 41) = 3.75$, $p=.06$, $\eta^2_p=.084$. Examination of the simple main effects indicated that participants in the MA condition were significantly faster to make images of attractive foods move towards them than images of neutral food, $F(1, 41)=5.46$, $p=.024$, $\eta^2_p=.118$. That is, individuals in the MA condition displayed an approach bias towards attractive, but not neutral, food. Conversely, individuals in the control conditions demonstrated an approach bias towards both attractive and neutral foods (i.e. participants in the control groups were faster to make images of both attractive and neutral foods move towards them); however, this approach bias was only significant for neutral foods, $F(1, 41)=4.85$, $p=.033$, $\eta^2_p=.106$. These results suggest that MA training was successful in eliminating the approach bias for neutral, but not attractive, foods.

To examine the effects of dietary restraint on response to MA training, we ran a 2 (condition: MA training vs. control training) x 2 (food type: attractive vs. neutral) x 2 (response type: approach vs. avoid) ANCOVA with a composite measure of dietary restraint entered as a covariate. The composite variable was computed by first transforming scores on the four self-reported measures of dietary restraint (TFEQ restraint subscale, DIS, RS, and EDE-Q restraint subscale) into z-scores. Z-scores were used in an attempt to standardize these four measures, as they vary in both the number of items and range of possible scores. These z-scores were then summed, and the sum was then standardized into a z-score to facilitate the subsequent analysis. The decision was made to use a composite variable given the strong correlations between the self-report measures of dietary restraint (see table 1); additionally, the decision was made to first examine the effects of self-reported dietary restraint and then to look separately at the effects of weight suppression as an indirect measure of dietary restraint, since weight suppression was not as strongly correlated with self-reported dietary restraint. The main effect of response type remained significant in this ANCOVA, $F(1, 38)=6.55$, $p=.015$, $\eta^2_p=.147$. The three-way interaction of condition, food type, and response type reached significance, $F(1, 38)=4.15$, $p=.049$, $\eta^2_p=.099$. Additionally, this ANCOVA revealed a significant four-way interaction of food type, response type, condition, and restraint, $F(1, 38)=8.98$, $p=.005$, $\eta^2_p=.191$.

To examine the nature of this four-way interaction, we employed Aiken and West's pick-a-point approach (Aiken & West, 1991; Cohen, Cohen, West, & Aiken, 2013). The two points selected were one standard deviation above and one standard deviation below the mean score on the standardized restraint composite variable, which represented the high and low ends of the restraint distribution. Pairwise comparisons between the experimental and control groups indicated no significant differences in response latency at the high end of restraint (z-score of sum of standardized restraint scores = 1; see Figure 2). Interestingly, there appeared to be a slight aversion towards neutral foods in the control groups; as this difference was not statistically significant, it is likely that this observation was a transient effect due to experimental error. These data suggest that individuals high in restraint display an approach bias towards both attractive and neutral food and that these approach biases are not reduced by MA training.

A different pattern emerged among individuals low in restraint. Significant within-participant differences persisted in both the experimental and control groups at the low end of restraint (z-score of sum of standardized restraint scores = -1; see Figure 3). Individuals in the MA group displayed an approach bias towards attractive foods ($F(1, 38)=5.47$, $p=.025$, $\eta^2_p=.126$) but not neutral foods ($p=.415$, $\eta^2_p=.018$). Conversely, those individuals in the control groups displayed a significant approach bias towards neutral foods ($F(1, 38)=12.86$, $p=.001$, $\eta^2_p=.253$)

while the approach bias towards attractive foods was not significant (p=.394, η^2_p=.019). This pattern mimicked the results of the 2x2x2 ANOVA depicted in figure 1 and again suggested that MA training was effective at reducing the approach bias for neutral, but not attractive, foods in individuals with low levels of restraint.

Lastly, in an attempt to utilize a more objective covariate rather than the composite of self-report scores, the aforementioned analyses were repeated using standardized weight suppression as a covariate. The main effect of response type remained significant, F(1, 38)=5.97, p=.019, η^2_p=133, and the three-way interaction of condition, food type, and response type was marginally significant, F(1, 38)=3.95, p=.054, η^2_p=.092. The four-way interaction of condition, food type, response type, and weight suppression was no longer significant, F(1, 38)=.71, p=.404, η^2_p=.018. Examination of the estimated marginal means at high and low levels of weight suppression revealed the same pattern of results as those described above: MA training reduced the approach bias for neutral, but not attractive foods, and only among those individuals low in weight suppression.

Discussion

The present study attempted to both replicate and extend the findings of Papies et al. (2012) in a sample of college women and to systematically examine the effects of dietary restraint on spontaneous food impulses. Participants randomly received training in either mindful attention (MA), in which they were taught to assume a distanced stance towards thoughts while viewing pictures of food and non-food stimuli, or one of two control trainings (cognitive immersion, CI, or relaxed viewing, RV). Approach biases towards food and non-food stimuli were then assessed using an approach-avoidance task to test the hypotheses that individuals high in restraint would display less of an approach bias towards attractive food stimuli and that MA training would be less effective for these individuals.

While Papies and colleagues (2012) found that training in mindful attention reduced spontaneous approach reactions towards both attractive and neutral food stimuli, the present study found that MA training eliminated approach biases towards neutral, but not attractive, food stimuli. Approach biases towards attractive food were not different between the MA and control groups. Furthermore, this pattern was only observed in at low levels of dietary restraint: at high levels of dietary restraint, no differences existed between individuals who received MA training and those who received control training. While consistent with our hypothesis that MA training would be less effective for individuals high in dietary restraint, this finding is in contrast to that of Papies et al. (2012), who did not find any differential effect of dietary restraint (as measured by the Concern for Dieting subscale of Herman and Polivy's Restraint Scale, (C Peter et al., 1978) on response to MA training. The discrepancy between high and low levels of dietary restraint observed in the present study suggests that these groups do, in fact, differ in their automatic responses to food stimuli as well as in their response to MA training.

Consistent with the results of the present study, a growing body of literature demonstrates that restrained eaters have different automatic responses to palatable food than do non-restrained eaters. In the present study, highly restrained eaters consistently displayed an approach bias towards both attractive and neutral food items, even when taught to assume a more distanced, mindful stance towards their thoughts. Papies and colleagues (Papies, Stroebe, & Aarts, 2007) found that restrained eaters, as compared to non-restrained eaters, activated spontaneous hedonic thoughts about food in response to reading sentences about palatable food. Additionally, in at least one study restrained eaters demonstrated an attentional bias towards attractive food cues

(Papies, Stroebe, & Aarts, 2008b), although conflicting results suggest that the individual's perception of their own dietary restraint may mediate this association (Ahern, Field, Yokum, Bohon, & Stice, 2010).

The suggestion that restrained eaters have an attentional bias towards food stimuli is consistent with the well-documented attentional biases towards food, weight, and shape stimuli among individuals with anorexia and bulimia nervosa (Brooks, Prince, Stahl, Campbell, & Treasure, 2011; Siep, Jansen, Havermans, & Roefs, 2010). Attentional biases in clinical eating disordered populations have been identified using a variety of experimental paradigms, including the Stroop task (Johansson, Ghaderi, & Andersson, 2005), the dot-probe task (Lee & Shafran, 2008; Shafran, Lee, Cooper, Palmer, & Fairburn, 2007), and the visual search task (E. Smeets, Roefs, & Jansen, 2009; E. Smeets, Roefs, van Furth, & Jansen, 2008). Thus, the consistent approach bias demonstrated by restrained participants in the present study may represent a preoccupation with food grounded in increased hedonic appraisals of, and attention for, palatable food in this population.

Support for differential responses to food stimuli also comes from neuroimaging data. Data from functional magnetic resonance imaging studies has demonstrated that restrained eaters show increased activation in the areas of the brain associated with hunger, desire for food, and reward processing (e.g. oribitofrontal cortex, left dorsolateral prefrontal cortex, and left insular cortex) relative to unrestrained eaters (Burger & Stice, 2011; Coletta et al., 2009; Demos, Kelley, & Heatherton, 2011). The same pattern of increased reward sensitivity has been observed in individuals with bulimia nervosa and binge eating disorder (for a review, see García-García et al., 2013). Furthermore, the mitigating effects of MA training on approach bias to food cues may also have clear neural substrates. A recent study by Paolini and colleagues (Paolini et al., 2012) demonstrated that among their sample of older, obese adults, higher levels of trait mindfulness were associated with faster return to resting neural activity following exposure to images of food. Individuals lower in trait mindfulness, by contrast, demonstrated neural activity suggestive of continued preoccupation with and elaboration of food cues (e.g. continued activation of insular, sensorimotor, visual, and orbitalfrontal cortices and the amygdala). Taken together, these neuroimaging data suggest that the approach bias and other cognitive biases towards food stimuli in restrained eaters may have a genuine neurological basis rooted in the hypersensitivity of the brain's reward systems, and that mindfulness-based interventions may function by facilitating the disengagement of these reward networks.

However, automatic reactions towards palatable food differ between successful and unsuccessful dieters: in successful restrained eaters exposure to palatable food activates the dieting goal, whereas the dieting goal is inhibited upon exposure to palatable foods in unsuccessful restrained eaters (Papies, Stroebe, & Aarts, 2008a). This distinction explains previously contradictory findings regarding the effect of dieting cues on the eating behavior of restrained eaters: while early research demonstrated that restrained eaters ate more than unrestrained eaters after exposure to diet commercials (Strauss, Doyle, & Kreipe, 1994), later work found the opposite (Anschutz, Van Strien, & Engels, 2008). However, neither of these studies differentiated between successful and unsuccessful restrained eaters. As the present study did not measure dieting success directly, we cannot distinguish between successful and unsuccessful restrained eaters in this sample. These groups may have different approach biases towards food stimuli and thus respond differently to MA training. For example, as demonstrated by Papies et al. (2008), exposure to food cues may activate the dieting goal in successful restrained eaters, thus reducing the approach bias and eliminating any effect of MA training, as was originally hypothesized in the present study; in contrast, unsuccessful restrained eaters may be primed by the food stimuli and show a dramatic approach bias that does not initially respond to MA training, as was observed in the present study. Unsuccessful restrained eaters may thus require more MA training to allow them to habituate to food cues (Morewedge, Huh, & Vosgerau, 2010) and reduce their approach bias.

Limitations

The current study is not without limitations. Foremost, the sample size used in the present study was relatively small, thus limiting our power and confidence in these findings. Furthermore, the present study did not differentiate between successful and unsuccessful restrained eaters, and, as discussed above, these groups likely have different automatic reactions to food cues and may differentially respond to MA training. Future studies should include self-report measures of dieting success as have been used in other studies (e.g. Papies et al., 2008).

Additionally, dietary restraint in the present study was assessed primarily by the use of self-report measures, which have been criticized for their lack of correlation with actual eating behavior; consequently behavioral measures of dietary restraint may be more accurate (Stice, Fisher, & Lowe, 2004). The use of weight suppression in the current analyses was an attempt to utilize a more objective measure, since weight suppression may be considered an indirect measure of dietary restraint (i.e. individuals higher in dietary restraint would presumably have higher levels of weight suppression). However, weight suppression may not be the optimal operationalization of dietary restraint as it likely differs between successful and unsuccessful restrained eaters. Future studies may consider using a behavioral measure of dietary restraint, such as observed eating behavior in a laboratory meal, in conjunction with self-report measures.

The design of this study also presents several limitations, some of which may have contributed to the failure to replicate precisely the findings of Papies et al. (2012). First, a relatively small number of trials were used for the approach-avoidance task, increasing the amount of within-subject variability. Future studies should increase the number of trials per participant to decrease variability and provide more accurate estimates of approach bias. Additionally, the instructions for the approach-avoidance task used in this study differed slightly from those used by Papies and colleagues (2012). Participants in the current study were instructed that pressing one key would cause the image on the screen to grow, while pressing the other key would cause the image to shrink; by contrast, participants in the Papies et al. (2012) study were told that they could move towards the picture by pressing one key and away from the picture by pressing the other key (E. K. Papies, personal communication, March 24, 2014). Presenting the task explicitly in terms of approach and avoidance and establishing the movement of the image relative to the participant may function to prime approach behaviors and thus be critical to establishing the approach bias.

Finally, the study design did not explicitly control for participants' hunger. While all subjects were run at the same time of day in an attempt to minimize the effects of hunger on participation, the wide range of time since subjects last ate prior to study participation indicates that this was an insufficient control. Future studies might consider controlling for hunger more rigorously, perhaps by requiring subjects to eat a standardized meal at a standardized time prior to study participation.

Conclusions and Future Directions

The results of the present study suggest that a brief, computerized training in mindful attention may successfully reduce or eliminate the approach bias towards food stimuli for individuals low in dietary restraint. However, the nonsignificant effects of mindful attention training in individuals high in dietary restraint observed in the present study suggest that more intensive mindfulness training may be necessary for this population. We cannot know from this study whether successful restrained eaters respond differently than their unsuccessful counterparts to training in mindful attention.

Future studies should examine the efficacy and feasibility of more extensive MA training for highly restrained eaters. More extensive interventions could include several brief MA training sessions with required daily practice. In addition to interventions that teach a mindful style of attention, highly restrained eaters may also benefit from learning alternative cognitive strategies such as cognitive reappraisal (Giuliani, Calcott, & Berkman, 2013). Internet-based training may greatly increase the feasibility of these interventions. Finally, future studies would do well to investigate the efficacy of computerized MA training in clinical populations, particularly among individuals with anorexia nervosa for whom dietary restraint is a chronic and life-threatening problem.

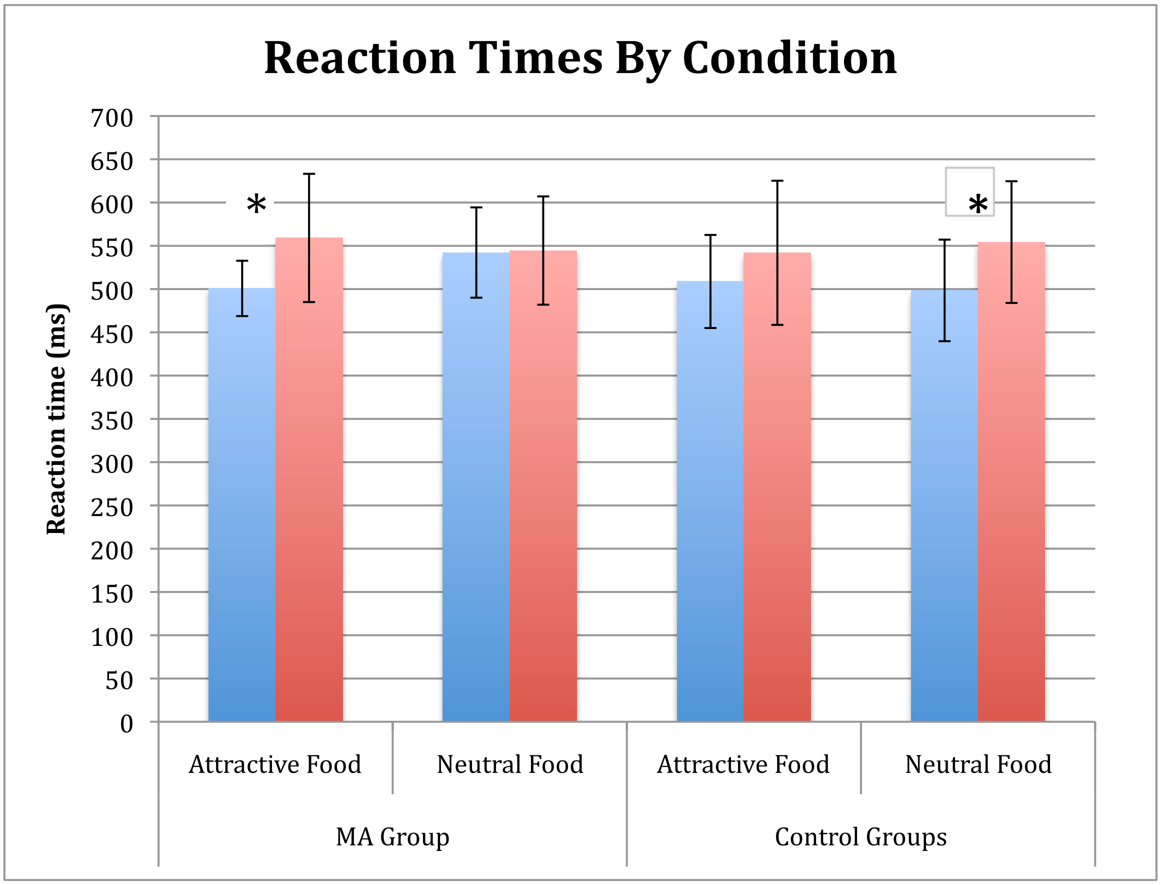
Appendices

Table 1. Descriptive statistics of the measures of restraint used and the correlations between measures of restraint.

	Mean	**SD**	**Range**	**α**	**1**	**2**	**3**	**4**	**5**	**6**
1. RS	13.4	5.6	4.0-25.0	.79	--					
2. TFEQ restraint subscale	9.8	5.2	2.0-21.0	.86	.602**	--				
3. DIS	20.5	7.4	9.0-39.0	.89	.581**	.850**	--			
4. EDE-Q restraint subscale	1.3	1.1	0.0-4.4	.70	.529**	.740**	.687**	--		
5. Weight Suppression (pounds)	6.6	6.7	0.0-30.0	--	.584**	.443**	.297	.356*	--	
6. Time Since Last Ate (hours)	3.4	4.4	0.2-20.0	--	.291	.149	.110	.259	.259	--

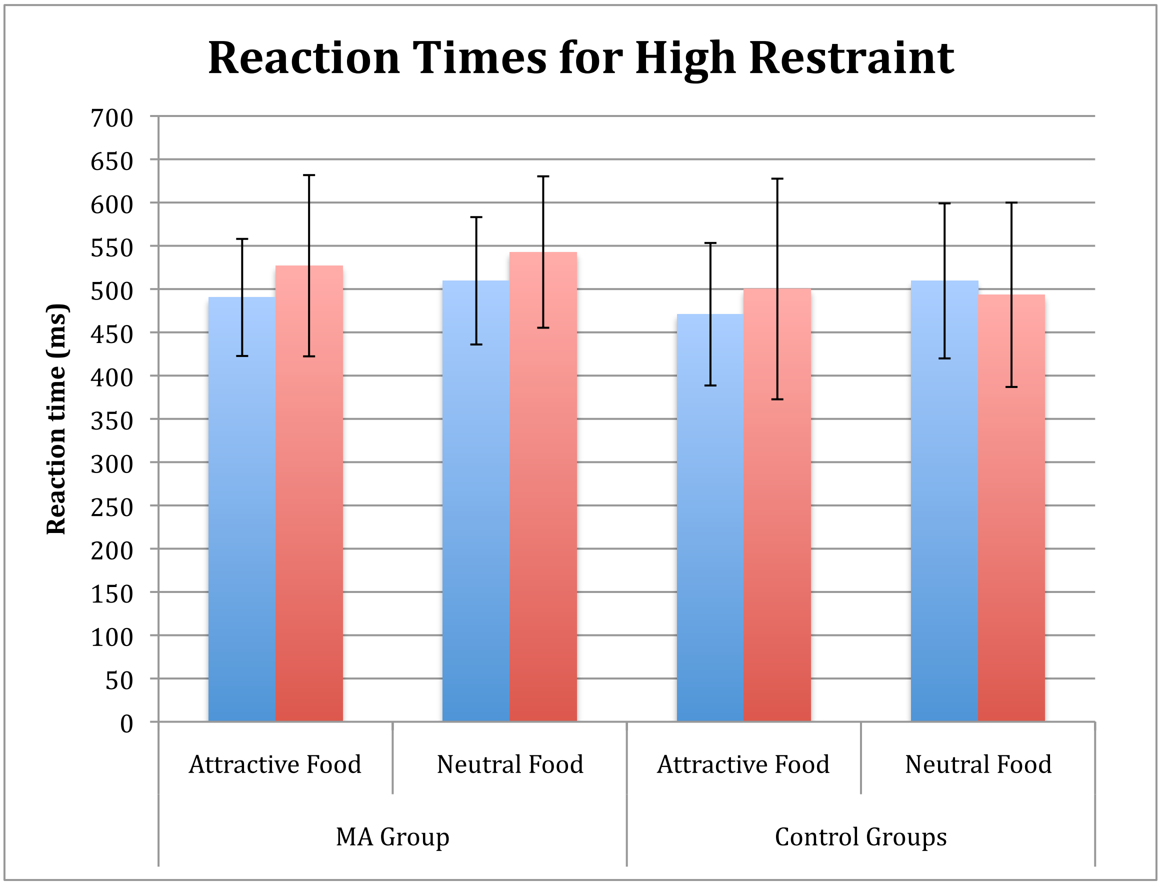
*p<.05
**p<.01

Figure 1. Graph of reaction times by condition.



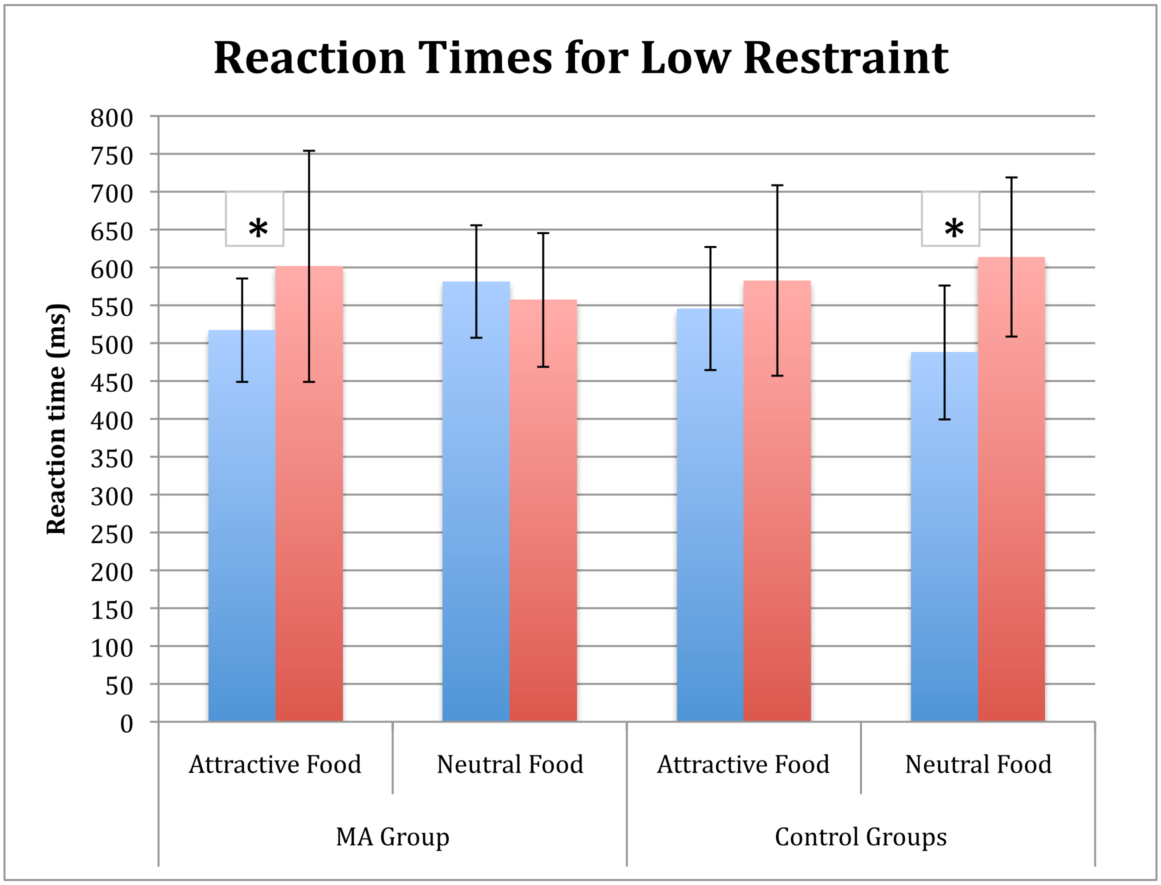
*p<.05
Error bars represent 95% confidence interval.

Figure 2. Graph of reaction times by condition at high level of restraint.



Error bars represent 95% confidence interval.

Figure 3. Graph of reaction times by condition at low level of restraint.



*p<.05
Error bars represent 95% confidence interval.

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