BEYOND EATING INTENTIONS: THE ROLE OF WORKING MEMORY CAPACITY IN MODERATING THE EFFECTS OF RESTRAINED EATING AND IMPLICIT FOOD ACTIVIATION ON EATING BEHAVIOR

BY

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Beyond Eating Intentions: The Role of Working Memory Capacity in Moderating the Effects of Restrained Eating and Implicit Food Activation on Eating Behavior
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ABSTRACT

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Beyond Eating Intentions: The Role of Working Memory Capacity in Moderating the Effects of of Restrained Eating and Implicit Food Activation on Eating Behavior

Dissertation directed by Professor Akira Miyake

Abstract: Restrained eating refers to individuals who consistently attempt to limit their intake of calories to reduce body weight (Herman & Polivy,1980). Restrained eaters have been noted for failures at converting dieting intentions into eating behavior (Stroebe, 2008). The primary goal of these studies was to determine what differentially contributes to eating behavior in women with highly restrained eating styles when: a) eating intentions alone do not predict intake, and b) someone is exposed to temptation. Given the self-regulatory nature of eating behavior, individual differences in working memory capacity (WMC) was expected to moderate the effect of restrained eating on food intake, over and above the impact of intentions. WMC was also expected to moderate the effect of implicit food activation, which has been shown to influence food choices. It was found that WMC moderated the effects of restrained eating and implicit food activation on self-report intake of unhealthy food. Unrestrained eaters ate less unhealthy food as WMC increased, and this effect was even stronger when implicit food activation was lower. WMC also moderated the effect of restrained eating and implicit food activation on intake of M&Ms. When WMC was lower, restrained eaters ate more M&Ms as implicit food activation increased. There was no effect of restrained eating or implicit food activation when WMC was higher. These results show the importance of considering the balance of control processes (i.e., WMC), explicit and implicit attitudes in determining food intake. The practical implications for regulating dieting and eating behavior are discussed.

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CHAPTER 1: GENERAL INTRODUCTION

Dieting and weight control has become an increasingly important concern in society as overweight, obesity, and rates of related health issues such as heart disease and diabetes, continue to rise (Ogden et al., 2006). Obesity rates have doubled since 1980 and as many as 32% of the U.S. population are now considered obese. Following suit, the rates of people actively dieting are also on the rise (Andreyeva, Long, Henderson, & Grode, 2010) and have been estimated to have tripled since 1960. As many as 24% of men and 38% of women report to be actively dieting in the U.S. (Stroebe, 2008). However, though more people are dieting, evidence suggests that many dieters tend to fail in their dieting attempts in the long term (Mann et al., 2007; Powell, Calvin, & Calvin, 2007; Wing, 2004). The term for chronic dieting in the literature is “restrained eating” and specifically refers to individuals who have consistently over time attempted to limit their intake of calories to reduce or maintain their body weight (Herman & Polivy, 1980). Restrained eaters in particular have been noted for their relative failures at converting their dieting intentions into eating behavior (Stroebe, 2008).

The primary goal of the following study is to determine what differentially contributes to eating behavior (i.e., intake of certain food items) in women who exhibit more highly restrained eating styles when: a) eating intentions alone do not predict eating behavior, and b) someone is exposed to temptation. Given the self-regulatory nature of dieting and eating behavior, it is thought that working memory capacity (WMC), the ability to control attention to maintain information in an active state (Engle, 2002) will moderate the effect of restrained eating on eating behavior and intake, over and above the impact of specific eating intentions. Furthermore, implicit associations have been shown to influence food choices. The current study also examined the hypothesized joint moderation effect of WMC on restrained eating and implicit influences on eating behavior, in terms of implementing intentions and resisting temptation.

WMC and Self-Regulation

Research on individual differences in WMC and executive functions (EF, a concept that is highly related to WMC, which will be treated fairly synonymously for the sake of this discussion) has become an area of increasing interest over the past decades for both cognitive psychologists and others who want to better understand self-regulatory behaviors (e.g., social, health, clinical psychologists). WMC has been conceived as reflecting executive attention and measures both active goal maintenance and resistance to interference (Engle, 2002, Kane, Bleckley, Conway, & Engle 2001; Kane, Poole, Tuholski, & Engle, 2006). WMC has been shown to predict failures in goal maintenance such that low WMC individuals tend to have difficulty in preventing attentional capture from distracters and maintaining attention on goal performance (Kane & Engle, 2003).

Research on individual differences in WMC, which refer to the range in capacity across individuals, focuses on what types of abilities and behaviors can be predicted from an individual's WMC. Individual differences in WMC (or EF, in some cases) are related to several cognitive, clinical, and social behaviors (for a review, see Miyake & Friedman, 2012). There is evidence that individuals with lower WMC are more likely to experience goal neglect, in which despite being aware of the requirement necessary to complete a given task, they sometimes lose access to their goal and fail to complete the task quickly or accurately (Kane & Engle, 2003). This particular aspect of individual differences in WMC is relevant to restrained eating because restrained eaters are presumably aware of both their intention to restrict their eating and the necessary behaviors to do so, but frequently fail to follow through on this behavior.

Restrained eating can be thought of as a self-regulation dilemma, where chronic and often unsuccessful dieters have the goal of eating healthy foods and limiting unhealthy foods in the long term, but frequently give in to the temptation of palatable food in the moment. Self-regulation generally refers to an ability to exert control over one's behavior (Baumeister, Bratslavsky, Muraven, & Tice, 1998), and has been defined as the ability to override habitual or tempting, but goal-incongruent behaviors to actively focus on long-term goals (Hofmann, Friese, Schmeichel, & Baddeley, 2011). Individual differences in WMC have also been shown to be related to several socially-relevant self-regulation behaviors such as avoiding binge-drinking (Mullan, Wong, Allom, & Pack, 2011), staying faithful to romantic partners (Pronk, Karremans, & Wigboldus, 2011), and overcoming racial bias (Payne, 2005) and the effects of stereotype threat (Schmader & Johns, 2003). Part of why self-regulation is such an interesting behavior to study is because we so often fail at it. Many self-regulatory behaviors involve some sort of conflict between a long-term goal and a short-term temptation or urge (Hall & Fong, 2007; Hofmann, Schmeichel, & Baddeley, 2012). Once an urge has been experienced, it can be difficult to avoid thinking about it and to reorient attention away.

Self-regulation can be particularly tricky, because it often involves a “hot” or emotional component that must be overcome to follow through on a certain goal (Mischel et al., 2011). In this framing, maintaining healthy eating behavior in the face of palatable food items is a prime example of a self-regulatory dilemma. It is this aspect of self-regulation, overcoming goal-incongruent influences, that individual differences in WMC are thought to influence. As outlined by Hofmann and colleagues (Hofmann et al., 2012), WMC is related to the following self-regulation mechanisms: active representation of self-regulatory goals, attentional control towards goal-relevant information and away from goal-incongruent (but frequently salient) stimuli, goal shielding, suppression of ruminative thoughts, regulation of unwanted affect, desires, and cravings, and active inhibition of prepotent or habitual behaviors.

Organization of paper

The primary goals of this paper, including Studies 1 and 2, were to determine how WMC contributed to predicting eating behavior in restrained eaters a) beyond the impact of intentions, and b) when exposed to temptation. Another goal was to determine if WMC moderated the effects of both restrained eating and implicit food activation on food intake. The overall study was run as a whole, over the course of two sessions; however, in this paper, it is presented as two separate studies, separated by the two primary goals listed above. Many of the measures used as predictor variables were the same, so for practical implementation reasons, the studies were run together as one. However, because the theoretical areas of emphasis for each goal are quite different, with different dependent measures and additional covariates or manipulations, the information is presented as two studies.

CHAPTER 2: THE MODERATING ROLE OF WORKING MEMORY CAPACITY BEYOND INTENTIONS IN EATING BEHAVIOR

WMC and the Intention-Behavior Relationship

Traditional health models have conceptualized intention as being the primary predictor of behavior (Ajzen & Madden, 1986). Although intention predicts much of the variance associated with behavior, typically about 33%, there is much variance leftover for which to account (Webb & Sheeran, 2007). Models of health behavior have begun to include individual differences variables to predict behavior, such as habit strength (Webb & Sheeran, 2007) or, more relevant to the proposed study, EF ability/WMC (Hall, Fong, Epp, & Elias, 2008). Specifically, individual differences in EF ability have been shown to moderate the relationship between eating intentions and actual eating behavior. EF was shown to have a main effect on consumption such that lower EF predicted greater consumption of fatty foods in people who intended to avoid unhealthy foods (Hall, 2012).

In a more direct test of moderation, Hall et al. (2008) measured women's self-reported intentions to eat fruits and vegetables, and then a week later, measured their actual consumption of fruits and vegetables. They found that EF ability moderated the relationship between eating intentions and subsequent actual eating behavior (Hall et al., 2008). Specifically, intention predicted consumption of fruits and vegetables more strongly for individuals with greater EF ability. This result was replicated using a measure of self-report trait self-control rather than WMC or EF per se, and was extended to attendance of dieting intervention meetings, decreased consumption of calories, less percentage of calories from fat, increased exercise, and greater weight loss after 12 weeks (Crescioni et al., 2011). However, it failed to be replicated in another study using the same EF task to predict breakfast consumption (Wong & Mullon, 2009). It may be that only certain types of eating intention-behavior relationships are moderated by EF, such as avoiding unhealthy, but tempting foods or increasing intake of fruits and vegetables, but not situations that may be more based on habits or availability, such as breakfast patterns. It also may be that other individual differences and their relationship to EF ability and WMC need to be taken into account.

Restrained Eating, Failed Intentions, and WMC

A major aim of Study 1 was to explicitly examine how WMC moderates individual differences influences on eating behavior beyond the effect of intentions. As mentioned, more highly restrained eaters are more likely to fail to convert their eating intentions into healthy eating behavior (Stroebe, 2008), which makes them a more vulnerable subset of eaters. The emphasis is not to say that restrained eating contributes to a larger intention-behavior gap; though this difference likely exists, the difference could be driven by restrained eaters having more extreme and potentially less plausible intentions. Instead the emphasis is on the behavior side, in which restrained eaters tend to have a higher BMI than less restrained eaters or gain back weight lost, self-report failures to maintain diets, and tend to eat more unhealthy food after food exposure (for a review, see Stroebe, 2008).

Higher restrained eating has also been shown to relate to lower WMC and EF ability. Restrained eating and current dieting have been shown to be related to decreased performance on several WMC-related tasks, such as short-term memory span tasks (Green, Elliman, & Kretsch, 2005; Kemps & Tiggemann, 2005; Kemps, Tiggemann, & Marshall, 2005), Tower of London planning time (Green et al., 2003; Green et al., 2005), and a switching task (Kemps et al., 2005), suggesting dieters have general impairments in WM-related processes.

There is also some experimental evidence that shows that dieting interventions can result in a reduction in EF. Although one study did not show any effects of a dieting intervention on a battery of EF measures (Bryan & Tiggemann, 2001), another study did find a certain group of dieters demonstrated decreases in WMC and planning (Green et al., 2005). An important element of the study by Green and colleagues is that they randomly assigned participants to a supported dieting intervention or an unsupported one. In the supported condition, dieters were given specific dieting guidelines and attended weekly support meetings. Unsupported dieters were told to follow a diet plan of their choosing, provided it did not include a support group element. The supported dieters performed equivalently on WMC measures to a no intervention group and showed no decrease in WMC across the 12-week intervention. However, the unsupported dieters showed a decline in WMC from baseline and compared to the other groups. Given that restrained eating relates to failures to enact healthy eating behaviors and to lower WMC, it was expected that WMC would be particularly important in determining eating behavior, over and above the effect of intentions, for more highly restrained eaters.

An additional consideration is that individual differences in WMC may influence intake of healthy foods and avoidance of unhealthy foods in different ways as those behaviors represent different problems spaces. The intake of healthy food involves more proactive, approach-oriented behavior, which may be mostly related to active goal maintenance. Avoiding unhealthy food, however, not only involves active goal maintenance, but may also require other mechanisms: for example, diverting attention away from salient, tempting items, or suppressing craving of those palatable, but goal-incongruent items. Study 1 examined the moderation effects of WMC for both healthy and unhealthy foods both beyond the impact of intentions.

Implicit Food Activation

As a final consideration, Study 1 also examined the impact of implicit food activation on eating behavior, and its relationship with WMC and restrained eating in predicting behavior, over and above intentions. The conceptualization of implicit food activation used here is people's tendency to spontaneously activate thoughts relating to food with or without their explicit awareness. This usage is distinct from more typical measures of implicit associations, such as the Implicit Association Task (IAT, Greenwald, McGhee, & Schwartz, 1998), the Affect Misattribution Procedure (Payne, Cheng, Govorun, & Stewart, 2005), or memory-association tasks (for a discussion of these types of tasks in heath behavior, see Hofmann, Friese, & Wiers, 2008), which reflect positive and negative associations with food items. These more typical measures were not used for two reasons. The first reason is that although the extent to which tasks such as the IAT reflect "true" measures of implicit attitudes is debatable, more recent evidence have shown that the IAT captures both automatic and controlled processes (for an extended discussion, see Conrey, Sherman, Gawronski, Hugenberg, & Groom, 2005). In other words, people's performance on the IAT depends not only on the strength of their implicit associations but also on their ability to overcome the influence of these associations to perform the task quickly and accurately. WMC has been shown to contribute to a person's performance on implicit association tests (for an example, see Payne, 2005). As the focus of this study was to understand how WMC moderates the effect of implicit food activations on eating behavior, it was necessary to use a task that did not partially reflect WMC.

The second reason to use the concept of implicit food activation is that there is evidence that women who exhibit more highly restrained eating are more preoccupied with thoughts about food, and that these preoccupying thoughts are responsible for their WMC deficits. Several studies have found that preoccupying thoughts about dieting are significantly negatively correlated with WM span task performance (Green et al., 2005; Kemps et al., 2005). It was also found that dieters performed worse on a phonological recall task (Green & Rogers, 1999), which was taken as evidence that dieting-related impairments are due to preoccupying thoughts (though for conflicting evidence using a double span task, see Kemps & Tiggeman, 2005). As such, it may be that an increased tendency to activate food-related thoughts in highly restrained eating contributes to unhealthy eating outcomes, and that WMC moderates the influence of both restrained eating and implicit food activation.

Current Study

In Study 1, I explored what other individual differences determine eating behavior besides intentions. Specifically, I examined how WMC moderated the effects of restrained eating and implicit food activation on eating behavior, over and above the effect of intentions. WMC was measured with two commonly used span tasks, the reading span task (Daneman & Carpenter, 1980) and the spatial span task (Shah & Miyake, 1996). Two tasks were used and aggregated in an attempt to circumvent the “task impurity problem” associated with WM and EF tasks (for a discussion, see Miyake et al. 2000). Restrained eating was also measured with two commonly used scales, the Dutch Eating Behavior Questionnaire- Restraint Subscale (DEBQ-R, (Van Strien, Frijters, Bergers, & Defares,1986), and Concern for Dieting subscale of the Restraint Scale (RS, Herman & Polivy, 1980).

A relatively novel task (at least, novel when used in this context as an independent variable), a word stem completion task, was used to assess implicit food activation. In this task, participants were presented with word stems that were missing one letter and their task was to complete those stems with an appropriate letter as quickly as possible. The idea is that this task taps an individual’s tendency to automatically activate thoughts about food (with or without awareness of that activation). As discussed above, more typical measures of implicit associations were not used because they reflect to some extent WMC, and do not represent the particular conceptualization of implicit influences of interest for this study.

Finally, self-report measures of intentions and actual intake of particular food items were used to assess intentions and behavior. Intentions toward and intake of both healthy and unhealthy food items were measured. In addition to intentions, other aspects of health attitudes that may contribute to intentions, intake, or the relationship between the two were also assessed. Specifically, participants were asked how healthy they thought particular food items are, how much they like them, how typical it is for them to eat them, and how much they would like to increase or decrease their intake of those items. Ratings of typicality and change served an additional purpose, in that they allowed me to specifically examine situations in which people have an established gap between their intentions and what is typical eating behavior for them, or when they explicitly intend to change their behavior, rather than when people's behavior is successfully aligned with their intentions. As such, two analyses were performed: the first using all of the stimuli to create an aggregate measures of women's attitudes, intentions, and behaviors toward healthy and unhealthy food items. The second analysis utilized the typicality and percent change variables to conduct a more individualized analysis, combining only items in which women had indicated they wanted to increase or decrease their intake. Using two analyses allowed me to determine if patterns for people's individual preferences were more important, or if the individualized results supported the overall, aggregate results.

Using these measures, this study's contributions were to examine a) the moderation effect of WMC on restrained eating and b) the joint moderation effect of WMC on both restrained eating and implicit food activation on eating behavior (i.e., self-report intake), beyond the effect of intentions alone, and c) whether individual preferences in desire to increase or decrease intake of specific food items lead to a different pattern of results than the aggregate measure.

Methods

Participants. Participants were 148 undergraduate women at the University of Colorado Boulder. Data from 17 women were removed because the participants did not return for the second session the following week or computer malfunction, leaving data from 131 women. Participants received course credit for their participation.

Materials and procedure. Tasks were completed in two sessions, one week apart, each lasting less than an hour. All tasks except the health behavior questionnaire (described below) were completed in the first session (note: other tasks were completed in the second session, but they are relevant only to Study 2 and will be described in detail in that section). Also, note that the tasks are described in the order in which they were administered.

Implicit food activation. Participants' automatic tendency to activate food-related thoughts was assessed using a word stem completion task. Participants were presented with a word stem that was missing one letter. They were instructed to type a letter that they thought completed the word. Each of the words could be completed in at least two ways. Of the 60 stems, 15 could be completed with food-related words and were randomly intermixed with neutral stems. For example, "STEA_" could be completed with "L" for "STEAL" or "K" for "STEAK". Stems were chosen such that alternative completion options were similarly accessible. Stems were piloted on another sample, and any stems in which the majority of responses were the same word were removed from the final list. Implicit Food Activation was defined as the number of stems completed with a food word.

Reading span. There were two measures of WMC: the reading span task (Daneman & Carpenter, 1980) and the spatial span task (Miyake et al., 2001, Shah & Miyake, 1996) (see Figure 1 for illustration of tasks). Of the two, the reading span was performed first. The Self-Control Questionnaire (described next) was completed between the two WMC measures to give participants a break from these more demanding tasks.

In the reading span task, participants first saw a sentence, and were instructed to read that sentence out loud and indicate the veridicality of the sentence. An example is, “Liquid is sharp and prickly”, to which the participant would respond, “False”. Then, they were presented with another word (e.g, “floor”), which they also read out loud, and were asked to recall at the end of a trial run. There were between 2-5 sentence-word presentations in each run. At the end of the run, participants were asked to recall the words presented (not the sentences), in the order in which the words were presented. Reading span was the proportion of words recalled in the correct order.

Self-control questionnaire. Participants completed the Self-Regulation Questionnaire, which has been shown to be reliable (alpha = 0.89) (Tangney, Baumeister, & Boon, 2004). This questionnaire is designed to assess day-to-day self-regulatory behaviors and includes items such as, “I have a hard time breaking habits”, “I am good at resisting temptation”, and “I am able to work effectively toward long-term goals”. Responses are indicated on a 5-point likert scale of how much the statements reflect the participant’s typical behavior, ranging from “Not at all like” to “Very much.”.Note that this task was not analyzed for this study, but is described here because it also served as a “filler” task to give rest between the two span tasks.

Spatial span. The spatial span task is structurally similar to the reading span task (see Figure 1), but requires spatial judgments rather than verbal ones. In the

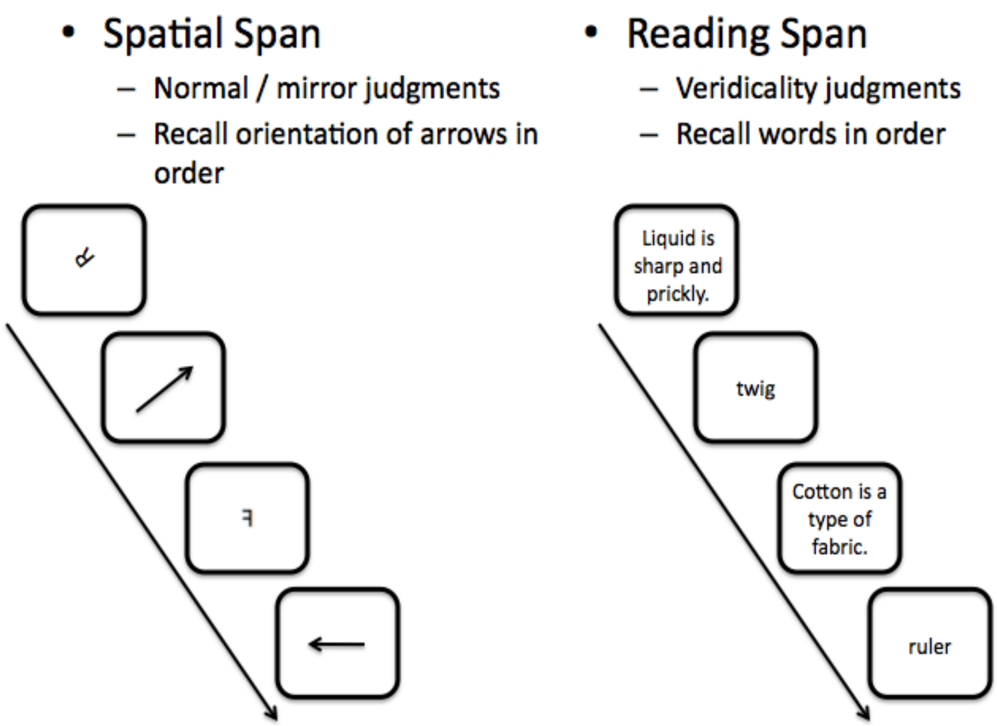

Figure 1. Illustration of WM span tasks for Studies 1 and 2

spatial span task, participants were presented with the rotated letters F, P, or R, and appeared either normally or mirrored. Participants determined whether the letters were normal or mirrored, then had to remember the orientation of an arrow presented after the letter. There were between 2-5 letter-arrow combinations in each trial run. At the end of each of the 12 runs, participants indicated on a sheet the order and direction of the arrows. Spatial span is the proportion of recalled arrows in the correct sequential position.

Health intentions and attitudes. Health intentions and other health attitudes were measured before dieting status, so that the dieting questionnaires did not serve as a reminder of potential dieting goals and influence intention estimates. Health variables were assessed with a self-report scale. Intentions were addressed with two different questions, (a) “Over the next week, how often do you INTEND to eat the following food items?” and (b) “How much do you intend to INCREASE or DECREASE your intake of the following food items?” (see Figure 2).

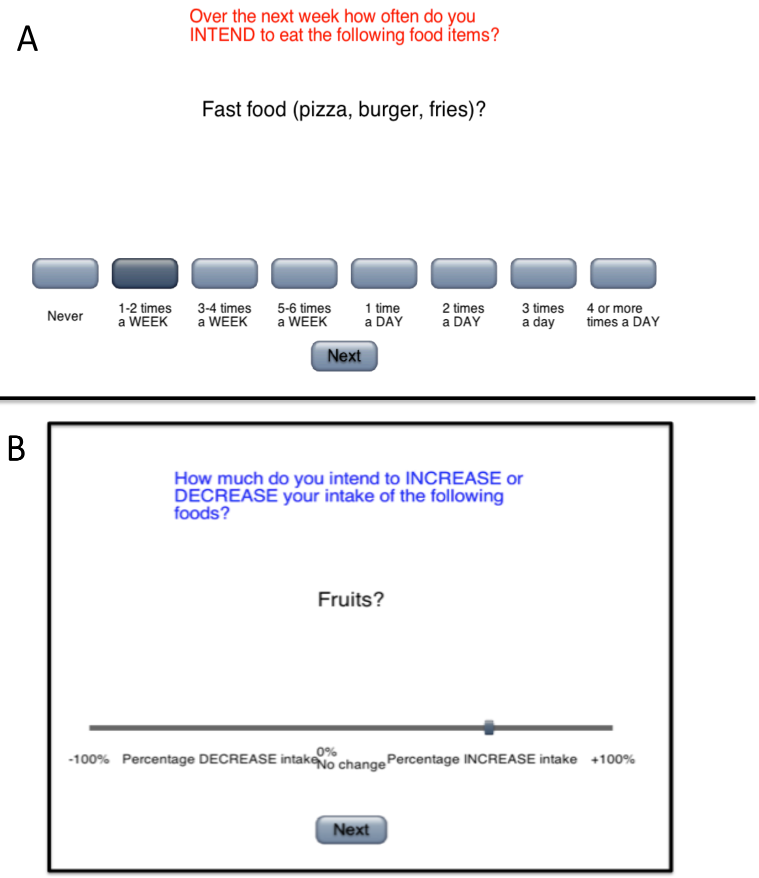

Figure 2. Example of intended percent change health intention measure for Study 1.

Responses to Question a were on an 8-point Likert scale ranging from never to 4 or more times a day. For Question b, participants indicated their responses on a sliding scale that ranged from -100% to +100% change. Food items included both unhealthy and healthy items: fruits; leafy green vegetables; other vegetables (broccoli, bell peppers, carrots, etc); potatoes and yams; breads, grains, rice or pasta (oatmeal, granola, etc), fish and lean meat, sweet snacks and dessert (chocolate, cookies, ice cream, etc.), chips (potato, corn, etc); soda or pop; and red meat.

Other aspects of health attitudes were assessed in addition to intentions. Participants were asked how *typical* it is for them to eat each food item, how much they *like* that item, and how *healthy* they consider each item. Typicality used the same Likert scale as the intention scale, ranging from “Never” to “4 times a day”. For both liking and health ratings, the 7-point Likert scale ranged from “Dislike a lot” or “Extremely unhealthy” to “Like a lot” or “Extremely healthy.”

Participants were asked not only about their intentions and attitudes to eat certain foods, but also about intentions toward other health and self-regulation behavior such as exercise (e.g., cardio, weight training), general health behaviors (e.g., brushing teeth, washing hands), and time management behaviors (e.g., watching TV, studying for classes). These other health topics were included partially to shield the purpose of this study from participants, but also to determine if the proposed relationships exist only for eating intentions and behavior, or if they generalize across health behaviors, though this extension is not examined here.

Restrained eating. Restrained eating was assessed with two frequently-used measures of restrained eating, the Dutch Eating Behavior Questionnaire- Restraint

Subscale (DEBQ-R, (Van Strien et al.,1986), and Concern for Dieting subscale of the Restraint Scale (RS, Herman & Polivy, 1980). The scales include items such as, “Do you deliberately eat less in order not to become heavier?” and “How often are you dieting?” (DEBQ-R and RS, respectively). Both scales use a 5-point Likert scale: Never, Seldom, Sometimes, Often, Very Often. Restrained eating refers to sustained attempts to lose or maintain weight by limiting food intake (Stroebe, 2008). These two measures tend to be highly correlated and were aggregated into z-scores for analyses.

BMI and body fat percent. Experimenters measured height in inches and weight in pounds for each participant. The scale was equipped to record body fat percent based on each participant’s height. Participants were asked to remove their shoes and socks, so that the electrodes on the scale were able to calculate body fat percent.

Health behavior questionnaire. The health behavior questionnaire was administered in the second session, a week after the first session. Questions about actual health behavior were structured identically to the health intentions and attitudes questions. Participants were asked the two types of intention questions, “Think back over LAST WEEK. How often LAST WEEK did you ACTUALLY eat the following food items?” and, “To the best of your ability, please estimate by what PERCENT your consumption of the following food items INCREASED or DECREASED over this past week. You should indicate how much your consumption changed compared to what is typical for you”. Again, their responses were an 8-point Likert scale and a sliding scale (-100% to 100% respectively). The question about typicality was repeated in this session, and was asked prior to asking about the previous week’s behavior to help anchor or distinguish between what is typical for that individual vs. how much she actually ate over the previous week. The two measures of typicality tended to be highly correlated (rs <0.80 for each individual item). The measures from the first session was used in the analyses because for both healthy and unhealthy food because they were less skewed and correlated better with the other health attitude measures than the typicality measure from the second session.

Aggregate Results

Preliminary data analysis. Aggregate mean scores for intentions and behavior were constructed separately for healthy and unhealthy food items. Some food items (bread and grains, red meat, and potatoes and yams) were dropped from their respective scales because not all participants agreed that those items were either healthy or unhealthy (i.e., there was much variability in ratings of healthiness for those items). The healthy food aggregates included fruits, leafy green vegetables, other vegetables, and fish and lean meat. The unhealthy food aggregates included savory snacks, sweets and desserts, chips, soda, and fast food.

All variables were z-scored for inferential analyses. An outlier analysis was conducted, and two observations were identified as potential outliers for healthy and unhealthy food behavior based on Cook's D values greater than 4 (Judd, McClelland & Ryan, 2009). Lever and studentized residuals were also examined, but yielded no outliers. To account for these potential outliers, all values that were greater than the absolute value of 3 SDs were adjusted to equal to plus or minus 3 SDs. Regression analyses were run on the original and adjusted data set. The pattern of results remained the same; therefore the original data set is used in the results described below. Note that BMI and body fat did not produce any significant effects and are therefore not further discussed in analyses. Additionally, for the aggregated analysis, there were no significant effects using the percent change measures, so this variable is not further addressed in the aggregate measure section of the results.

Descriptive statistics and correlations. Means and standard deviations for all predictor and dependent variables are presented in Table 1.Correlations among z-scored variables are presented in Table 2. As expected, intentions and intake were positively correlated for both healthy and unhealthy food items, such that greater intentions were associated with increased intake and vice versa. Intentions towards healthy and unhealthy items were negatively correlated where greater intentions towards healthy food times were associated with lesser intentions towards unhealthy food items. Unhealthy food intentions were negatively correlated with healthy food

Table 1.
Descriptive statistics for predictor variables and dependent measures.

	M	SD	minimum	maximum	skew	kurtosis	α
Working Memory Capacity							
Reading Span	17.9	4.9	5	33	0.15	0.55	0.76
Spatial Span	23.4	7.2	3	42	-0.07	0.63	0.76
Restrained Eating							
RS	11.4	4.9	0	24	0.23	-0.11	0.75
DEBQ-R	16.3	9.5	0	40	0.49	0.18	0.75
Implicit Food Activation	4.6	1.7	0	10	0.14	1.02	0.77
Healthy Food Intentions	3.9	1.3	0.5	6.25	-0.57	-0.35	0.43
Unhealthy Food Intentions	1.0	0.82	0	4	1.48	2.39	0.42
Healthy Food Intake	2.4	1.26	1	6.25	-0.16	-1.0	0.44
Unhealthy Food Intake	2.2	0.9	1	5.6	1.11	1.31	0.46

Table 2.
Correlations between z-scored variables (r).

	WMC	RE	IFA	HF_Intent	UF_Intent	HF_Intake	UF_Intake
1. WMC	1						
2. Restrained Eating	-0.01	1					
3. Implicit Food Activation	0.073	0.029	1				
4. Healthy Food Intentions	0.007	0.015	-0.09	1			
5. Unhealthy Food Intentions	0.009	-0.13	-0.05	-0.23**	1		
6. Healthy Food Intake	0.03	-0.01	-0.04	0.62**	-0.24**	1	
7. Unhealthy Food Intake	-0.01	-0.04	0.02	-0.12	0.57**	-0.18*	1

***p<.001*
**p≤.05*

intake. People who have low intentions to eat unhealthy food, tend to eat more healthy food. There were no other significant correlations.

Regression analysis. Several linear models were run using WMC (aggregated proportion correct on reading and spatial spans), implicit food activation (number of food words created), restrained eating (aggregate of RS and DEBQ-R), and intentions to eat certain foods (healthy and unhealthy aggregates) as predictor variables, including interactions for all the primary predictor variables as recommended by Yzerbyt, Muller, and Judd (2004). For the final analysis, intentions were included as a covariate, excluding its interactions. There were not significant interactions with intentions in a full model, therefore the model was simplified for the final output. All of these variables were continuous measures and were z-scored. Separate models were run with healthy and unhealthy food intake aggregates as the dependent variables. To better understand any significant interactions, floodlight analyses were conducted in accordance with Spiller, Fitzsimmons, Lynch, and McClelland (2013), an approach that is akin to and expands on the slope analysis recommendations made by Aiken and West (1991).

Starting with unhealthy eating behavior, there was a significant main effect of intention, $F(1,123)=71.1$, $p<0.001$, $\eta_p^2=0.38$ (the full regression results are presented in Table 3). Keep in mind that this relatively large effect was over and above any other significant effects, a result that is in line with previous literature. There was a significant two-way interaction between WMC and restrained eating, $F(1,123)= 4.67$, $p=0.03$, $\eta_p^2=0.04$, controlling for intentions, implicit food activation, and their interactions. Figure

Table 3.

Results of regression model for aggregate measures.

Variable	F	p	η_p^2
WMC	0.02	0.89	<0.001
Restrained Eating	0.55	0.46	0.34
Implicit Food Activation	0.08	0.89	<0.001
Intentions	71.7	<0.001**	0.38
WMC x Restrained Eating	4.67	0.03*	0.04
WMC x Implicit Food Activation	0.10	0.75	<0.001
Restrained Eating	0.03	0.86	<0.001
Implicit Food Activation x			
WMC x Restrained Eating x	3.61	0.059*	0.03
Implicit Food Activation			

Note: all effects tested were 1-degree of freedom tests, with the denominator dF=123.

3 presents an illustration of the floodlight analyses. Using this approach, the simple effect of WMC was estimated at several different deviations of restrained eating (i.e., re-running the regression model after adding or subtracting a constant from individual restrained eating scores). Figure 3 graphs the regression line for the simple effect of WMC at each deviation. Note that solid lines reflect a significant effect of WMC at that level of restrained eating, whereas the dotted lines are nonsignificant. Figure 3 suggests that women who are relatively low on restrained eating (-2 SD) (i.e., non-dieters, red lines) tend to eat less unhealthy food as WMC increases. This pattern reverses for women who are relatively highly restrained eaters (+2 and +2.5 SD)(dieters, blue lines), who tend to eat more unhealthy food as WMC increases. Note that there is no effect of WMC for the mean level and somewhat low and high (-1 and +1 SD) levels of restrained eating.

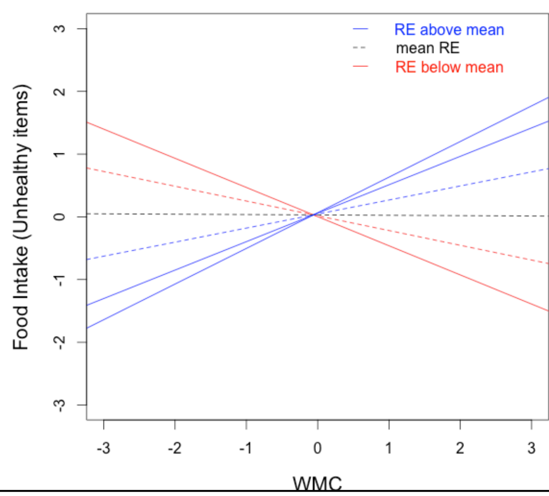

Figure 3. This figure presents the floodlight illustration of the two-way interaction effect between WMC and restrained eating on intake of unhealthy food items in Study 1. Each line represents the simple effect of WMC at different estimates of restrained eating. The red lines represent regression estimates when restrained eating was adjusted to 1 and 2 SDs below the mean, whereas the blue lines represent estimates at 1, 2, and 2.5 SD above the mean. These values were chosen because they reflected the range of restrained eating z-scores. Finally, the solid lines indicate a significant simple effect of WMC, while the dotted lines are non-significant. RE=restrained eating.

The two-way interaction is qualified by a significant three-way interaction effect between WMC, restrained eating, and implicit food activation on unhealthy food intake, $F(1,123)=3.61$, $p=0.059$, $\eta_p^2=0.03$, controlling for intentions and relevant interactions. The floodlight approach was again used to unpack this interaction, illustrated in Figure 4. Looking at the top two panels of Figure 4, when restrained eating is low, women tend to eat less unhealthy food as WMC increases, and this effect is even stronger when

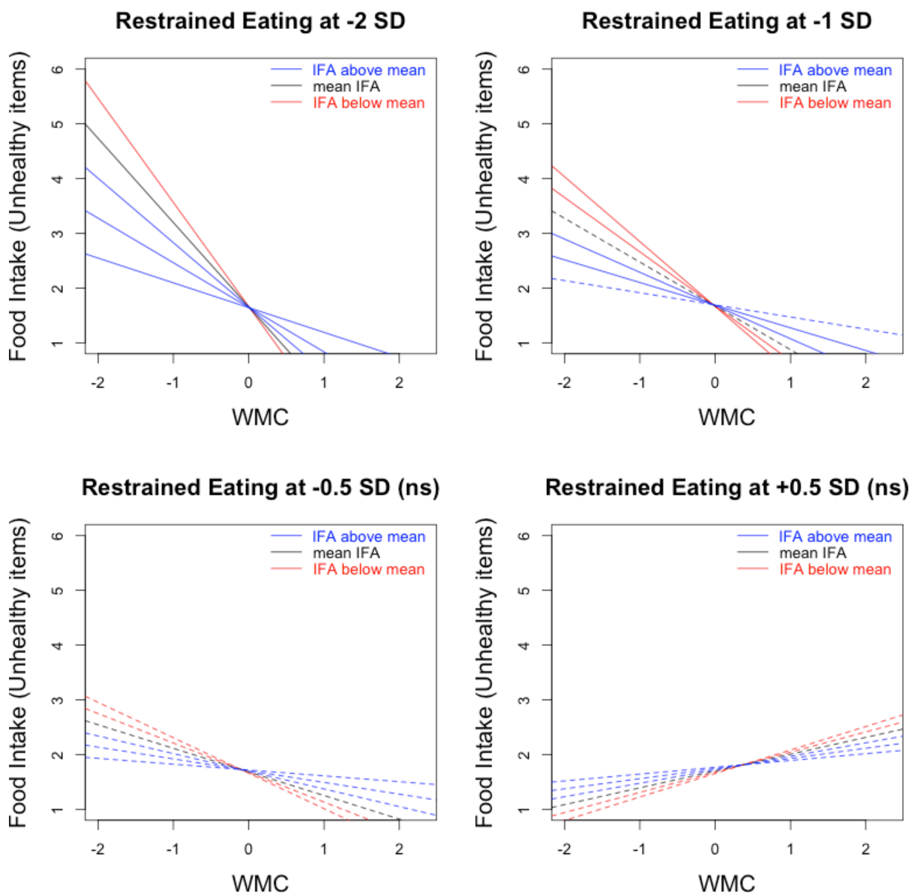

Figure 4. This graph illustrates the three-way interaction of WMC, restrained eating, and implicit food activation on unhealthy food intake. Each panel represents different levels of restrained eating in Study 1. Within each restrained eating level, the simple effect of WMC was estimated as various levels of implicit food activation (-2SD to +3SD, to reflect the actual range of data in this sample), indicated by each line. Note that the only significant effects occur when restrained eating is low, in the top two panels; the nonsignificant results in the lower panels are shown for reference purposes. IFA= implicit food activation.

implicit food activation is low (red lines). This trend remains significant as implicit food activation increases, though the slope of the effect decreases (blue lines). Note that the slope did fail to reach significance when implicit food activation is estimated at +3SD. If it were possible to graph confidence bands around the slopes for this three-way effect, it is likely that the estimate at +3SD would fall outside that range. Unfortunately, this calculation is not currently possible due to computational limitations. However, the slope for that line is clearly approaching 0, which means that it makes sense that it was not significant. The slope for the line estimated at the mean for IFA is marginally significant, p=0.09. The simple effects of WMC failed to reach significance at any level of implicit food activation when restrained eating is deviated to -0.5 SD and value up to at least +5 SD, which is well beyond the boundaries of the data set (represented in the bottom two panels of Figure 4).

An analogous set of analyses was applied to healthy food behavior. With the exception of intentions, $F(1,123)= 82.9$, $p<0.0001$, $\eta_p^2 =0.42$, none of the primary predictors of interest or the relevant interactions demonstrated any significant effects on intake of healthy food items.

Individualized Results

The overall goal of this study was to examine what influences women's eating behavior when a gap did exist between their eating intentions and their typical intake, or in other words, when they intended to change their current eating behavior. Due to the highly specific and multi-faceted nature of people's individual food preferences, it is reasonable to expect that there are only certain foods in which certain individuals would like to increase or decrease their intake. As such, individualized analyses may be more appropriate for this type of question about these data.

There were two ways of assessing intended change in this data set: self-reported percent change, and the difference between what participants reported as intended intake and typical intake of each food item (see the Health Intentions and Attitudes description in the Methods section). Using these two measures, individual items were selected from each participant to calculate an individualized measure for items in which people intended to increase intake and items in which people intended to decrease intake in two different ways. The first way was to take *any* items that people wanted to change, by selecting items for which the percent change or intention-typical difference score was not equal to zero. The second way was to take items that people *most* wanted to change, by ranking the non-zero items and selecting the top two intended increase and intended decrease items. This created 8 different new sets of measures (2 (non-zero vs. top two) x 2 (intention-typical vs. percent change) x 2 (increase vs. decrease)). Table 4 displays the resulting descriptive statistics for each set of criteria measures and other relevant health attitude measures, including the descriptive statistics for number of stimuli used for each individual-item measure.

Note that there were some participants who did not intend to increase or to decrease their intake of any items for both intention-typical and percent change. Therefore individualized measures were not able to be calculated for these participants and they were dropped for the following analyses. For intention-typical, there were 12 participants who did not intend to increase their intake of any items and 7 participants who did not intend to decrease their intake of any items. There were an additional 6 participants who only wanted to increase their intake of one item, therefore they were not included in the analyses using the top-two method. There were not any participants that only wanted decrease only one item. Therefore the final N for the intention-typical analyses that used intended decrease was 124 and for analyses that used intended increase was 119 (non-zero) and 113 (top two).

Table 4.
Descriptive statistics for the individual-item measures.

Intended Increase Items						
Non-zero selection:						
Intention-Typical	M	SD	min	max	skew	kurtosis
Intention-Typical	1.6	0.6	1	3.33	0.86	-0.19
Intention	3.84	1.2	1	7	-0.41	0.09
Healthiness	4.9	1.0	1	6	-1.45	2.55
Liking	4.8	1.0	1	6	-1.19	1.68
Intake	3.3	1.4	0	6	-0.17	-0.37
Number of included stimuli	3.4	1.7	1	8	0.30	-0.76
Top two selection:						
Intention-Typical	M	SD	min	max	skew	kurtosis
Intention-Typical	1.7	0.8	1	4	1.02	0.09
Intention	3.9	1.2	1	7	-0.39	0.10
Healthiness	5.0	1.0	1	6	-1.72	3.36
Liking	4.8	1.0	1	6	-1.09	1.08
Intake	3.4	1.5	0	6.5	-0.07	-0.42
Number of included stimuli	2.9	1.3	1	6	0.11	-0.61
Non-zero selection:						
Percent change	M	SD	min	max	skew	kurtosis
Intended percent change	28.4	17.2	3.8	100	1.24	2.21
Healthiness 5.4	0.6		3	6	-1.38	2.60
Liking	4.9	0.94	1.67	6	-1.13	1.3
Actual percent change	4.0	15.1	-41	72	1.58	6.05
Number of included stimuli	3.8	1.6	1	8	0.16	-0.65
Top two selection:						
Percent change	M	SD	min	max	skew	kurtosis
Intended percent change	33.1	20.4	4.08	100	0.85	0.41
Healthiness	5.6	0.5	3	6	-1.71	3.81
Liking	4.9	0.9	1.7	6	-1.14	1.34
Actual percent change	5.0	16.7	-41	72	1.42	3.85
Number of included stimuli	2.7	0.6	1	4	-1.31	1.39

Table 4 continued.

Intended Decrease Items

Non-zero selection: Intention-Typical	M	SD	min	max	skew	kurtosis
Intention-Typical	-1.5	0.6	-4	-1	-1.25	1.91
Intention	1.27	0.88	0	4	0.74	0.39
Healthiness	1.78	1.24	0	6	0.71	0.18
Liking	4.86	0.89	1	6	-1.22	2.35
Intake	2.9	1.2	0	6.5	0.27	0.35
Number of included stimuli	3.6	1.6	1	9	0.71	0.56

Top two selection: Intention-Typical	M	SD	min	max	skew	kurtosis
Intention-Typical	-1.85	0.94	-5	-1	-1.02	0.29
Intention	1.2	0.9	0	4	0.79	0.61
Healthiness	1.7	1.3	0	6	0.76	0.12
Liking	4.9	0.9	1	6	-1.28	2.00
Intake	3.0	1.3	0	8	0.49	1.02
Number of included stimuli	2.7	1.1	1	7	1.07	1.51

Non-zero selection: Percent change	M	SD	min	max	skew	kurtosis
Intended percent change	-33.7	20.3	-85.1	-4	-0.72	-0.28
Healthiness	1.4	0.9	0	5	0.81	1.15
Liking	4.8	0.9	1	6	-1.02	1.98
Actual percent change	0.03	14.2	-31.2	81	2.24	11.9
Number of included stimuli	4.2	1.8	1	8	-0.14	-0.79

Top two selection: Percent change	M	SD	min	max	skew	kurtosis
Intended percent change	-46.4	28.7	-100	-5.3	-0.50	-0.90
Healthiness	0.9	1.0	0	5	1.32	1.84
Liking	4.8	1.1	2	6	-0.83	-0.18
Actual percent change	-0.42	18.4	-63.5	100	1.77	10.74
Number of included stimuli	1.9	0.5	1	5	2.43	16.8

For percent change, there were 11 participants who did not want decrease any items and 14 participants who did not want increase any items. There were 2 additional participants who only wanted to decrease one item and 4 participants who only wanted to increase one item. For those analyses, the final Ns were 120 (non-zero decrease), 117 (non-zero increase), 118 (top two decrease), and 113 (top two increase).

Individual-item measures: correlations and model results. Correlations and regression models were run for each set of the individual-item measures. When intention-typical differences scores were used as the criterion, intention and intake were used. When intended percent change scores were used as the criterion, intended percent change and actual percent change were used. Examining correlation matrices, the various health attitude measures continued to correlate with each other, notably healthiness and liking tended to correlate with intention and intake measures (r values ranging from 0.19-0.56, ps<0.01), in addition to the common intention-intake behavior correlation (r values ranges from 0.37-0.59, ps<0.001). For the most part, health attitudes measures did not correlate with the other predictor variables (i.e., WMC, restrained eating, and implicit food activation). There was one exception: Intended percentage change for decrease items was negatively correlated with restrained eating for both the non-zero selection, $r(118)=-0.20$, $p=0.02$, and the top two selection, $r(116)=-0.19$, $p=0.04$. A more negative score for intended percentage change indicates a greater intention to decrease consumption of that item, so this correlation indicates that the more highly restrained a participant's eating, the greater the intended intake decrease, in line with theoretical conceptions of restrained eating.

Independent models were run on each set of the individual-item measures with behavior (i.e., intake or actual percent change) as the dependent measure, WMC, restrained eating, and implicit food activation and their interactions as predictor variables, and intentions (i.e., intention or intended percent change), liking, and healthiness as covariates. Table 5 displays the p values for all the predictors across all of those models. The first striking pattern across all results for percent change was that intended percent change did not predict actual behavior change. In other words, in these models, intentions did not predict behavior, a relationship that is so robust in previous literature. For that reason, I concluded that percent change was not measuring what I had intended (i.e., lacked construct validity) and chose not to focus further on those results.

Examining the results using intention-typical, the patterns for non-zero and top two are highly similar for both intended increase and decrease items, although several terms that were trending failed to reach significance using the non-zero selection method. Based on the marginally significant terms and higher skewness and kurtosis for the non-zero method, at least for intended decrease items, I chose to more closely examine the results for the top two selection method for intention-typical criterion only.

An outlier analysis was conducted on the top two intention-typical selection measures. One observation was identified as a potential outlier for food intake based on a high studentized residual value, -4.13. There was no further evidence of outliers based on Cook's D or lever. Analyses were performed with and without this value. Removal of the potential outlier did not change the results of the regression model or

Table 5.
Significant regression results with each individual-itemized criteria measures.

Individual-Item Criterion

Intention-Typical

	WMC	RE	IFA	Intent	Like	Healthy	WMC x RE	WMC x IFA	RE x IFA	WMC x RE x IFA
Intended Increase										
Non-Zero	0.72	0.35	0.20	**<0.01***	0.22	0.91	0.94	0.63	0.93	0.57
Top Two	0.93	0.27	0.33	**<0.01***	0.50	0.60	0.76	0.63	0.52	0.38
Intended Decrease										
Non-Zero	0.36	0.17	0.91	**<0.01***	*0.08*+	**<0.01***	*0.09*+	0.86	0.43	0.58
Top Two	0.12	0.77	0.88	**<0.01***	**<0.01***	**<0.01***	**0.03***	0.93	0.28	0.46

Percent Change

	WMC	RE	IFA	Intent	Like	Healthy	WMC x RE	WMC x IFA	RE x IFA	WMC x RE x IFA
Intended Increase										
Non-Zero	0.32	0.40	0.61	0.28	0.29	0.66	0.17	**0.04***	*0.06*+	0.73
Top Two	0.29	0.87	0.85	0.22	0.39	0.74	**0.05***	0.10	*0.07*+	0.99
Intended Decrease										
Non-Zero	0.22	0.64	0.26	0.29	**<0.01***	0.99	*0.06*+	0.95	**0.01***	0.26
Top Two	0.51	0.93	0.58	0.63	**0.02***	0.40	0.15	0.53	**<0.01***	0.23

X p<0.05
+p>0.05 and <0.1

resulting pattern. Therefore, the observation was left in the data set for the analyses reported below.

Top two intention-typical correlations and regressions. The correlation matrix for the health attitude variables for the top two intention-typical criterion and the primary predictor variables is presented in Table 6. For both intended increase and intended decrease, intentions were positively correlated with healthiness and intake. For intended decrease, intentions and intake were also positively correlated with liking.

Given the correlations with rating of healthy and liking, those variables were included as covariates in the regression models in addition to intention and the primary predictor variables of WMC, restrained eating, and implicit food activation. Two separate regressions were run with the top two intention-typical selection criteria for the intended increase and intended decrease items.

Intended decrease. The full regression model for the intended decrease scale is presented in Table 7. There were significant main effects of all of the health attitude variables on intake of items women intended to decrease: intentions, $F(1,113)=19.12$, $p<.0.001$, $\eta_p^2=0.15$, liking, $F(1,113)=11.32$, $p=0.001$, $\eta_p^2=0.09$, and healthiness, $F(1,113)=10.34$, $p=0.002$, $\eta_p^2=0.09$. All relationships were positive, such that stronger intentions (to eat those items, not to avoid those items) related to greater intake and vice-versa. The more a women liked food items or perceived those items as healthy also related to greater intake.

There was also a significant two-way interaction effect of WMC and restrained eating on intake, controlling for implicit food activation, interactions among primary predictors, intentions, liking, and healthiness, $F(1,113)= 4.94$, $p=0.03$, $\eta_p^2=0.04$ (see

Table 6.

Correlations between combined individual-item criteria measures and primary predictor variables.

	WMC	RE	IFA	Intent(I)	Intent(D)	L(I)	L(D)	H(I)	H(D)	Intake(I)	Intake(D)
1. WMC	1										
2. Restrained Eating	-0.01	1									
3. Implicit Food Activation	0.07	0.02	1								
4. Intentions (Increase)	0.05	-0.13	-0.01	1							
5. Intentions (Decrease)	-0.01	-0.05	-0.11	-0.09	1						
6. Liking (Increase)	0.03	-0.08	-0.14	0.27	0.10	1					
7. Liking (Decrease)	0.12	0.14	0.04	-0.10	0.34**	0.13	1				
8. Healthy (Increase)	0.13	0.05	0.05	0.42**	-0.15	0.37**	0.07	1			
9. Healthy (Decrease)	-0.04	-0.02	-0.13	-0.18	0.54**	0.17	0.06	-0.14	1		
10. Intake (Increase)	0.02	-0.17	0.05	0.59**	-0.09	0.21+	-0.19	0.30	-0.08	1	
11. Intake (Decrease)	-0.11	0.05	-0.01	0.03	0.37*	-0.04	0.37**	-0.11	-0.07	-0.08	1

Table 7.

Full regression model for top two selection method using intention-typical as criterion scores.

Variable	F	p	η_p^2
WMC	2.46	0.12	0.11
Restrained Eating	0.08	0.77	<0.001
Implicit Food Activation	0.02	0.89	<0.001
Intentions	19.12	<0.001**	0.15
Liking	11.32	0.001**	0.09
Healthiness	10.34	0.002**	0.09
WMC x Restrained Eating	4.94	0.03*	0.04
WMC x Implicit Food Activation	<0.01	0.92	<0.001
Restrained Eating	1.16	0.28	0.007
Implicit Food Activation x			
WMC x Restrained Eating x Implicit Food Activation	0.56	0.46	0.005

Note: all effects tested were 1-degree of freedom tests, with the denominator dF=113.

$^{**}p<.001$, $^{*}p\leq.05$

Figure 5). This interaction replicated to some extent the two-way interaction obtained from the analysis of the full aggregated measures for unhealthy food items. As seen in the previous interaction, when restrained eating is relatively low (red lines), intake decreases with greater WMC. However, unlike the previous interaction, there is no evidence of a significant effect of WMC on intake when restrained eating is relatively high (blue lines). This lack of effect for highly restrained eaters echoes the three-way interaction from the full aggregate measures, where there was also no evidence to

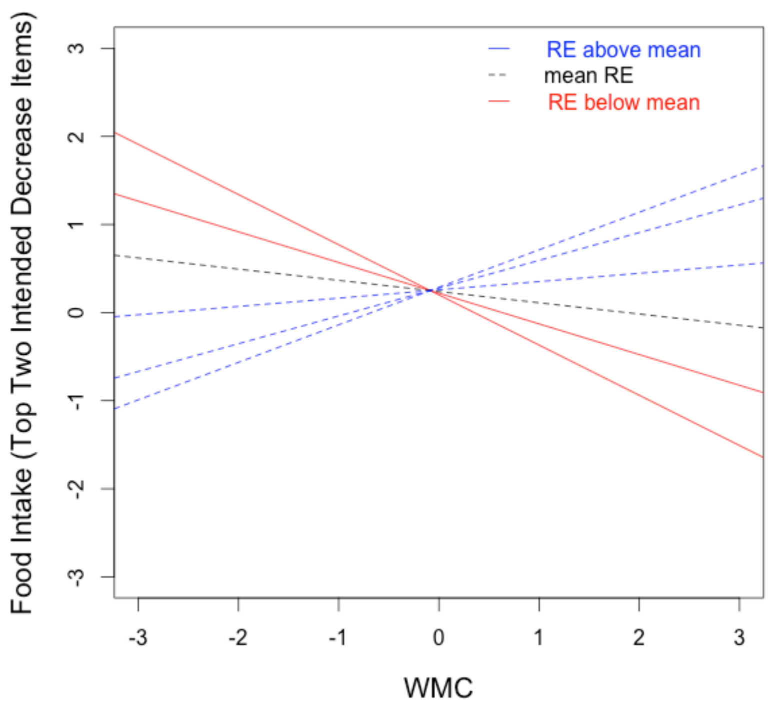

Figure 5. This figure presents the floodlight illustration of the two-way interaction effect between WMC and restrained eating on intake of the top two food items that participants had intended to avoid in Study 1. Each line represents the simple effect of WMC at different estimates of restrained eating. The red lines represent regression estimates when restrained eating was adjusted to 1 and 2 SDs below the mean, while the blue lines represent estimates at 1, 2, and 2.5 SD above the mean. These values were chosen because they reflected the range of restrained eating z-scores. Finally, the solid lines indicate a significant simple effect of WMC, and the dashed lines are non-significant. RE=restrained eating

suggest an effect of WMC or (implicit food activation) at higher levels of restrained eating.

Intended increase scale. The only significant predictor of intake of food items women intended to increase was intentions, $F(1,102)=35.53$, $p<0.001$, $\eta_p^2=0.27$, replicating the results of the full aggregate measures for healthy food items. Greater intentions to increase consumption of specific food items were related to greater intake of those items.

Discussion

Study 1 examined the contribution of individual differences in WMC as a moderator of restrained eating and implicit food activation in predicting eating behavior, above and beyond the role of eating intentions. A summary of the findings for both the full data set and the individualized analyses is presented in Figure 6. As shown in the figure, the result that unrestrained eaters with greater WMC ate less is the most consistent pattern in both the two-way and three-way interactions. As such, this result will receive the most emphasis in the discussion and be considered to be the strongest effect. The other results will be considered, but will need to be taken with a grain of salt given their inconsistency.

		Full Data Set	Individualized Data Set
2-way	Unrestrained eaters	Ate less with greater WMC	Ate less with greater WMC
	Restrained eaters	Ate more with greater WMC	No effect
3-way	Unrestrained eaters	Ate less with greater WMC especially at lower levels of IFA	
	Restrained eaters	No effect	

Figure 6. This figure presents the consistency of results in Study 1. The two-way interaction where there was an effect for unrestrained eaters is the most consistent pattern. The three-way interaction was not significant for the individualized data, therefore those cells are empty.

In addition to the main findings, which will be elaborated below, an important contribution of this study was the use of the individualized analyses, that provide a level of specificity and details not present in other studies on intentions for eating behavior.

Additionally, in line with previous work, intentions related to intake of both healthy and unhealthy foods (or alternatively, foods people intend to eat more of vs. avoid). Intentions were also related to healthiness for both intended increase and decrease items. Intentions were related to liking only for intended decrease items. Liking was also related to actual intake of those items. This divergence in relationships (i.e., liking was only related to intentions and intake of foods women were trying to avoid) suggests that control over intake of healthy and unhealthy food items rely on different processes or influences. The items that women intended to avoid were mostly highly palatable items that are generally well-liked. This additional layer of having to resist temptation may relate to why different patterns were seen for healthy vs. unhealthy food items.

The pattern for the primary result of Study 1, the consistently significant two-way interactions, for both unhealthy food and foods women are trying to avoid suggests that when restrained eating is low (i.e., non-dieters), intake was increasingly lower in women with greater WMC, as expected. The three-way pattern also demonstrated that when restrained eating is low, intake decreased with greater levels of WMC. There was some evidence that decrease in intake of unhealthy food items was even stronger for individuals who exhibited low levels of implicit food activation, although this was not replicated for individualized intended decrease items.

At least when using the full aggregate measure of unhealthy food items, the two-way interaction suggested that when restrained eating is higher (i.e., dieters), this pattern reversed such that intake increased with greater levels of WMC. There are two reasons why this pattern could occur. The first explanation is based on the so-called, "What the hell" effect in restrained eaters. Restrained eaters tend to eat more food after given a pre-load than unrestrained eaters and restrained eaters not given a pre-load. For example, restrained eaters who are given a small amount of ice cream tend to eat much more ice cream (again compared to both pre-load unrestrained eaters, and not pre-loaded restrained eaters) when given the opportunity to eat as much as they want afterwards. One explanation for the pre-load effect is that restrained eaters perceive themselves as having already violated their goal to restrict their unhealthy food intake., and therefore stop attempts to continue to regulate their intake (Stroebe, 2008). It may be that restrained eaters with greater WMC more strongly activate their dieting goals, and are more reactive when they violate that goal, leading to a stronger "what the hell" response. Conversely, individuals with lower WMC may be less aware of their dieting goal violation, mitigating their “what the hell” response. An alternative explanation is that women with greater WMC are more accurate in their self-reported intake and that intake simply appears to be greater at higher levels of WMC. Regardless this pattern should be interpreted judiciously as it was not replicated in the individualized analysis or in the pattern for the three-way interaction

Keeping in mind that these results occurred after taking into account the role of intentions, they suggest that WMC aids “normal” eaters who are not attempting to restrict their intake of food (i.e., non-dieters) in eating less unhealthy or to be avoided food. Given that the more someone likes a certain food, the more they tend to eat of that food despite the intention to avoid it, based on the significant correlation between liking and intake of to be avoided food, this result indirectly suggests that WM may be acting as a buffer against tempting food items, at least when restrained eating is low. Though unrestrained eaters do not have the explicit goal to restrict their food intake like restrained eaters do, there was general agreement that the a priori classified “unhealthy” items from the full analysis and the to-be-avoided items from the individualized analysis were unhealthy. Though outside the scope of the current data, unrestrained eaters may have a general goal to avoid unhealthy food (which at least is confirmed by the data that unhealthy food items were generally the to-be-decreased items). WMC may help unrestrained eaters maintain that goal to be healthy and avoid eating unhealthy eating The interpretation is in line with previous findings about individual differences in WMC that individuals with greater WMC tend to experience stronger goal maintenance and less goal neglect, when people temporarily lose access to, or otherwise fail to successfully enact their goals (Kane & Engle, 2003).

The Role of WMC for Highly Restrained Eaters

The question remains, why did WMC not influence the eating behavior of restrained eaters? One possibility is that measurement of eating behavior over the course of a week reflects multiple factors, only one of which taps the type of self-control that should be tied to WMC. For example, eating over the course of the week may also reflect how well individuals limit temptation in their environment, which may not be tied to WMC. As a result, our measure may not have been sensitive enough to detect differences in how well people exerted self-control in the face of temptation, which should be tied to WMC. One other possibility is that restrained eaters are not accurately reporting their intake; some restrained eaters may not want to admit the extent to which they are violating their dieting goals and therefore underreport their intake. Or they could be so focused on avoiding unhealthy food that they overreport their intake, assuming that they fail at their dieting attempts more often than they actually do. At this point, it is difficult to make strong conclusions using a null result, the lack of an effect for restrained eaters.

Though this relationship was not present in the current data, restrained eating has been shown to be related to reduced WMC (Green et al., 2005; Green & Rogers, 1999; Jones & Rogers, 2003; Kemps et al., 2005; Kemps & Tiggemen, 2005). Furthermore, dieting interventions (a least, unsupported dieting; Green et al., 2005) and craving, which can be triggered by tempting food cues in the environment, have been shown to reduce or interfere with WMC (for a review, see Kemps & Tiggeman, 2010). Reduced WMC in dieters is associated with greater vulnerability to the effects of craving and temptation (Kemps & Tiggeman, 2010), and ultimately is associated with unhealthy eating behavior (i.e., greater intake of unhealthy foods) (Allan, Johnston, & Campbell, 2010). It is possible that the situational context plays a role here. WMC resources may be more important for influencing eating choices in highly restrained women when they are exposed to the foods they are trying to restrict, or in other words, when they are experiencing temptation or craving. This study could not address this potential issue as it measured overall behavior over the course of the week, where the level of temptation was undetermined (this issue will be further explored in the next study). WMC may indeed be unrelated to the intake of unhealthy foods for highly restrained women, when they are not experiencing temptation or craving.

Implicit Food Activation

An implication of the three-way interaction is that implicit processes are also important to consider in addition to explicit, self-report eating and dieting intentions, and control processes (i.e., WMC), though this effect needs to be replicated in future studies, given that it was not consistently found in the current study. The effect of implicit food activation was to lessen the buffering influence of having greater access to WM resources due to greater WMC on intake of unhealthy food, at least when restrained eating is fairly low. At a more moderate level of restrained eating (-1 SD), when implicit food activation was at its highest, WMC ceased to influence food intake. This pattern suggests that there may be a threshold to the amount of buffering greater WMC can provide, before a person has limited to capacity to maintain access to her eating goal, and that threshold is determined in part by levels of restrained eating and implicit food activation.

There is consistent evidence to show that dieters are more impacted by food cues than normal eaters. Heightened cue reactivity has been indicated by increased physiological responses such as salivation (Brunstom, Yates, & Whitcomb, 2004), increases in desire and craving for cued food (Federoff, Polivy, & Herman., 1997), and particularly, increased consumption after food cue exposure (Coelho, Idler, Werle, & Jansen, 2011; Coelho, Jansen, Roefs, & Nederkoorn, 2009; Federoff et al., 1997, Federoff, Polivy, & Herman, 2003; Ferriday & Brunstrom, 2008). Furthermore, *unsuccessful dieters* have been shown to react specifically to the hedonic associations with food and consume more food after cue exposure, whereas *successful dieters* are able to counteract the influence of the cues and consume less (Fishbach, Friedman, & Kruglanski, 2003; Houben, Nederkoorn, & Jansen, 2012; Papies, Stroebe, & Aarts, 2008). Implicit food activation can be thought of as an internal food cue that may heighten the influence of tempting food in the environment. As such, more highly restrained eaters may be even more susceptible to the effect of strong implicit food activation, to the point where WMC no longer has an effect on intake of unhealthy food.

Health Attitudes and Intentions

As described earlier, a central component of many models of health behavior is that intentions predict behavior. A specific version of that model, the Theory of Planned Behavior (TPB) (Azjen & Madden, 1986), claims that intention is influenced by attitude, subjective norms, and perceived behavioral control, and intention, in turn, influences behavior. Attitude is defined as the general evaluation of the behavior (Conner, Norman, & Bell, 2002). In the case of eating behavior, it may be helpful to use a more nuanced definition of attitude that includes both evaluations of healthiness and liking. Based on the current results, where healthiness influenced intentions, whereas liking influenced behavior, in terms of TPB, it may be necessary to weight the relative contribution of healthiness vs. liking, or consider their independent effects on both intentions and behavior, rather than channeling the effect of attitudes through intentions. In more practical terms, these results highlight that attitudes toward food lend themselves to ambivalence, where someone realizes a certain food item is unhealthy and therefore intends to avoid it, but may like that food and end up eating it anyways.

Methodological Issues and Limitations

Comparison of aggregate and individualized results. A primary contribution of this study was the comparison of the overall results with the more individualized analyses. At this point, there do not appear to be major differences in the two approaches. It is possible that the specific stimuli chosen were not varied or nuanced enough to evoke individually-driven patterns of results. The pattern of results may have been different if participants had been asked to generate the items they most wanted to increase or avoid. Even so, for the current study, the similar pattern of results for the two-way interaction of WMC and restrained eating from the individualized analyses is interpreted as corroborating the pattern from the full results.

Though the two-way interaction between the results of the full, aggregated data set and the individualized data set were similar, it remains unclear why there was a discrepancy with the three-way interaction. It is not wholly surprising that some of the results were replicated with the individualized data set. For the most part, the items that women indicated they were trying to avoid matched the items that had been classified as “unhealthy” in the full data set. The goal of the individualized analyses was to improve power by only choosing items in which people had an established intention-typical behavior gap. However, there were some participants who did not have intention-typical gaps for any food items, meaning that the selection criteria resulted in the dropping of participants. This removal may have inadvertently reduced statistical power enough to prevent the detection of the three-way interaction.

In summary, these results emphasize the moderating role of WMC on restrained eating and implicit food activation on eating behavior (i.e., self-reported food intake), over and above the influence of intentions. At least when restrained eating was low, intake of unhealthy food decreased as WMC increased, and this effect was even stronger when implicit food activation was low. There was no evidence to suggest that WMC played a moderating role when restrained eating was at higher levels. It was hypothesized that this lack of relationship may depend on contextual or situational factors, and that a relationship may exist, for example, when restrained eaters are exposed to temptation and must attempt to resist in order for the behavior stay in line with their intentions. This hypothesis was explored in Study 2.

CHAPTER 3: THE ROLE OF WORKING MEMORY CAPACITY IN THE FACE OF TEMPTATION IN EATING BEHAVIOR

In Study 1, there were inconsistent effects of WMC or implicit food activation when restrained eating was high, while the more consistent results were for unrestrained eaters though highly restrained eaters were the primary population of interest One difficulty with Study 1 is that it relied on self-report information on eating behavior over the course of a week. Women who are highly concerned about their eating habits may have learned strategies to reduce their exposure to temptation and therefore are better able to keep their behavior in line with their intentions when looked at over a longer time period or may not be reporting intake accurately. What happens in the moment when women are exposed to a tempting food item? And how do individual differences in WMC affect consumption of tempting food? The primary goal of Study 2 is to examine the moderation by WMC on the effects of restrained eating and implicit food activation on consumption of a tempting food item, after exposure to that item.

Restrained Eating and Temptation

There is extensive evidence that restrained eaters are particularly prone to overeat tempting food items after they have been exposed to that food (Brunstom et al., 2004; Coelho et al., 2011; Coelho et al., 2009; Federoff et al., 1997; Federoff et al., 2003; Ferriday & Brunstrom, 2008). As mentioned, restrained eaters will eat more of a tempting food item after an initial serving or tasting of that item than when not initially exposed to that food (whereas unrestrained eaters will eat less after exposure) (for a review, see Stroebe, 2008). Typically, participants are given a “pre-load”, such as a milkshake, of a specified amount. After consumption of the pre-load, they are then given as much of the food item as they like. Although unrestrained eaters tend to eat less of the milkshake after pre-load, restrained eaters eat more (compared to unrestrained eaters, and to restrained eaters not given a pre-load). Restrained eaters also tend to eat more of a food item simply after they were exposed to it by sight, smell, or thought, rather than having to consume a pre-load, suggesting that exposure to temptation alone impacts the consumption of restrained eaters (Federoff et al., 2003; Soetens, Braet, Van Vlierberghe, & Roets, 2008).

There is further evidence that increased consumption is related to how tempting a food item is. Several studies have shown that the pre-load effect occurs based on perceived calorie content of the offered food, where consumption increased for items that were perceived to be greater in caloric content (for a review, see Stroebe, 2008). The pre-load also only occurs when items are perceived as “forbidden” when compared to unforbidden foods of the same caloric content, such as a milkshake compared to cottage cheese (Knight & Boland, 1989).

WMC Moderation of Implicit Food Associations on Consumption

As elaborated below, there is also evidence that WMC moderates the effect of implicit associations on consumption of tempting food such as chocolate (Hofmann, Friese, & Roefs, 2009; Hofmann, Gschwendner, Friese, Wiers, & Schmitt, 2008, Nederkoorn, Houben, Hofmann, Roefs, & Jansen, 2010). However, it is not yet clear if that moderation effect still occurs when restrained eating is high. It is also not clear how prolonged exposure to temptation might affect the WMC moderation effect.

In a series of studies, individual differences in WMC have been shown to moderate the influence of implicit associations on consumption (Hofmann et al., 2008; 2009) and long-term weight changes (Nederkoorn et al., 2010). In these studies, implicit associations were measured by a food IAT. In this particular version of the food IAT, participants are asked to alternately sort positively- or negatively-valenced words and tempting food items (i.e., chocolate). In some blocks, the tempting, but unhealthy food items are mapped to the same response as the negative words (“incongruent” pairing), whereas in others, the tempting food pictures are sorted with positive words (“congruent” pairing). Generally, slower RTs on the incongruent blocks (tempting food and negative words) are interpreted to reflect increased positive associations (or decreased negative associations) with tempting, but unhealthy food. Using the food IAT, it has been found that in women with lower WMC, greater positive associations predict both increased consumption (Hofmann et al., 2008, 2009) and long-term weight gain (Nederkoorn et al., 2010). In other words, women both with lower WMC and greater positive food associations ate more unhealthy, but tempting food (i.e., M&Ms) and experienced an increase in weight gain over time. Conversely, one of these studies showed that consumption in women with greater WMC is driven by explicit goals (e.g., goal to forego sweets) (Hofmann et al., 2008) rather than positive implicit associations.

These results are relevant because they show the interaction of WMC and implicit processes, and how they jointly contribute to eating behavior effects. However, as described in Study 1, a limitation of this particular set of studies is the use of the IAT to measure implicit processing, on which performance has been shown to partially rely on WMC/EF ability. Furthermore, the moderation of implicit processes by WMC has not yet been observed specifically in restrained eaters, individuals who are generally more vulnerable to being influenced by food temptation, discussed in detail above) and who have specifically been shown to have increased positive associations with tempting food (Hoefling & Strack, 2008; Houben, Roefs, & Jansen, 2010).

Current study

One aim of Study 2 was to extend the results of Study 1 and better determine what affects consumption in highly restrained eaters. Specifically, I examined how WMC moderated the effects of restrained eating and implicit food activation on consumption under different exposures to temptation. An additional goal was to determine the effect of temptation exposure on underlying implicit positive associations, in conjunction with the individual differences variables (i.e., does temptation affect positive food associations of highly restrained eaters with low WMC differently than unrestrained eaters?). To answer this question, a food IAT was used, but it was used as the dependent measure rather than an independent variable as in the studies described above. Highly restrained eaters with lower WMC may have more difficulty overcoming the influence of positive associations with tempting food, particularly when exposed to temptation, which may be reflected in IAT scores. The idea was not that the underlying positive associations will necessarily be stronger when exposed to temptation, but that the effect of temptation will make the associations more difficult to overcome. Food temptation was not expected to reduce WMC per se, but may reduce ability to ignore the distracting positive associations with tempting food.

This study was run concurrently with Study 1, therefore the measures for WMC, restrained eating, and implicit food activation are the same as described previously. The focus of Study 2, however, was the temptation exposure manipulation, the amount of tempting food consumed subsequently, and the effect on implicit associations. The temptation manipulation is described in detail below, but briefly, some participants were exposed to a tempting food item (i.e., M&Ms) early in the experimental session and told they could not consume the M&Ms at that time. Later in the session, when the experimenter left the room, participants were given an opportunity to eat as many M&Ms as they chose. A control group was also given the chance to eat M&Ms, but they were not exposed prior to receiving them. This manipulation is similar to the exposure studies mentioned earlier, where the mere sight of tempting food led to increased consumption in restrained eaters. They were asked not to consume the M&Ms in part to draw their attention to them, but also to keep the opportunity to consume M&Ms consistent with the control group.

The contributions of this study were to examine a) the moderation of WMC on the effects of restrained eating and implicit food activation on real-time consumption of a tempting food item and underlying associations, and b) the impact of temptation exposure on that moderation effect. It was predicted that when WMC was high, restrained eaters would eat less M&Ms and exhibit less positive associations (lower IAT scores) with tempting food compared to when WMC was lower, especially when implicit food activation (word stem score) was lower. Temptation is expected to lessen the moderating effect of WMC particularly when both restrained eating and implicit food activation is high (when overall food vulnerability is high).

Method

Participants, materials, and procedure. As described, Studies 1 and 2 were run at the same time for ease of data collection, so participants, materials and procedures were identical to Study 1 (N=131). There was an additional manipulation and variables measured for Study 2 during the second experimental session that are described below. The independent variables in this study were the same as in Study 1: WMC restrained eating, and implicit food activation. Based on the results of Study 1, health attitude variables were also taken into account in Study 2. The exact use of the attitude measures is described in more detail in the data analysis section.

Session 2 Experimental Manipulation and Measures

Temptation manipulation. Before participants arrived at the lab, experimenters measured out 300 grams of M&Ms into a bowl, which was placed 20 cm from the computer. For the temptation group, the bowl was in place prior to arrival, and upon arrival participants were told that the M&Ms were for them to enjoy after task performance, but not before or during. After completion of the IAT, the experimenter informed the participant that she had to code the logical reasoning and vocabulary tasks (described next) in another room, but that the participant was welcome to enjoy the M&Ms while waiting. The experimenter then left the room for 3 minutes. For the control group, the bowl was kept out of sight until after IAT performance, at which point they were given to the control participants who were allowed to eat the M&Ms right away. After the 3-minute interval, experimenters re-entered the room but did not refer to the M&Ms again.

Logical reasoning. Aside from being used as filler tasks, logical reasoning and vocabulary were included to attempt to demonstrate that the temptation manipulation only affected performance on EF-related tasks, but not tasks that are unrelated to EF. They were also used to confirm there were no initial differences between the control and experimental groups. Logical reasoning partially relies on EF and therefore was more likely to be affected by the temptation manipulation, at least in dieters. However, vocabulary is distinct from EF and therefore was not expected to be influenced by the temptation manipulation.

Logical reasoning was measured using nonsense syllogisms from the Kit of Factor-Referenced Cognitive Tests (Ekstrom, French, Harman, Derman, 1976), where participants were presented with three sentences that did not make sense based on real world relationships, but exhibit either good or poor logical reasoning (i.e., the third sentence logically followed from the first two sentences). For example, for the following set of sentences, “All trees are fish. All fish are horses. Therefore all trees are horses.”, the correct response was good reasoning. This measure was on paper, and participants were given 4 minutes each to complete two sets of 15 items.

Vocabulary. To measure vocabulary, participants were presented with a word and given four possible synonyms for that word (Kit of Factor-Referenced Cognitive Tests) (Ekstrom et al., 1976). This measure was on paper, and participants were given 4 minutes each to complete two sets of 18 items.

Food IAT. The food IAT included two different sorting tasks (see Figure 7 for

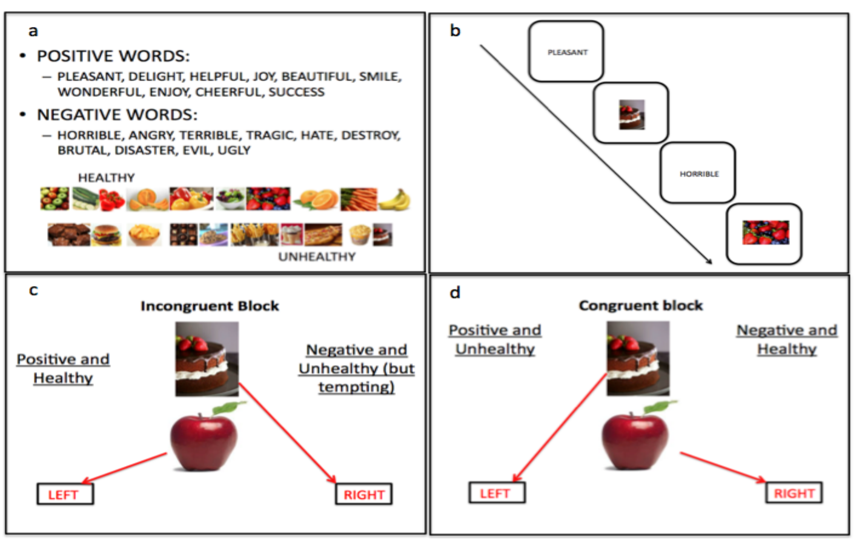

Figure 7. This figure presents an overview of the IAT task set up. Panel a presents the stimuli used. Panel b displays the timing of the task. Panel c and d display the button mapping for incongruent and congruent blocks.

overview of task and stimuli). Participants sorted either positive vs. negative words or pictures of healthy vs. unhealthy food items on alternating trails. The positive and negative words included: PLEASANT, DELIGHT, HELPFUL, JOY, BEAUTIFUL, SMILE, WONDERFUL, ENJOY, CHEERFUL, SUCCESS and HORRIBLE, ANGRY, TERRIBLE, TRAGIC, HATE, DESTROY, BRUTAL, DISASTER, EVIL, UGLY respectively. The unhealthy food pictures included dessert, snack, and fast food items (i.e., cookies, chips, pizza) and the healthy food pictures included fruits and vegetables (see Figure 7).

Sorting responses were made by pressing the “E” or the “I” keys. In the congruent blocks, positive words and unhealthy (but palatable) food items were mapped to the “E” key, and negative words and healthy food items were mapped to the “I” key. For the incongruent blocks, the button mapping was switched such that negative words and unhealthy (but palatable) food items were paired together, while positive words and healthy food items were paired together. Stimuli remained on the screen until the participant made the correct response. If the first response was incorrect, an red X appeared on the screen and remained there until participants corrected the error. Response category labels were also displayed throughout the blocks (i.e., in the incongruent block, “POSITIVE” and “HEALTHY FOOD” appeared on the left side of the screen, and “NEGATIVE” and “UNHEALTHY FOOD” appeared on the right side of the screen).

D was calculated using an improved algorithm as recommended by Greenwald, Nosek, & Banaji., 2003 (see Table 4 on p. 214 in that reference). Specifically in line with their recommendations, data from all incongruent and congruent blocks were utilized, instead of only data from the second block of each. Trials with latencies greater than

10,000 ms were deleted. Percentage of trials less than 300 ms were checked; no participants had more than 10% short latencies, therefore no one was dropped based on this criteria. Participants were required to give a correct response; therefore latencies for previously incorrect, but corrected responses were used on trials where errors were made. Finally, pooled standard deviations were computed for each block individually and used to calculate D. If people had positive associations with unhealthy but palatable food, they may have experienced more interference on the incongruent block resulting in less accurate responses and longer response times. In other words, larger (more positive) D scores will be indicative of increased positive associations with tempting but unhealthy food.

M&M consumption. A bowl containing 300 grams of M&Ms was placed in front of the participants either at the beginning of Session 2 or after IAT performance, depending on temptation group assignment. After IAT completion, participants in both groups were told they may eat as many M&Ms as they liked. Experimenters left the room, under the guise of scoring the logical reasoning and vocabulary tasks with the aim of making participants more comfortable eating the M&Ms. After completion of the experiment, experimenters weighed the remainder of the M&Ms, and subtracted that amount from the original 300 grams to obtain the number of grams consumed.

Results

Preliminary data analysis. As in Study 1, all predictor variables were aggregated when appropriate (i.e., WMC tasks and restrained eating questionnaires) and z-scored for regression analyses. For analysis using the IAT, the aggregate scores for healthy attitudes for unhealthy food items from Study 1 was used. The framing of the

IAT was around healthy vs. unhealthy food items, therefore the health attitudes aggregate for unhealthy foods, rather than the individualized scores from to-be-avoided items. For M&M consumption, rather than using an aggregate score, only intentions, liking, healthiness that were specific to chocolate (i.e., "sweet snacks and dessert (chocolate, cookies, ice cream, etc.)") were used. BMI and body fat percentage did not yield any significant effects and are not further discussed. T-tests were performed on all predictor and control variables comparing the experimental and control groups to confirm that the groups did not have any relevant a priori differences. None of the tests yielded any significant differences, p values > 0.3, including for logical reasoning and vocabulary. Finally, there was no indication of outliers based on studentized residuals, Cook's distance, or lever values.

Descriptive statistics and correlations. Means and standard deviations for all predictor and dependent variables for each group are presented in Table 8. M&M consumption was positively skewed in both groups, therefore the log of each score was taken and used in the regression model described below. Correlations among z-scored variables are presented in Table 9. The patterns of correlations were similar across groups, therefore the correlations across all cases are presented. Intention to eat sweets was involved in all the correlations among variables, and was negatively related to restrained eating, positively related to liking and healthiness, and marginally, positively related to M&M consumption.

Linear regression model. A linear regression was run with the individual differences variables of WMC, restrained eating, implicit food activation, and the between-subject temptation group as predictors, and the log of M&M consumption as the dependent measure (see Table 10 for full regression results). Intentions, liking and healthiness ratings of sweets were also included as covariates. For the four main predictor variables, all interactions were included in accordance with the recommendations of Yzerbyt and colleagues (2004). To keep the model from becoming too complex, the interactions with intentions, liking, and healthiness were not entered into the model.

The expected 4-way interaction between WMC, restrained eating, implicit food activation, and temptation exposure group was not significant. However, there was a significant two-way interaction effect of restrained eating and implicit food activation on M&M consumption, $F(1,113)= 5.64$, $p=.02$, $\eta_p^2=0.05$. The two-way pattern is depicted in Figure 8. The figure suggests that highly restrained eaters consumed more M&Ms as

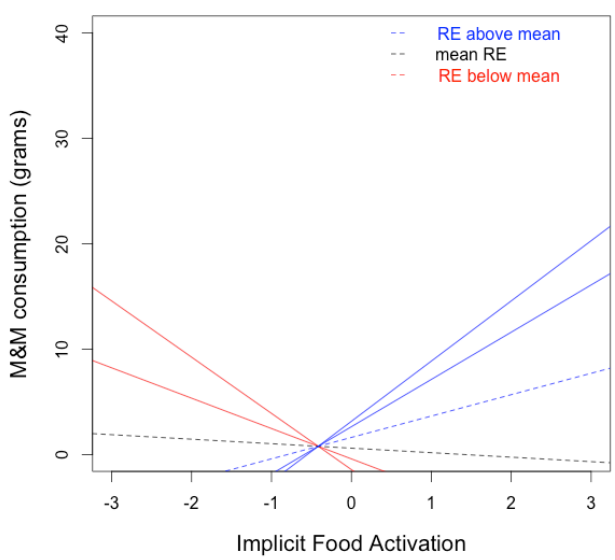

Figure 8. This graph represents the significant two-way interaction effect of restrained eating and implicit food activation on MM consumption. The blue lines are estimates of the simple slopes of implicit food activation when restrained eating is above the (+1SD, +2,SD, and +2.5SD); the red lines are estimates of the simple slopes when restrained eating is below the mean (-1SD and -2SD, reflecting the range of data). Solid lines indicated significant slopes; dotted lines are not significant.

Table 8.

Descriptive statistics for predictor variables and dependent measures.

A. Experimental		M	SD	minimum	maximum	skew	kurtosis	α
Working Memory Capacity								
Reading Span	18.0	4.8	5	31	0.01	0.22	0.76	
Spatial Span		24.3	7.0	4	42	-0.06	0.04	0.76
Restrained Eating								
RS		11.3	5.1	0	24	0.45	0	0.75
DEBQ-R		16.2	10.3	0	40	0.64	-0.23	0.75
Implicit Food Activation		4.5	1.7	0	10	0.34	1.6	0.77
Attitudes towards sweets								
Intentions		1.4	1.4	0	6	1.42	1.89	0.55
Liking		4.9	1.2	1	6	-1.3	1.26	0.53
Healthiness		0.89	0.98	0	5	1.47	3.17	0.5
M&Ms consumption		7.5	12.9	0	55	1.94	2.99	0.58
IAT D		1.22	0.44	-0.1	2.63	0.48	2.01	0.75
B. Control		**M**	**SD**	**minimum**	**maximum**	**skew**	**kurtosis**	**α**
Working Memory Capacity								
Reading Span	17.8	5.1	5	33	0.27	0.7	0.75	
Spatial Span		22.5	7.3	3	38	-0.05	-0.31	0.76
Restrained Eating								
RS		11.6	4.7	0	23	-0.04	-0.33	0.75
DEBQ-R		16.4	8.6	0	40	0.19	-0.44	0.77
Implicit Food Activation		4.8	1.7	0	9	-0.05	0.53	0.75
Attitudes towards sweets								
Intentions		1.6	1.4	0	5	1.03	-0.03	0.46
Liking		5.2	1.1	1	6	-1.59	2.96	0.55
Healthiness		0.75	0.85	0	4	1.39	2.44	0.53
M&Ms consumption		7.4	10.7	0	45	1.68	2.33	0.54
IAT D		1.33	0.49	0.4	2.9	1.0	1.25	0.77

Table 9.
Correlations between z-scored variables (r).

	WMC	RE	IFA	Int	Like	Health	M&Ms	IAT D
1. WMC	1							
2. Restrained Eating	-0.01	1						
3. Implicit Food Activation	0.073	0.029	1					
4. Intentions (Sweets)	-0.07	-0.24**	0.07	1				
5. Liking (Sweets)	0.12	0.14	-0.07	0.27**	1			
6. Healthiness (Sweets)	-0.04	0.12	-0.01	0.36**	-0.001	1		
7. M&M consumption	-0.05	0.02	-0.04	0.16^{+}	0.12	0.01	1	
8. IAT D	-0.14	-0.01	0.11	-0.07	-0.06	-0.09	0.02	1

$^{**}p<.001$
$^{+}p=0.06$

Table 10.
Results of regression model for Study 2 for grams M&Ms intake.

Variable	F	p	η_p^2
Temptation Exposure	2.75	0.10	0.06
WMC	0.03	0.86	<0.001
Restrained Eating	1.56	0.21	0.01
Implicit Food Activation	0.06	0.81	<0.001
Intentions	0.24	0.62	0.002
Liking	2.03	0.16	0.02
Healthiness	0.81	0.37	0.007
Temptation Exposure x WMC	0.19	0.66	0.002
Temptation Exposure x Restrained Eating	1.97	0.16	0.002
Temptation Exposure x Implicit Food Activation	8.29	0.004**	0.06
WMC x Restrained Eating	0.75	0.40	0.006
WMC x Implicit Food Activation	1.45	0.23	0.01
Restrained Eating x Implicit Food Activation	5.64	0.02*	0.05
Temptation Exposure x WMC x Restrained Eating	1.51	0.22	0.01
Temptation Exposure x WMC x Implicit Food Activation	0.02	0.88	<0.001
Temptation Exposure x Restrained Eating x Implicit Food Activation	0.01	0.91	<0.001
WMC x Implicit Food Activation x Restrained Eating	3.41	0.06^{+}	0.03
Temptation Exposure x WMC x Restrained Eating x Implicit Food Activation	0.004	0.95	<0.001

Note: all effects tested were 1-degree of freedom tests, with the denominator dF=113.
** significant at p<0.01.
*significant at p<0.05.
$^{+}$marginally significant. Note that this term becomes significant (p=0.03) if the model is simplified by dropping all the temptation exposure terms, except the significant Temptation Exposure x Implicit Food Activation term.

implicit food activation increased. Unrestrained eaters ate less M&Ms as implicit food activation increased. Note that though the interaction effect was significant, the individual slopes did not reach significance ($ps \geq .09$) when all of the interaction terms were included. The main regression model with all interaction terms included had 18 terms in the model. To increase power, non-significant effects/interactions with temptation exposure were dropped from the model. This adjustment did not change the pattern of results, but affected the significance of some of the slopes. The solid lines represent significant slopes ($ps<.05$), while the dotted slopes are not significant ($ps>.05$).

The three-way interaction between WMC, restrained eating and implicit food activation also had a marginally significant effect on M&M consumption, $F(1,113)=3.41$, $p=.06$ $\eta_p^2=0.03$. Again, the non-significant effects/interactions with temptation exposure were dropped from the model to simplify and improve power. After this step, the three-way interaction effect of WMC, restrained eating, and implicit food activation reached significance, $F(1,120)= 4.31$, $p=.04$, $\eta_p^2=0.035$.

The pattern of results of the three-way interaction is depicted in Figure 9 using the flood light approach described in Study 1 (Spiller et al., 2013). Note the solid lines represent significant slopes ($ps<.05$), while the dotted slopes are not significant ($ps>.05$). The general pattern suggests that when WMC is lower (top panels), more highly restrained eaters (blue lines) consumed more M&Ms as implicit food activation increased (x-axis). Conversely, the pattern also suggests that low restrained eaters (i.e., non-dieters, red lines) ate less as implicit food activation increased. Note that this interaction occurred over and above temptation exposure (and significant interactions)

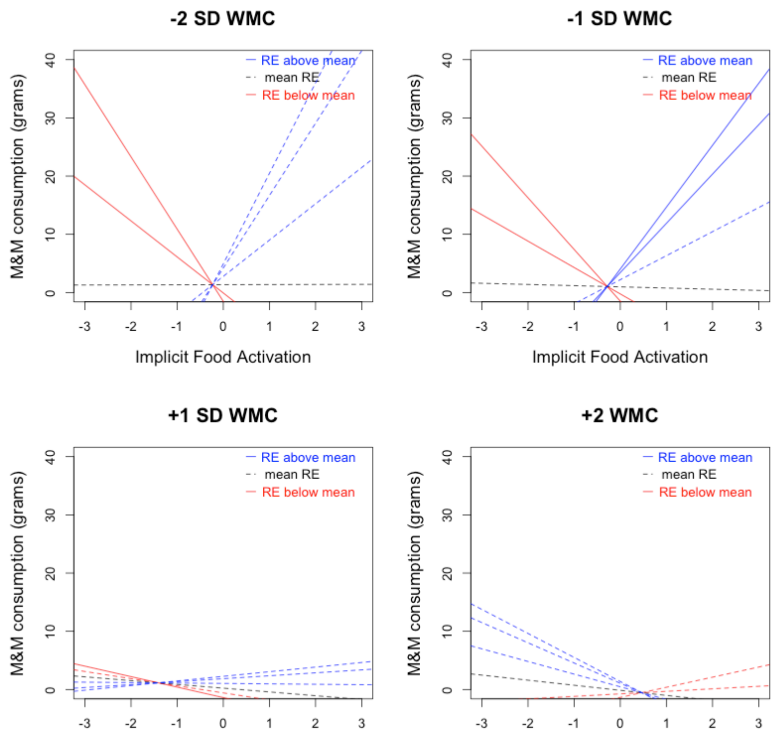

Figure 9. This figure presents the floodlight illustration of the three-way interaction effect between WMC, restrained eating, and implicit food activation on M&M consumption. Each panel presents estimates at various levels of WMC, reflecting the range of scores. Each line within the panels graphs the simple effect of implicit food activation at different estimates of restrained eating (again, -2SD to +2.5SD). The red lines represent regression estimates when restrained eating was adjusted below the mean, while the blue lines represent estimates above the mean. Finally, the solid lines represent significant slopes, while dotted lines are

and intentions, liking, and healthiness rating of sweets, specifically including chocolate. This same pattern does not hold for higher levels of WMC (bottom panels). The pattern for restrained eaters was in line with predictions. The pattern for unrestrained eaters was not predicted a priori. Note that the range of the patterns for unrestrained eaters does not reach above the mean for implicit food activation (z scored, M=0). As such, though there is a pattern for unrestrained eaters to eat less as implicit food activation increases, there is only evidence for this pattern when implicit food activation is below the mean. Tentatively, it may be that unrestrained eaters, who are less explicitly concerned about food intake, are better able to regulate their intake when they have at least some implicit food activation.

The presentation of the pattern for the three-way interaction presented in Figure 9 is consistent with the two-way results presented in Figure 8, and demonstrates specifically that WMC moderates the two-way interaction of restrained eating and implicit food activation. However, the focus of this study is to understand the role of WMC; as such, the three-way pattern was graphed in a different way, paneled by restrained eating with WMC on the x-axis in Figure 10. Figure 10 makes is clear that the effects occur for restrained eaters (bottom panels), but not unrestrained eaters (top panels). Furthermore, WMC had an effect on restrained eaters if they also exhibited greater implicit food activation (blue lines). In other words, the most vulnerable group, restrained eaters with high implicit food activation, ate fewer M&Ms at greater levels of WMC.

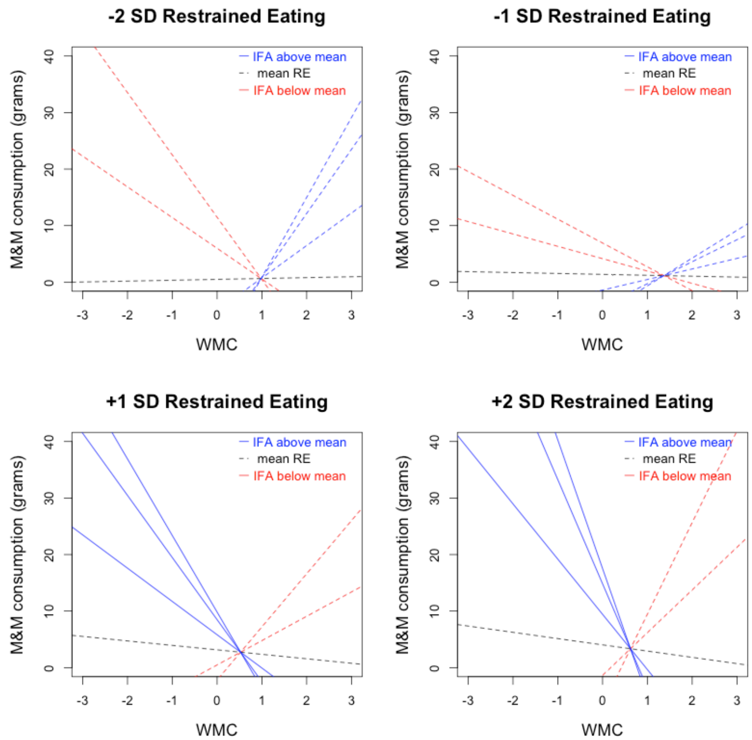

Figure 10. This figure represents the same three-way interaction in Figure 9, but is paneled by restrained eating with WMC along the x-axis, with the various line for different levels of implicit food activation (-2SD to +2.5SD). The goal of this figure was to look at the interaction through the lens of the effect of WMC more specifically.

The only significant effect of temptation exposure was that it interacted with implicit food activation, F(1,113) = 8.29, p=.004, η_p^2=0.06. As illustrated in Figure 11, the pattern of results was opposite of what might be expected: participants in the control group ate significantly more M&Ms as implicit food activation increased. While there was a trend for women in the group who were exposed to temptation early in the experimental session to eat fewer M&Ms as implicit food activation increased, this slope was not significant.

Finally, there were no significant effects on IAT D scores (see Table 11). The closest result was a main effect of liking, F(1,113)=3.14, p=.08, η_p^2=0.03; however this particular result did not add much to the current theoretical focus—the more a woman liked tempting food items, the greater her positive associations with those tempting items—therefore is not considered in detail in the discussion.

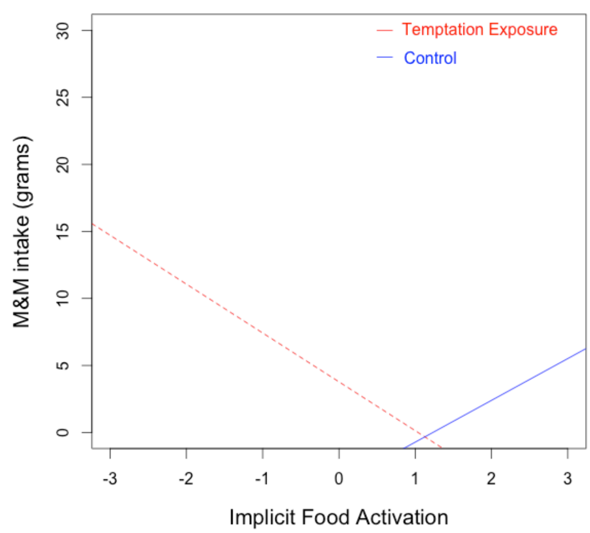

Figure 11. This graph represents the significant interaction effect of temptation exposure and implicit food activation on M&M consumption. The red line is the non-significant simple slope of implicit food activation for the group exposed to temptation early in the experimental session; the blue line is the significant simple slope for the control group.

Table 11.
Results of regression model for Study 2 for IAT D scores.

Variable	F	p	η_p^2
Temptation Exposure	0.09	0.76	<0.001
WMC	1.91	0.17	0.02
Restrained Eating	0.08	0.77	<0.001
Implicit Food Activation	1.57	0.21	0.01
Intentions	0.99	0.32	0.009
Liking	3.13	0.08	0.03
Healthiness	2.14	0.15	0.02
Temptation Exposure x WMC	0.08	0.78	<0.001
Temptation Exposure x Restrained Eating	2.13	0.15	0.02
Temptation Exposure x Implicit Food Activation	0.32	0.86	<0.001
WMC x Restrained Eating	0.38	0.54	0.002
WMC x Implicit Food Activation	0.03	0.86	<0.001
Restrained Eating x Implicit Food Activation	0.15	0.70	0.001
Temptation Exposure x WMC x Restrained Eating	0.09	0.77	<0.001
Temptation Exposure x WMC x Implicit Food Activation	0.37	0.54	0.003
Temptation Exposure x Restrained Eating x Implicit Food Activation	0.81	0.37	0.007
WMC x Implicit Food Activation x Restrained Eating	0.43	0.51	0.004
Temptation Exposure x WMC x Restrained Eating x Implicit Food Activation	0.32	0.57	0.003

Note: all effects tested were 1-degree of freedom tests, with the denominator dF=113.

Discussion

Study 2 examined the moderation by WMC on the effects of restrained eating and baseline implicit food activation (as measured by the word stem task) on the consumption of tempting food when exposed to that temptation. The primary finding was that WMC moderates restrained eating and implicit food activation, regardless of when someone is exposed to temptation. More specifically, when WMC is low, highly restrained eaters ate increasingly more M&Ms at higher levels of implicit food activation. This result suggested that restrained eaters with lower WMC have a difficult time resisting temptation, particularly when they have a tendency to activate thoughts about food (i.e., greater number of word stems completed with food words). Conversely, there was no evidence of these relationships when women's WMC was higher, implying that greater capacity allows the opportunity for WM to act as a buffer to temptation even for restrained eaters with high implicit food activation, a particularly vulnerable group. There was further evidence that the effects on M&M consumption only affected restrained eaters, rather than unrestrained eaters. These patterns were observed after taking into account women's intentions to eat chocolate, how much they like chocolate, and how healthy (or unhealthy) they thought chocolate was.

There was also some indication that unrestrained eaters ate fewer M&Ms as implicit food activation increased, at least when WMC was low. As mentioned in the results section, evidence for this pattern only occurred when implicit food activation was below the mean. It may be that unrestrained eaters are able to utilize small amounts of implicit food activation as an internal cue to help them regulate their intake of unhealthy food items. This interpretation is in line with the results for restrained eaters. Implicit food activation may also serve as a cue for restrained eaters, but restrained eaters are known to be more reactive to food cues and are more likely to overeat in response to exposure to food cues than unrestrained eaters. Unrestrained eaters, however, may be using the cue from implicit food activation as a reminder to regulate their intake.

These results expand on Study 1 because there is some indication that WMC is an important moderator for highly restrained eaters, and not just unrestrained eaters. They also more consistently indicate that implicit food activation is related to increased intake when offered tempting food, at least at lower levels of WMC.

An unexpected finding was that was for women who had prolonged exposure to the temptation item (the experimental group), there was no relationship between baseline implicit food activation (keep in mind that implicit food activation, as measured by the word stem task was measured at the beginning of Session 1 prior to any exposure to food stimuli or temptation) and M&M consumption. Women that were not previously exposed to the temptation (control group) ate more M&Ms at higher levels of baseline implicit food activation. It may be that women in the experimental group caught on to the manipulation and were therefore able to regulate or overcome any influence of implicit food activation. Alternatively, the temptation manipulation may have caused their food activation to be at ceiling, so that baseline implicit activation no longer had an effect; however, there was no indication of a main effect of the temptation manipulation on M&M intake, which one would expect if all women in the experimental group were pushed to have higher food activation that led to greater intake. Regardless, this result and the lack of evidence for the temptation manipulation having any other effects suggest that the manipulation did not function how it was intended.

One possibility was that the manipulation itself was not strong enough to elicit effects. Rather than setting the bowl nearby, the experimenters could have asked the participants to try only one M&M, or to actively attempt to ignore the M&Ms to increase the effect of the manipulation. It may be that having to actively abstain from the temptation is what drives the deleterious effects of temptation exposure. For example, women who were asked to taste their favorite snack, and to carry around a bag of that snack but to abstain from eating it for 24 hours, subsequently ate more of that snack than women who were not exposed. This effect was even stronger for highly restrained eaters (Soetens et al., 2008). Another explanation may be that some individuals did not find the M&Ms to be all that tempting, although there was no relationship between liking and M&M consumption.

Another unexpected result was that there were no effects whatsoever for the food IAT. Again, this lack of effect points to the weakness of the temptation manipulation, in that it was no more difficult to overcome the effect of positive associations on IAT performance. Also, it may suggest that although there is evidence that food associations are changeable (Hollands, Prestwich, & Marteau, 2011), associations or the influences of those associations do not change that quickly or easily, and that repeated exposure is necessary to evoke change.

CHAPTER 4: GENERAL DISCUSSION

Taken together, these studies provide evidence that WMC moderates the effects of restrained eating and implicit food activation on consumption, over and above the influence of intentions, liking, and healthiness. Study 1 suggests that WMC plays a role for unrestrained eaters for self-reported intake over the course of a week; specifically, unrestrained eaters ate less unhealthy or to-be-avoided food at greater levels of WMC. Study 2 expanded the findings to highly restrained eaters by showing that these women ate increasingly more M&Ms with greater levels of baseline implicit food activation when their WMC was lower. Women with greater WMC did not display these effects, suggesting that WMC influenced the ability to resist temptation in the moment.

The divergence in results for unrestrained and restrained eaters in each study suggest two different roles for WMC. The difference in WMC may not be related to unrestrained vs. restrained eating per se, but the benefits of WMC may be deployed differently in the varying situations of Study 1 and Study 2. Study 1 measured behavior over the course of a week where the women had some level of control over their exposure to temptation, whereas Study 2 measured the reaction of women when temptation level was manipulated.

In Study 1, WMC may have played a more general role, allowing women to keep the goal to be healthy and avoid unhealthy food items activated. Unrestrained eaters may not have the goal to explicitly restrict their intake like restrained eaters, but it is not unlikely that college-aged women would have a general goal to eat healthfully. Greater WMC may allow these women to activate that general goal when making food choices, and allow them to make choices where they are not confronted with unhealthy food as frequently. As discussed, it is difficult to determine why WMC did not influence restrained eaters' self-reported intake.

In Study 2, WMC had a more specific, online role to influence ability to resist temptation in the moment. In Study 2, women had no control over whether or not they were exposed to temptation, or furthermore, offered some of that tempting item. The self-report measure used in Study 1 does not speak to the level of temptation women are experiencing in day-to-day life. It's possible that restrained eaters are better at avoiding situations where they would be tempted; regardless, WMC is important for this more vulnerable group when they are directly offered tempting food.

Another indirect implication of the current results is that WMC may be particularly important in driving self-regulation in "hot", emotional or hedonic, situations (Mischel et al., 2011). This interpretation is based on the WMC moderation effect on intake of unhealthy, but palatable or tempting foods, and not on healthy foods. The emotional or hedonic component of tempting foods may be more salient and therefore distracting than healthy foods, particularly to individuals who are already more reactive to food cues in their environment (i.e., highly restrained eaters).

Novel Measurement and Use of Implicit Food Activation

One important contribution of these studies is establishing the utility of the word stem as a measure of implicit food activation. Results of both studies suggested that greater implicit food activation reduced the effectiveness of greater WMC. Implicit food activation may be serving as an internal cue towards food for both restrained and unrestrained eaters. For restrained eaters, the internal cue of implicit food activation may function similarly to external food cues, and may serve as an additional influence to overcome in the service of avoiding unhealthy food or temptation. For unrestrained eaters, the internal cue may remind them or increase activation of a general health goal of avoiding unhealthy food.

Although the results concerning the word stem task need to be replicated and extended, these results are a first step and call for more work to determine its predictive validity. Word stem tasks are more typically used as dependent measures of priming effects (for example, see Ward & Mann, 2000); however, they have been described as assessing not only the activation of cognitive constructs that have been recently primed, but also activation that has been self-generated (Steele & Aronson, 1995), which relates to its current intended use. While the word stem task is not viewed as a replacement for the more common measures of implicit processes such as the IAT, it is viewed as a potential complement, and particularly useful when a researcher needs to reduce to confounding effects of WMC or EF ability (though, arguably, due to selection processes, the word stem task may not be completely free from elements of control). A practical benefit of word stem task is that it is quick, and relatively easy to implement and score. The word stem task was administered at the beginning of the session with the goal of getting a baseline measure of an individual's implicit food activation. However, it is plausible to use the task at a different point during the study session to determine, for example, if food cue exposure affects the level of implicit food activation.

Dual-Process Models

The results of these two studies are important because explicit (i.e., restrained eating) and implicit (i.e., implicit food activation) factors were measured together in the same study, and WMC was found to moderate their effects, rather than acting on each factor independently. There is a class of models, known as dual-process models, which highlight the importance of considering both explicit and implicit effects on behavior, that is relevant to the current findings. Although there are several variations of dual-process models, one that has been applied to health behavior is the reflective-impulsive model originally outlined by Strack and Deutsch (2004) (for a review of application to health behavior, see Hofmann, Friese, & Wiers, 2008). This model outlines three main components that jointly determine health behavior. The first is the explicit or reflective component, which refers to reasoned attitudes or decisions and are typically self-reported. The second is the implicit or impulsive component, which includes automatic associations or reactions. Finally, this model outlines a set of boundary conditions that influence the degree to which the explicit and implicit components contribute to health behavioral outcomes. Boundary conditions can include situational factors such as ego depletion, mood, and alcohol consumption, and dispositional factors such as self-control.

In the current findings, WMC functions as a boundary condition for the effects of restrained eating and eating intentions, reflective components, and implicit food activation, the impulsive component, on food bias. Although the present findings differ from typical dual-process models in that in this case, the explicit and implicit factors do not necessarily elicit competing behavioral outcomes, they demonstrate the importance of considering all three components when examining health behaviors.

Measurement of WMC

Although the focus of the current studies was on how restrained eating and implicit food activation interact with WMC to influence eating behavior, it is important to note that they did not replicate previous findings that WMC moderates the intention-behavior relationship for healthy food intake (Hall et al., 2008) or that specific components of WMC differentially predicted intake of saturated fat vs. fruits and vegetables (Allom & Mullan, 2014). One consideration is that both of the previous studies used different measures to assess different aspects of WMC. The current discussion of WMC has treated it as being fairly synonymous with EF, and as a unitary construct. However, an influential model conceives of EF as involving multiple processes that serve both common and unique functions (Friedman et al., 2008; Miyake et al., 2000; Miyake & Friedman, 2012). In other words, there are different EF processes that are both highly correlated with each other and demonstrate some unity, but also maintain distinct functions and demonstrate some diversity. There are three primary unique EF processes in this model: updating of working memory, switching, and inhibition. However, there are also elements that are unitary across updating of WM, switching, and inhibition, referred to as common EF. Current thinking describes common EF as encompassing “one’s ability to actively maintain task goals and goal-related information and use this information to effectively bias lower-level processing” (Miyake & Friedman, 2012).

In general, common EF tends to be responsible for much of the power of EF in predicting clinically and socially relevant behavior (Miyake & Friedman, 2012). Based on this repeated result and the conceptualization of common EF as being responsible for goal maintenance, it was expected that common EF would be driving the influence on healthy vs. unhealthy eating choices by restrained eaters. WMC measures tend to be highly reliable and were therefore used as a proxy for assessing goal maintenance ability. However, updating involves additional processes that make it unique from common EF, which may be influencing the current results. Hall and colleagues (2008) used a Go-No Go task, which is more typically thought to index motor inhibition. Allom and Mullan (2014) assessed both inhibition, using Stroop and stop-signal tasks, and updating, using n-back and operation span tasks. They found that inhibition was related to intake of saturated fat, in contrast with results of Hall and colleagues (2008), and that updating was related to intake of fruits and vegetables. Although the present results support the idea that there may be different mechanisms underlying consumption of healthy and unhealthy foods, the pattern of results across these studies is conflicting. A future direction in the service of reconciling this conflict would be to use latent variable modeling which requires multiple measures of the different components of EF to better specify which component of EF drives certain effects and to decrease the influence of the "task-impurity" problem (i.e., measures of EF must be embedded in tasks that require non-EF processing, and are therefore muddied by those processes; for a discussion, see Miyake et al., 2000).

Practical Implications and Conclusion

Based on the current results, although WMC is helpful in decreasing intake of tempting food for some people, this effect goes away at higher levels of restrained eating and implicit food activation. As such, dieting interventions could be tailored to support individuals who fit this profile. For example, highly restrained eaters could be encouraged to rely less on their self-control abilities or "willpower" and instead be taught to structure their environment is such a way that decreases temptation and to rely on other external strategies, such as joining support groups, that encourage dieting success.

Another route may be to explicitly train restrained eaters' abilities to implement their dieting goals. Although general WMC may not reduce the intake of highly restrained eaters, it may be possible to target more specific eating-related goal setting and implementation skills. Currently, there are two intervention/training techniques that have shown some utility in changing goal associations or inhibition of goal-incongruent behaviors: 1) implementations intentions and 2) inhibition training. Implementation intentions have been shown to be effective in changing old habits or creating new ones in a variety of self-regulatory and health domains, such as maintaining academic work, taking medications or vitamins, and exercising (for a general review, see Gallo & Gollwitzer, 2007). There is growing research on the effectiveness of implementation intentions in improving eating behavior, by either increasing intake of healthy food or decreasing unhealthy food. So far, implementation intentions have shown to be more effective in promoting healthier eating behavior than intentions or access to nutrition information alone (for a meta-analysis, see Andriaanse, Vinkers, De Ridder, Hox, & De Wit, 2011). Implementation intentions are a specific type of goal-related instructions that specify both the precipitating situation (e.g., “I am hungry/bored”), and the accompanying desired behavior (e.g., “I will eat fruit”). They are typically formulated as if-then statements, such as “If I become hungry and want a snack, then I will eat fruit.” It is likely that implementation intentions are effective in supporting healthy eating choices because they support restrained eaters in keeping their eating goals active.

Particularly for restrained eaters who tend to be unsuccessful at their dieting attempts, implementation intentions may serve as a cueing device that unsuccessful dieters fail to do for themselves. Taking it one step further, implementation intentions may ultimately contribute to changing the automatic goal associations restrained eaters have with tempting food. It was found that the use of implementations intentions increased the associations between a tempting food cue and the dieting goal (Kroese, Adriaanse, Evers, & de Ridder, 2011).

Another relevant intervention technique that has yielded results is the use of inhibition training. In these studies, tempting food items, such as chocolate or potato chips, are paired with a stop or no-go signal using the stop signal or Go-No go paradigms, respectively. Generally speaking, in both paradigms, the idea is that while most of the time a stimulus requires a response, on some trials there is either a separate signal or specific stimulus that indicates no response is needed. It has been found that in restrained eaters, consumption of the paired food item is decreased when it has been paired with the stop or no go signal (Houben & Jansen, 2011, Veling, Aarts & Papies, 2011). Furthermore, this effect has been shown to specifically affect restrained eaters with decreased EF ability (Houben, 2011), which indicates that this technique is most effective for those who are most vulnerable. However, these particular results should be interpreted with caution because recent reviews on the trainability of WMC have concluded that while training can lead to improvements on a specific task, the training rarely generalizes to other aspects of EF or related measures (for a review, see Shipstead, Redick, & Engle, 2012). Food inhibition training may be useful for a specific food item, but not as a general tool to avoid a range of unhealthy foods.

In conclusion, the two studies presented here confirmed the expected moderation by WMC on the effects of restrained eating and implicit food activation on intake of unhealthy food items, over and above the impact of intentions, and when exposed to temptation. These results speak directly to health behavior models and suggest that although intentions and other health attitudes are primary driving factors in actual behavior, self-regulatory processes need to be considered across different situations. In future studies, researchers are encouraged to take both explicit and implicit factors into account, considering that WM buffers their effects and that WMC may play different roles depending on individual differences or situational context, particularly as it relates to eating and other health domains.

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