COGNITIVE INTERFERENCE IN RESPONSE TO WEIGHT LOSS STIMULI IN INDIVIDUALS PARTICIPATING IN A STRUCTURED WEIGHT LOSS PROGRAM

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Tina D. Bhargava, DrPH

University of Pittsburgh, 2012

Although a central concern of public health is the self-management of chronic diseases, the cognitive demands required by behavior change are seldom explored. The purpose of this study was to examine the effect of cognitive limitations—with a focus on cognitive interference (i.e. "off task" thoughts)—on weight loss efforts through both an experimental and a qualitative approach. Individuals currently enrolled in a structured weight loss program completed positive and negative weight-loss related Stroop tasks to measure cognitive interference levels. Response times were compared between and within participants who were engaged (N=25) vs. unengaged (N=15) and successful (N=16) vs. unsuccessful (N=24) with the weight loss program. Successful participants had significantly faster response times (p=.01) on the positive Stroop compared to the negative Stroop (716.6 ± 98.1, 761.3 ± 106.4), as did the engaged participants (p=.02; 725.1 ± 96.7, 759.9 ± 111.7). No statistically significant differences were found between successful & unsuccessful or engaged & unengaged groups, however the experimental findings suggest that cognitive interference in response to weight-loss related cues may be related to success with and engagement in a weight loss program. A qualitative exploration of interview responses identified themes related to cognitive processes and interference and supported the supposition that unhealthy behaviors are often automatic, and changing them can have high cognitive demands. However, participant responses also indicated that healthy behaviors can be automatized with practice. In addition, the external factors that participants identified as

influencing their health behavior choices indicate that a social and built environment that supports healthier decisions would make the health behavior changes less cognitively demanding. The public health significance of these findings is that they indicate that both cognitive limitations and environmental influences should be taken into account when examining the need for health behavior change and designing interventions to address this need. Further research into how cognitive factors affect lifestyle decision-making may contribute to a deeper understanding of how to promote self-care behaviors that lead to better health outcomes.

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PREFACE

I would like to acknowledge the Amy Roberts Health Promotion Award and the Department of Behavioral and Community Health Sciences at the University of Pittsburgh for supporting this study.

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1.0 INTRODUCTION

Chronic diseases—such as obesity, diabetes, heart disease, and stroke—create an enormous health and economic burden in the United States and around the world (Association, 2008; Engelgau et al., 2004; Zimmet, Alberti, & Shaw, 2001). One of the key elements in addressing this burden is self-management. Health behavior change interventions designed to facilitate self-management of chronic diseases typically ask people to make several specific changes in their lifestyles, such as healthy eating and physical activity. However, the ability to self-manage chronic conditions relies not only on knowing what to do, but also on having the adequate skills and resources to do so (P. D. Larsen & Lubkin, 2009). Given the limited success of many typical health behavior interventions—particularly those designed to help individuals lose weight through diet and exercise—it is important to reflect on what resource limitations individuals may have that could be a barrier to successful self-management.

Researchers in the fields of applied psychology and neuropsychology study how cognitive factors affect task performance (Paas & Van Merrienboer, 1994; Schneider, Dumais, & Shiffrin, 1984; Steele-Johnson, Beauregard, Hoover, & Schmidt, 2000; Wood, 1986). In other words, what kinds of cognitive demands do certain tasks require and what determines whether people have the capacity and motivation to complete those tasks? Although a central concern of public health is the self-management of chronic diseases, the cognitive demands required by

these tasks are seldom explored in the public health literature. The complexity and cognitive demands of health self-management behaviors affect how well they are completed.

The concept of **cognitive interference** illustrates this point. Cognitive interference is a term to describe "off-task" thoughts that affect task performance (Sarason, Pierce, & Sarason, 1996b). Using cognitive resources for off-task thoughts may make it harder to accomplish the task at hand. For example, a woman who is trying to lose weight and is in a restaurant deciding what to order will likely be thinking about what the healthiest option might be, how many calories it is, and how much of it she should eat. But other thoughts may intrude upon this decision-making process—for example, whether her dining companion is paying attention to what she's eating, how she feels about how she looks that day, or whether she feels she's capable of losing weight when she's failed so many times in the past. These off-task thoughts may interfere and make it more difficult to focus on selecting the appropriate thing to eat.

Limited attention has been paid to the effects of cognitive interference on health behavior change. Some forms of cognitive interference may be preventable or controllable, which may lead to overall improvement in self-management. Careful consideration and further understanding of how cognitive factors affect the performance of self-management tasks—such as healthy eating and active living—may contribute to a deeper understanding of how best to promote self-care behaviors that lead to better health outcomes.

2.0 REVIEW OF THE LITERATURE

2.1 COGNITION AND ATTENTIONAL RESOURCES

The concepts of attention and attentional resources have been studied extensively, particularly in the psychology literature. These concepts are important to consider when examining how well individuals complete different tasks because they help explain the cognitive processes—and limitations—of the individual.

Attention serves as an information processing resource. It is widely accepted in the field that individuals possess a fixed amount of attentional resources (Kahneman, 1973). Attention is also discussed in terms of types of information processing. This area of study focuses around the theory that there are two qualitatively different processes of human performance (Chaiken & Trope, 1999; Schneider et al., 1984). One type of processing is a fast and fairly effortless process, which is often referred to as "automatic." Automatic processing is generally not under direct control of the individual. In other words, individuals are seldom conscious of the automatic information processing that takes place. The other type of processing is characterized as slow, effortful, regulated processing, and is sometimes referred to as "control." Control processing is typically used to deal with novel tasks or information. While the distinction between automatic and control processing is an important one, it is also necessary to note that,

most likely, all tasks are carried out with some mixture of automatic and control processing (Schneider et al., 1984).

Control processing uses most of an individual's attentional resource capacity. Automatic processing tasks, on the other hand, use very little attentional capacity. Therefore, several automatic processing tasks can be completed successfully even when they are conducted simultaneously and without full awareness of the individual. In contrast, control processing tasks must compete for attentional resources in order to be completed successfully. Individuals are generally well aware of the completion of these tasks. The part of our brains that governs conscious awareness and control processing is estimated to be able to process about 40-60 bits per second, which is roughly equivalent to a short sentence. Yet the overall processing capacity of brain is estimated to be 11 million bits per second, indicating that the vast majority of tasks are carried out automatically (D. Cohen & Farley, 2008; Dijksterhuis, Smith, van Baaren, & Wigboldus, 2005).

2.2 COGNITIVE INTERFERENCE

Cognitive interference is the term used to describe off-task, and typically unwanted, thoughts that affect task performance. Using attentional resources for off-task thoughts, e.g. worrying about what someone else is thinking about you instead of attending to the task, may take away from task performance. Mounting evidence has shown that cognitive interference plays an important role in stress, performance, learning, and psychopathology (Sarason et al., 1996b).

There are many potential sources of cognitive interference. Some of these sources are considered to be specific to each individual's traits, such as tendency towards anxiety or

depression, or ability to cope (Yee & Vaughan, 1996). For instance, multiple studies have demonstrated that anxiety can lead to task performance deficits, likely due to the focus on intrusive threat-related thoughts that occur frequently in anxious individuals (MacLeod, 1996). Depressed persons report particular difficulty with cognitive functioning, such as poor concentration, forgetfulness, and intrusive negative thoughts (Gotlib, Roberts, & Gilboa, 1996). However, the presence and severity of cognitive deficits in depression seems to depend on the situation and type of task. Stress may also lead to cognitive interference. This often depends on whether the stress is self-imposed (a challenge to oneself to do better) or externally imposed (a demand to do better), with externally imposed stress creating greater reductions in task performance.

Self-doubts (worries about one's ability to attain a goal) can interfere with actions when thoughts about outcome expectations or self-efficacy are intrusive and are connected to the belief that one is unable to attain the goal at hand. The self-doubts interfere with normal self-regulatory processes that allow one to move forward in goal attainment (Schwartzer, 1996). Individuals may also differ in the extent to which they are capable of filtering irrelevant information, leading to cognitive interference from relative distractibility. Furthermore, individuals who are stigmatized may experience higher levels of cognitive interference from worrying about what other people think of them.

2.3 THE STROOP TASK

The Stroop task is used to measure attentional resources or attentional fatigue, and is considered the "gold standard" of all attention measures (Chajut, Schupak, & Algom, 2010; MacLeod, 1992; Melara & Algom, 2003). It is also used to measure cognitive interference in response to stimuli. The Stroop task measures the amount of time it takes a person to name the printed color of a word. The underlying premise of the Stroop task is that people are more automatically able to identify a written word than to name a color. The explanation for this is that each written word has only one automatic response in the human brain, whereas a color can elicit multiple associated responses, of which one needs to be voluntarily selected (MacLeod, 1991). In other words, identifying the word "blue" is fast and automatic, whereas identifying the color blue is slower and requires control processing. In situations with higher cognitive interference, fewer control processing resources are available and therefore color-naming response times will be slower.

Stroop's original test (1935) measured color-naming response times with two sets of stimuli: a control condition (Figure 1), in which blocks of colors were displayed; and an incongruent condition, in which color words were displayed in conflicting colors of ink. In recent administrations of the Stroop task, a congruent condition in which the color of the word matches the color word, is often also conducted (Dobson & Dozois, 2004). In both the incongruent and congruent conditions, the individual is asked to ignore the *content* of the word and name the *color* the word is written in.

Figure 1: Stroop Conditions

In order to "ignore" the written word and name the color in the incongruent condition, it is necessary for an individual to use attentional resources. When response times are slower, it indicates that fewer attentional resources are available(Stroop, 1935). As an example of how the Stroop task is used, it is often the instrument of choice in experimental studies in conjunction with the "air traffic controller" (ATC) task, in which individuals use a simulated computer program to manage and land virtual planes—a task with high cognitive demands. The Stroop task is conducted before the ATC task to measure baseline attentional resources, and then is conducted after the task to measure attentional fatigue.

General sources of cognitive interference were described earlier. However, because Stroop interference is related to word recognition, it is also related to age. Stroop color-naming interference begins early in the school years, rises to its highest level when reading skill develops (about grades 2-3), then declines through adulthood until approximately age 60, when it begins to increase again (MacLeod, 1991).

2.4 EXPLANATION OF THE "EMOTIONAL" STROOP

In the last forty years, the Stroop task has been modified to use both classic and "emotional" stimuli. The "emotional Stroop task" focuses not on general attentional interference, but rather on the cognitive interference that people exhibit for emotional stimuli relative to comparable

neutral stimuli (Dobson & Dozois, 2004). In the emotional Stroop task, there is no "incongruent" condition that delivers conflicting messages to the brain. Instead, individuals are presented with both emotional (e.g. danger, snake) and neutral (e.g. paper, tree) word stimuli and asked to ignore the content of the word and name the color of the word as quickly and accurately as possible. The underlying premise is that the content of the emotional words differentially interferes with color naming and slows response times by capturing cognitive resources (Egloff & Hock, 2003; Linda Johansson, Lundh, & Andersson, 2005; R. J. Larsen, Mercer, & Balota, 2006; Wentura, Rothermund, & Bak, 2000; Williams, Mathews, & MacLeod, 1996).

There is some disagreement as to why the emotional stimuli lead to slower response times (Chajut, Schupak, et al., 2010; Linda Johansson et al., 2005; Williams et al., 1996). One view of the emotional Stroop effect is that emotional stimuli are **noticed earlier** then neutral stimuli, causing a delay in directing attention to the color of the word (MacLeod, Mathews, & Tata, 1986; Pratto & John, 1991; Williams et al., 1996). The alternate view is that the emotional stimuli **hold the attention longer**, leading to a difficulty in disengagement from the stimuli (Fox, Russo, Bowles, & Dutton, 2001; McKenna & Sharma, 2004). However, the Stroop task itself cannot distinguish between these two mechanisms (Hollitt, Kemps, Tiggemann, Smeets, & Mills, 2010). It is possible that further exploration of brain function through imaging studies may lead to additional understanding of the specific cognitive mechanisms underlying the emotional Stroop effect.

The emotional Stroop task has become a valuable tool for examining cognitive processes in psychopathology (Dobson & Dozois, 2004; Segal, Gemar, Truchon, Guirguis, & Horowitz, 1995). Williams (1996) stated that "the emotional Stroop task is fulfilling much of it early promise as a way of establishing the extent to which attentional bias is involved in the

development of emotional psychopathology." In fact, the use of the Stroop task and other cognitive measures has increased due to the concern that simple questionnaires do not measure attitudes sufficiently (Dobson & Dozois, 2004; Faunce, 2002; Vitousek & Hollon, 1990). Furthermore, the Stroop task can be used to measure the mechanisms underlying attitudes, as opposed to attempting to measure the attitudes themselves (Davidson 02). Measures such as the Stroop task provide observable responses to controlled stimuli, and reveal information that self-reported measures cannot (S. Channon, Hemsley, & de Silva, 1988; Hermans, Pieters, & Eelen, 1998; Linda Johansson et al., 2005). Consequently, in recent years, the emotional Stroop task has been modified to include "disorder-specific" stimuli, such as anxiety words for anxiety-disordered populations or drug or alcohol words for addiction populations (Cox, Fadardi, & Pothos, 2006; Dobson & Dozois, 2004).

2.5 FOOD AND BODY STROOP TASKS

The emotional Stroop was first modified to include food and body shape words (see Appendix A for examples) to study eating-disordered populations (Overduin, Jansen, & Louwerse, 1995; Perpina, Hemsley, Treasure, & de Silva, 1993). Fairly extensive studies have been conducted with the Stroop task in this area (Dobson & Dozois, 2004; Faunce, 2002; Linda Johansson et al., 2005). Patients with eating disorders such as anorexia and bulimia display color-naming interference with food and body shape-related words, which indicates cognitive interference in this domain (Ben-Tovim, Walker, Fok, & Yap, 1989; S. Channon et al., 1988; Davidson & Wright, 2002; Fairburn, Cooper, Cooper, McKenna, & et al., 1991; Jones-Chesters, Monsell, & Cooper, 1998; Sackville, Schotte, Touyz, Griffiths, & Beumont, 1998).

The use of the food Stroop has been more limited and yielded inconsistent results in non-eating-disordered populations, such as restrained eaters (dieters). In comparing restrained eaters and unrestrained eaters, numerous studies have shown higher interference on the food Stroop for restrained eaters, in some cases even among normal weight individuals (Francis, Stewart, & Hounsell, 1997; Green & Rogers, 1993; Hollitt et al., 2010; Huon & Brown, 1996; Kemps, Tiggemann, & Marshall, 2005; Long, Hinton, & Gillespie, 1994; Overduin, Jansen, & Eilkes, 1997; Overduin et al., 1995; Perpina et al., 1993; Polivy, Herman, & Coelho, 2008; Shaw & Tiggemann, 2004; S. H. Stewart & Samoluk, 1997; Tapper, Pothos, Fadardi, & Ziori, 2008). But other studies have not found significant differences in food Stroop response times between these two groups (Ben-Tovim & Walker, 1991; Cooper & Fairburn, 1992; Jansen, Huygens, & Tenney, 1998; Sackville et al., 1998), leading some to conclude that there is no significant difference in cognitive interference in response to food cues in restrained eaters (Dobson & Dozois, 2004). The conflicting results may be explained by the lack of standardization of the food Stroop instruments and methods of conducting the Stroop task (e.g. fasting states, order of emotional and neutral stimuli, etc.).

Studies of Stroop interference among non-eating-disordered obese populations have yielded more consistent results, indicating that obese individuals have higher cognitive interference in response to food cues. However, very few studies have been conducted with this population (Linda Johansson et al., 2005). Braet (2003) and Soetens (2007) showed slower food Stroop response times in obese children and adolescents, respectively. More recent studies by Nijs et al. and Castellanos et al. demonstrated higher interference for obese adults using the food Stroop task, as well as fMRI brain imaging and eye movement tracking (Castellanos et al., 2009; Nijs, Franken, & Muris, 2008, 2010). While the results of these studies are convincing, it may

be early to proclaim higher food Stroop interference for obese individuals given the extremely limited number of published studies.

Some factors that are commonly associated with overweight and obesity are likely to increase cognitive interference. Studies have also shown that overweight individuals deal with high levels of stigma in their daily lives (Crandall, 1994; Crocker, Cornwell, & Major, 1993). Dealing with stigma has been shown to increase cognitive interference when completing a task (Sarason, Pierce, & Sarason, 1996a). Therefore it is likely that stigma creates significant cognitive interference, especially when dealing with tasks that are associated with being overweight, such as eating and exercising. Individuals dealing with stigma devote attentional resources to thoughts about what others think of them (e.g. Is everyone watching what I eat? Do I look silly when I exercise?), causing a reduction in task performance. Mood and attitude can also affect cognitive ability (Yee & Vaughan, 1996). It is common for people who have previously attempted self-management of eating and exercise to feel discouraged or wary when initiating a new effort (Linde, Jeffery, Finch, Ng, & Rothman, 2004). Low self-efficacy and an attitude of "well, it probably won't work," are likely to lead to cognitive interference during self-management tasks (Sarason et al., 1996a).

3.0 PURPOSE OF STUDY

As summarized above, many studies have been conducted to examine the level of cognitive interference from food and body shape words among individuals with eating disorders. Other studies have been conducted to compare cognitive interference to food cues between restrained and unrestrained eaters, and between obese and normal weight individuals. Phelan et al. (Phelan et al., 2011) were the first to examine cognitive interference in response to food cues in weight loss maintainers, and found higher interference in response to high-calorie food words for weight loss maintainers than for normal weight or obese individuals. However, levels of cognitive interference among obese individuals engaged in a structured weight loss program (i.e obese, restrained eaters) or in response to weight-loss related cues (rather than food cues) have not been explored. Furthermore, no literature has been identified that has explored cognitive interference and weight through a qualitative approach. When differences are found in Stroop results, authors propose multiple reasons for these differences, without evidence to support these suppositions. A qualitative approach may help provide support for some of these explanations of differences in cognitive interference.

In this study, I have addressed gaps in the literature in three ways. First, I examined the role of cognitive interference in a new population: **obese individuals engaged in a structured weight loss program**. Second, I designed and implemented versions of the Stroop task that use

general weight-loss-related stimuli, as opposed to food stimuli. And finally, I explored the phenomenon of cognitive interference through a **qualitative approach**.

The objective of this study was to examine the relationship between cognitive interference and engagement and weight loss for obese individuals enrolled in a structured weight loss program through the following three specific aims:

Specific Aim 1: To explore the relationship between cognitive interference in response to weight loss stimuli and engagement in a structured weight loss program.

Hypothesis 1: Individuals with higher levels of cognitive interference in response to weight loss stimuli will be less likely to engage in the structured weight loss program.

Specific Aim 2: To explore the relationship between cognitive interference in response to weight loss stimuli and success with a structured weight loss program.

Hypothesis 2: Individuals with higher levels of cognitive interference in response to weight loss stimuli will be less likely to successfully lose weight in the structured weight loss program.

Specific Aim 3: To explore the types of interfering thoughts and potential sources of cognitive interference through a qualitative approach.

4.0 METHODS

4.1 SUMMARY OF METHODS

This study was conducted as a sub-study of a larger ongoing study. The specific aims were accomplished through a combination of experimental and qualitative methods. For the experimental portion of the study, a sample of participants in the structured weight loss program completed several versions of the Stroop task to measure cognitive interference. Cognitive interference was compared between those who actively engaged in the program and those who didn't, and between those who did and did not lose weight successfully.

For the qualitative portion of the study, a brief interview was conducted with the majority of those who completed the Stroop tasks as part of the sub-study. The transcripts were reviewed for emerging themes related to cognitive processes and interference, and the identified themes were compared across participants.

4.2 DESCRIPTION OF PARENT STUDY

This study was conducted as part of a larger ongoing randomized study (PI – Kathleen McTigue, MD MS MPH) which aimed to test the effectiveness of Virtual Lifestyle Management (VLM)--

an online adaptation of the Diabetes Prevention Program (DPP) lifestyle curriculum, delivered in coordination with primary care (McTigue et al., 2009). The parent study compared changes in body weight, physical activity, body composition, quality of function, and satisfaction between participants randomized to VLM with standard lifestyle coaching (VLM-S, N=126), VLM with modulated lifestyle coaching (VLM-M, N=131) and access to online information regarding lifestyle goals and resources (OGR, N=120). The study was conducted in Pittsburgh, PA, in collaboration with several UPMC primary care clinics. Participants for the study (N=377) were recruited through referrals from primary care providers (PCP) and enrolled between May 19th, 2010, and December 7th, 2010. Only the participants randomized to the VLM arms of the parent study (N=257) were recruited for this sub-study. Baseline characteristics of the VLM participants are shown in Table 1. Participation in the study was ongoing at the time of the sub-study and participants had been enrolled in the program for a total of 12 months.

Table 1: Baseline Characteristics of VLM Participants (N=257)

	Mean (range) or N(%)
Age (years)	50.4 (22-74)
Baseline BMI	37.9 (30-62)
Female gender	196 (76)
Race	
White	197 (76)
African-American	56 (22)
Other/Not Reported	4 (2)

Participants were eligible for the parent study if they were obese (BMI $\geq$ 30 kg/m^2) primary care patients, aged 21-75, who were receiving primary care at one of the study's participating clinics. Exclusion criteria for the study included:

- PCP felt they were unable to safely undertake a low-fat diet and unsupervised moderate physical activity;

- heart attack within the last 3 months;
- currently pregnant, planning pregnancy in the next two years, or currently breast feeding;
- bariatric surgery in the last 2 years, or planned during the next two years;
- presence of a medical condition or medication that is likely to influence body weight;
- already engaged in weight loss therapy or program;
- participation in either pilot program for this study (e.g. WiLLoW or VLM) during the past year;
- perceived lack of basic computer skills, or lack of access to a computer with high-speed internet;
- another member of their household already enrolled;
- lack of access to a body weight scale;
- inability to attend an in-person orientation session.

All participants attended an in-person orientation session appropriate to the study arm to which they were assigned. Written informed consent and a HIPAA authorization were obtained at the orientation session, along with all baseline physical measures and survey items. Participants were educated by the study staff (research assistants and lifestyle coaches) about the Diabetes Prevention Program (DPP) lifestyle intervention and its health effects, and told that their lifestyle and body weight goals for this study would be based on the behavioral lifestyle program developed for the DPP. These goals included weight reduction of at least 7% of initial body weight and a gradual increase in moderate-intensity physical activity up to 150 minutes/week. In addition to learning about the program's lifestyle goals and recommendations, all participants were instructed on how to communicate with study staff, and procedures for outcome collection were reviewed.

Those patients randomized to VLM-S or VLM-M completed an online "VLM Orientation" lesson designed to teach them how to use the software and what to expect from the program. They were encouraged to complete 16 lessons (the original DPP's core curriculum) in order, on an approximately weekly basis, and then to complete 8 monthly lessons. The VLM curriculum provided standard information about healthy lifestyle and behavioral techniques for integrating it into daily living. In each lesson, participants provided feedback about how they interpreted the information, and ideas for integrating it into their lives. As the program progressed, participants were encouraged to track their fat and calorie intake and physical activity on a daily basis, and were provided with the technology to do so online within the VLM program. The VLM lifestyle coaches reviewed lesson and tracking entries weekly, and provided support, feedback about progress, and tips on how to problem-solve around lifestyle barriers. The program included additional secure electronic messaging (email) with the coaches to answer questions that arose from reviewing or trying to implement the curriculum lessons, as well as questions regarding self-monitoring.

VLM participants were encouraged to complete 16 lessons (the original DPP's core curriculum) in order, on an approximately weekly basis, and then to complete 8 monthly lessons. The VLM curriculum provided standard information about healthy lifestyle and behavioral techniques for integrating it into daily living. In each lesson, participants provided feedback about how they interpreted the information, and ideas for integrating it into their lives. As the program progressed, participants were encouraged to track their fat and calorie intake and physical activity on a daily basis, and were provided with the technology to do so online within the VLM program. The VLM lifestyle coaches reviewed lesson and tracking entries weekly, and provided support, feedback about progress, and tips on how to problem-solve around lifestyle

barriers. The program included additional secure electronic messaging (email) with the coaches to answer questions that arose from reviewing or trying to implement the curriculum lessons, as well as questions regarding self-monitoring.

4.3 EXPERIMENTAL METHODS

Specific Aim 1: To explore the relationship between cognitive interference in response to weight loss stimuli and engagement in a structured weight loss program.

Specific Aim 2: To explore the relationship between cognitive interference in response to weight loss stimuli and success with a structured weight loss program.

4.3.1 Definition of Analysis Groups

The sample for the experimental portion of the study was recruited from the participants in the VLM arms of the parent study. In order to investigate specific aim 1, cognitive interference levels in response to weight loss-related words were compared between participants who were **engaged** in the program and those who were **unengaged**. The criteria for engagement in the program were based on the participants' usage of the program on their 12-month date and were defined as follows:

Logged in during the last 30 days AND at least <u>one</u> of the following:

- Completed a lesson in the last 45 days
- Sent a secure message in the last 30 days
- Tracked food and/or physical activity for at least 1 day in the last 30 days

- Entered a weight in the last 30 days

Fulfillment of the above criteria was determined by a review of the standard VLM program logs and reports.

In order to investigate specific aim 2, cognitive interference levels in response to weight loss stimuli was compared between participants who were **successful** (≥5% body weight loss) with weight loss in the last year versus those who were **unsuccessful** (<5% weight loss or weight gain in the last year). A 5% weight loss has been shown to be clinically significant in improving health status (Ditschuneit, Flechtner-Mors, Johnson, & Adler, 1999; L. Johansson, Ghaderi, & Andersson, 2005; Pi-Sunyer et al., 2007). Weights from the baseline study visits were compared to weights from the 12-month visits to determine success.

4.3.2 Recruitment

For the parent study, all participants were asked to attend a study visit within a 4-week window of the date one year from their orientation date (12-month visit). Participants were contacted via US mail, phone, and email. The 12-month study visits for the parent study were conducted between May 6, 2011, and December 21, 2011. The visits consisted of measurements of weight, blood pressure, and waist circumference. Socio-demographic surveys (45-60 minutes to complete) were completed at the visit or prior to the visit via the Internet. Participants were also asked to wear a pedometer for two weeks and return it at their visit or via US mail. Participants who completed their visit and returned their pedometers were compensated $40.00, with an additional $10.00 bonus for those who completed and returned their pedometers within the specified time frame.

The sub-study research activities were conducted as part of the 12-mo visit. When participants scheduled this visit (in chronological order based upon their enrollment date), all those who were assigned to a VLM arm of the parent study were asked if they would like to participate in the sub-study (see Appendix B: Phone Script for Recruitment). Because the Stroop task is a color-naming task, interested participants were asked if they were color-blind and excluded from the sub-sample if they were. An intentional effort was made to balance the sub-study participants in terms of success and engagement, leading to an over-sampling of successful and engaged participants in the sub-sample. When recruited, participants were informed that the sub-study segment of the visit would last approximately 45-60 minutes, beyond the time of their standard 12-month visit, and that they were eligible for an additional $20.00 compensation for their participation in the sub-study. Recruitment ended when a sufficient number of participants—based on the study design and power analysis described below—were enrolled in the sub-study. The study was approved by the institutional review board of the University of Pittsburgh.

4.3.3 Instruments

4.3.3.1 Development of the Stroop Tasks

In the early stages of the study, the intention was to create three emotional Stroop tasks with different semantic categories—weight loss, diet, and physical activity. Therefore, potential word lists for the target emotional Stroop tasks (Table 2) were generated through a three-step process. First, the frequency of word use in the parent study in-person orientation session script, the online orientation lesson, and the first online lesson (entitled “Getting Started Losing Weight”) was examined. Then the frequently-used words from these sources (excluding irrelevant words

such as “lesson” or “online”) were given an initial categorization as either weight loss, dieting, or physical activity words. Second, six individuals from the target population were informally asked: “What words come to mind when you think of weight loss?”, and then asked the same question again with the categories of dieting and physical activity. Common responses were added to the potential word lists. Finally, experts in the field of lifestyle change interventions were asked to fill gaps in the potential word lists, based on their experience and perspectives.

Table 2: Potential words for the weight-related emotional Stroop tasks

Weight Loss	Dieting	Physical Activity
Activity	Calories	Active
Diet	Cup	Chafe
Eating	Diet	Exercise
Exercise	Fat	Fatigue
Fat	Food	Gym
Goal	Fruit	Intensity
Lifestyle	Gram	Minute
Lose	Hungry	Moderate
Obese	Label	Physical
Overweight	Measure	Steps
Pound	Ounce	Strength
Scale	Portion	Stretch
Tracking	Serving	Sweat
Unhealthy	Teaspoon	Tired
Weight	Vegetables	Walking

Semantic relatedness—or how much words are related to each other—has been shown to be an important factor in emotional Stroop response times (Cox, Brown, & Rowlands, 2003; Cox et al., 2006; Green & Rogers, 1993; Sherry H. Stewart, Hall, Wilkie, & Birch, 2002; Warren, 1972). Therefore, because the words from the weight loss Stroop tasks would all be associated with specific categories, the neutral Stroop also needed to consist of words that would be

associated with one category. The potential word list for the neutral Stroop (Table 3) consisted of office-related words and was compiled through review of an office supply catalog.

Table 3: Potential office-related words for the neutral emotional Stroop task

Binder	Letter	Print
Chair	Marker	Printer
Computer	Monitor	Shredder
Desk	Mouse	Stamp
Envelope	Notes	Staple
Ink	Paper	Stapler
Keyboard	Pen	Tape
Lamp	Pencil	

In a process similar to that of Calitri (2009) and Chajut (2010), semantic relatedness and emotional valence (perceived positivity or negativity) were examined by pilot-testing these potential word lists with a small sample of the population being studied, who subsequently did not participate in the experimental activities[1]. The first eleven sub-study participants recruited from the parent study were asked to complete a questionnaire (see Appendix C for "Stroop Words Pre-test") to indicate level of agreement regarding how related each group of words was to its associated category and how positive or negative they felt each word was. Emotional valence was assessed because including a combination of words that are balanced between positivity and negativity in a Stroop task is likely to lead to response times that "cancel each

[1] Participants who completed the Stroop Words Pre-Test were also asked to complete the Eating Inventory and the brief interview, as described elsewhere in the methods section. These participants were compensated the same amount of $20.00 as the participants in the experimental portion of the study.

other out." Therefore, each Stroop task needs to have words that all have the same emotional valence (positive, negative, or neutral).

These 11 participants were asked to rate how they felt about each word—including all the words from tables 2 and 3 above—on a scale of 1 ("very positive") to 7 ("very negative"), with 4 marked as "neutral." They were then asked how well words from each group belonged to their assigned categories, on a scale of 1 ("strongly agree") to 6 ("strongly disagree"). Participant responses were averaged together to create a mean score for emotional valence (EV) and semantic relatedness (SR) for each word.

Average EV of the 23 potential office-related words ranged from 3.00 to 4.50 (mean = 3.64; SD =0.39), indicating that these words were perceived by participants as neutral. The ten words that were "most neutral" (i.e. average EV closest to 4) were selected for use in the neutral Stroop task (see Table 4). Likewise, SR of these 10 words was confirmed as it ranged from 1.00 to 1.63 (mean = 1.25, SD = 0.18), with 1 indicating that the participant "strongly agreed" and 6 that they "strongly disagreed" that the word belonged to the category of "office supplies."

Participants were asked to assess SR of the potential weight loss, diet, and physical activity words to their assigned categories, as well as the relatedness of the diet and physical activity words to the category of "weight loss." The average SR of each of these groups of words, as well as the words combined, is shown in Table 5. Because there was minimal difference in how related participants felt that words in the "diet" and "physical activity" categories were to their own categories versus the general category of weight loss, it was determined that the original division of words into different semantic categories would not be prudent. All the words from these three categories were therefore collapsed into the single category of "weight loss."

Table 4: Final words for the neutral Stroop task

Word	Semantic Relatedness	Emotional Valence	Length	Frequency of Use (LogFreqHAL*)
Desk	1.13	4.00	4	9.52
Envelope	1.38	3.75	8	9.29
Keyboard	1.13	3.63	8	10.47
Lamp	1.63	4.13	4	8.80
Letter	1.38	4.00	6	10.97
Mouse	1.25	4.00	5	10.54
Notes	1.00	3.63	5	10.67
Stamp	1.13	4.25	5	8.83
Staple	1.25	3.88	6	7.01
Tape	1.25	4.00	4	11.02
MEAN	**1.25**	**3.93**	**5.5**	**9.71**

* Higher values indicate more frequent word use

Table 5: Semantic relatedness of weight-loss related words

Category of Words	Number of words	Semantic Relatedness to own category [Mean(SD)]	Semantic Relatedness to weight loss [Mean(SD)]
Weight loss	15	1.58 (0.44)	N/A
Diet	15	1.68 (0.27)	2.12 (0.77)
Physical Activity	15	1.94 (0.94)	2.01 (0.78)
Weight loss/diet/PA combined	45	N/A	1.89 (0.69)

However, the EV for the combined list of weight words varied greatly (mean = 3.36, SD = 1.30), with "strength" being the most positively perceived word (EV = 1.38) and "overweight" and "obese" being the most negatively perceived words (EV = 1.67). In order to end up with Stroop tasks that were at a consistent level of EV, the ten most positively- and the ten most

negatively-perceived words were used to create a "Positive Weight-Loss Stimuli Stroop" and a "Negative Weight-Loss Stimuli Stroop," respectively (see tables 6 & 7).

Table 6: Final words for the positive weight-related Stroop task

Word	Semantic Relatedness	Emotional Valence	Length	Frequency of Use (LogFreqHAL*)
Active	1.25	1.88	6	10.48
Activity	1.50	1.75	8	10.18
Exercise	1.00	1.88	8	9.88
Food	1.67	2.25	4	11.00
Fruit	1.38	2.00	5	9.28
Goal	1.25	2.00	4	10.17
Gym	1.75	2.13	3	8.17
Lifestyle	1.00	2.38	9	N/A
Strength	1.75	1.38	8	10.16
Vegetables	1.63	2.25	10	8.39
MEAN	**1.42**	**1.99**	**6.5**	**9.74**

*Higher values indicate more frequent word use

Table 7: Final words for the negative weight-related Stroop task

Word	Semantic Relatedness	Emotional Valence	Length	Frequency of Use (LogFreqHAL*)
Calories	1.38	4.00	8	7.86
Diet	1.88	3.75	4	9.43
Fat	2.88	5.63	3	10.29
Fatigue	2.00	5.88	7	8.24
Hungry	2.00	3.75	6	8.75
Obese	1.67	6.25	5	6.60
Overweight	1.67	6.25	10	7.34
Tired	2.00	5.63	5	9.86
Unhealthy	1.67	5.63	9	7.15
Weight	1.33	3.63	6	10.43
MEAN	**1.85**	**5.04**	**6.3**	**8.59**

*Higher values indicate more frequent word use

Therefore, following the pre-testing process, the three emotional Stroop tasks that were designed for the study included words categorized as positive weight loss stimuli, negative weight loss stimuli, and neutral stimuli.

As mentioned previously, the mechanism of the Stroop task depends on word recognition. Because of this, the lexical characteristics (e.g. word length) of the words used in an emotional Stroop task are crucial to the ability to use response times to examine cognitive interference. If the lexical characteristics of the words in each version of the Stroop tasks are significantly different, then it will be likely that some of the differences in response times between Stroop tasks will be due to those characteristics, rather than differences in interference (R. J. Larsen et al., 2006). For example, word recognition for a word like "carbohydrate" will take longer than for a word like "paper" because of the difference in length, number of syllables, frequency of use, and so on. Based on previous studies and reviews, the two most influential lexical characteristics of words for Stroop tasks appear to be frequency of use in the English language and word length. Larsen et al. (2006) therefore suggest that either words between versions of emotional Strops be matched on length and frequency, or that these characteristics are controlled for in the statistical analysis of response times.

Because this study employed three different emotional Stroop versions, matching the mean word frequency and length exactly between all versions was not feasible. Therefore, using the eLexicon database (Balota et al., 2007) to determine word use frequency, mean length and frequency were matched as closely as possible (see table 8).

Table 8: Selected lexical characteristics of the final emotional Stroop tasks

Stroop Task	Average Word Length (# letters)	Average Word Use (LogFreqHAL*)
Neutral Stimuli	5.5	9.71
Positive Stimuli	6.5	9.74
Negative Stimuli	6.3	8.59

*Higher values indicate more frequent word use

4.3.3.2 Programming the Stroop

Once the words were selected for the Stroop tasks, the tasks were programmed into a computer format using E-Prime 2.0 software (Psychology Software Tools, Pittsburgh, PA). As shown in Figure 2, the Stroop process included several elements. First, a screen with a welcome message was displayed, followed by a screen displaying general instructions for the series of Stroop tasks. Next, the participants were given the opportunity to practice how to respond to the Stroop tasks. At the end of the practice task, the screen displayed the participant's accuracy. If the participant had achieved 80% or greater accuracy, s/he proceeded to the next Stroop task. However, if the participant achieved less than 80% accuracy, the accuracy score was shown and the participant was guided to redo the practice task until 80% was achieved.

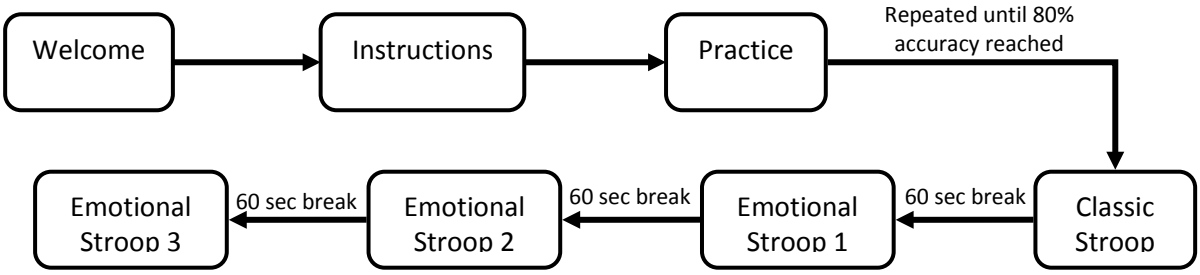

Figure 2: Stroop study visit process

Next, the Classic Stroop task was conducted, including both the congruent and incongruent conditions. Following a 60-second break, the first of the three emotional Stroop tasks was started. The emotional Stroop tasks were presented in random order for each participant, with a 60-second break between tasks. After the third emotional Stroop task, a screen was displayed thanking the individual for participating, and instructing him/her to let the research assistant know the tasks were completed.

The format for each of the Stroop tasks was the same (see Figure 3). First, a screen with the instructions was displayed. Participants were instructed to ignore the content of the words, and to select the color of the word by pressing the corresponding color button on the keyboard as quickly and accurately as possible. Then, as is standard in Stroop tasks, each stimulus was preceded by a black screen with a "fixation cross," that was displayed for 1000ms. Next, the computer displayed the stimuli in capital letters in the center of the screen in either red, blue, green, or yellow against a black background. The use of four color choices has been shown to be the optimal condition for the Stroop task (Cox et al., 2006). The next fixation cross and stimulus were displayed once the participant had entered a response, or after 3000 ms had elapsed (in which case the response was marked as inaccurate).

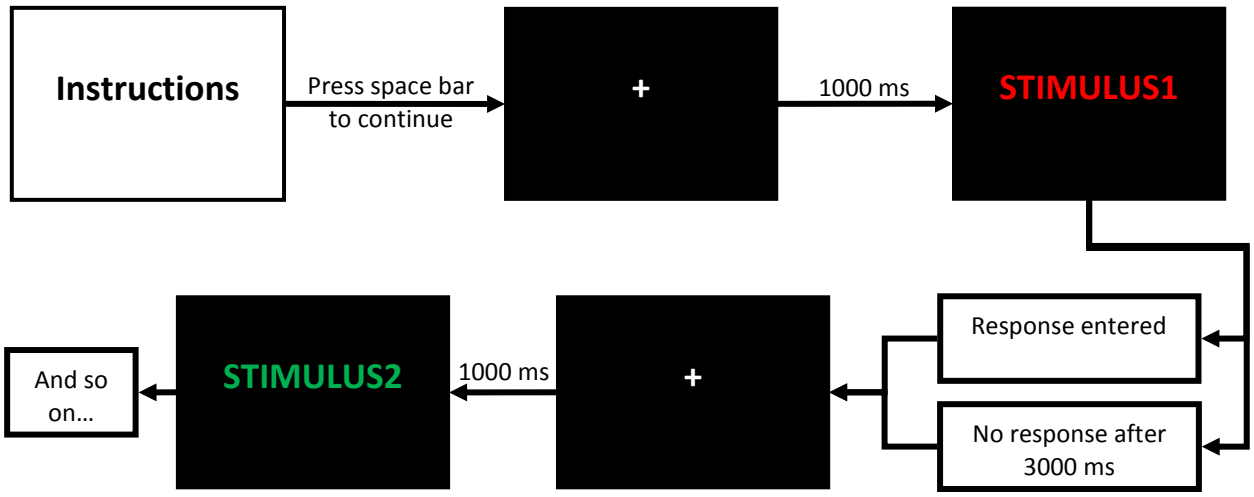

Figure 3: Stroop task flow chart

For the practice task, 12 stimuli (see Table 9) were displayed in the order shown. The classic Stroop consisted of a block of 40 color words in the congruent condition (font color matches the color word), followed a block of 40 color words in the incongruent condition (font color is different from the color word), with the stimuli presented in random order within each block. Each emotional Stroop task consisted of a block of 40 stimuli, with each of the 10 stimuli words displayed in random order in each of the four colors (e.g. OBESE, OBESE, OBESE, OBESE). For all the Stroop tasks, response times (in milliseconds), errors (e.g. wrong color or no response) and correct responses were recorded for each stimulus.

Table 9: Stimuli for the practice Stroop task

XXX	BALL	BLUE
XXX	SHOE	YELLOW
XXX	RED	GREEN
XXX	BLUE	RED

4.3.3.3 Eating Inventory

Prior studies with obese individuals have demonstrated significant differences in food Stroop task response times based on level of eating restraint, which is defined as conscious restriction of food intake to prevent weight gain or promote weight loss. The Eating Inventory (Appendix D), which is also known as the Three-Factor Eating Questionnaire, measures three dimensions: cognitive restraint of eating, disinhibition (loss of control of eating or tendency to overeat), and susceptibility to hunger (Stunkard & Messick, 1985). The Eating Inventory is a 51-item questionnaire that takes approximately 5-10 minutes to complete. All participants were asked to complete this instrument as described in section 4.3.4 below.

4.3.3.4 Hunger

At the beginning of the sub-study visit, self-reported level of hunger was assessed by asking participants two questions. First, how hungry they were at the moment and, second, when was the last time they ate.

4.3.3.5 Data from Parent Study

Additional data collected by the parent study was available to include in data analysis. The parent study administered self-report questionnaires to measure education, socio-economic status, medical history, smoking status, weight loss history, diet (Diet Habit Survey), physical activity (BRFSS physical activity estimate questions), depression (PHQ-8 and MHC from RAND SF-36), stress (Cohen Perceived Stress scale), interpersonal support (ISEL), health-related quality of life (SF-36, WOMAC, EuroQOL), health literacy (Newest Vital Sign) and satisfaction with the structured weight loss program (modified TSUQ). Data on use of the online program was also available, including number of lessons completed, number of days the

participant logged into the program, and number of days enrolled in the program at the time of the most recent login.

4.3.4 Data Collection

At the end of the in-person, 12-mo study visit for the parent study, participants who agreed to participate in the sub-study then reviewed and signed an IRB-approved consent addendum. A research assistant assisted the participants with starting the Stroop tasks, and then provided them with a paper copy of the Eating Inventory to complete. Finally, participants who were able to be scheduled at appropriate times met with the investigator for a brief, audio-recorded interview (described in the qualitative methods section below). The research assistants were trained regarding the data collection procedures, but blinded as to how the groups were determined for data analysis (i.e. engaged vs. unengaged).

For the Stroop tasks, participants were seated at a computer and a study research assistant initiated the computer program. The S, D, K, & L keys on the keyboard were labeled with colored stickers in corresponding colors. The order of the color stickers on the keys was counter-balanced across participants (Chajut, Mama, et al., 2010), and changed and recorded by the research assistant for each participant. As described above, the participants were first given the opportunity to practice identifying colors and familiarize themselves with the computer setup. In order to move on to the experimental tasks, participants had to achieve 80% accuracy for the practice stimuli.

After practicing identifying colors on the computer, the participants completed the four versions of the Stroop task: the classic Stroop and the three modified versions of the emotional Stroop (positive weight loss stimuli, negative weight loss stimuli, neutral stimuli).

4.3.5 Statistical Analyses

4.3.5.1 Sample Size

The sample size was determined based on the primary outcome measure for specific aims 1 and 2: response time on the Stroop tasks. Using the g*power software (Faul, Erdfelder, Lang, & Buchner, 2007), an a priori power analysis was conducted based on the anticipated statistical analyses. In a meta-analysis of Food Stroop studies, Dobson & Dozois (2004) reported that in 6 studies comparing dieters versus non-dieters on a Food Stroop, the average effect size using Cohen's *d* statistic was 0.4 (J. Cohen, 1992). This effect size was used for the power calculation for this study as it is somewhat conservative (typically designated as a small-medium effect) and should have allowed for a sample size that was sufficient for the anticipated analyses. It is notable that in a recent study of weight-loss maintainers versus normal weight and obese individuals, an effect size of 1.96 was demonstrated when looking at response times for a high-calorie food words Stroop, indicating that the anticipated effect size of 0.4 certainly seemed to be conservative. According to the conducted power analysis, a total sample size of 32 (8 in each of four groups) would have been sufficient to detect an effect size of 0.4, given $\alpha = 0.05$ and $\beta = .95$ using a repeated-measures ANOVA with within-between interaction.

4.3.5.2 Statistical Analyses

The primary independent variables for this study were success with weight loss and engagement in the weight loss program (defined in section 4.3.1 above). The primary dependent variables were the response times on the positive and negative Stroop tasks.

Descriptive statistics were run to examine the distribution of the outcomes and covariates of interest for the entire sample, as well as for the engaged vs. unengaged participants and successful vs. unsuccessful participants. Independent-samples t-tests (for continuous variables) and χ^2-tests were used to examine group differences in baseline demographic variables.

Due to the design of the Stroop tasks (described above), each participant had 40 response times for each Stroop task (4 response times for each of the ten stimuli in the task). An average response time was calculated for each individual for each Stroop task by taking the median of the participant's accurate response times, as is often used in the emotional Stroop literature(Phelan et al., 2011). Using the mean response time was considered, but review of the data showed that the median was more appropriate given the skewness of the data. As data becomes skewed, the mean loses its ability to provide the best central location for the data, as the skewed data drags it away from its typical value. However, the median best retains this position and is not as strongly influenced by skewed values.

Analyses of response times on the positive and negative Stroop tasks between groups were conducted using ANCOVAs, with neutral Stroop response time as a covariate, to compensate for individual differences in response times (e.g. effects of mild cognitive impairment, reduced agility, etc.). Age and sex were also entered as covariates in all analyses given their potential influence on weight-related and cognitive processing variables (Phelan et

al., 2011). Similar analyses were conducted for number of correct responses during the positive and negative Stroop tasks.

Due to the sample size, the number of covariates that could be included in the regression models was limited to four. Therefore, additional between-group analyses were run, adjusting for age, sex, and neutral response time, with the addition of one of the following variables: education, depression (as measured by the PHQ-8), self-report level of hunger at the time of the Stroop task, cognitive eating restraint, percent weight loss, weight loss in pounds, number of program lessons completed, and number of days since the last login to the program. Comparisons of response times between subsets of participants based on these variables were also conducted using ANCOVAs, with neutral response time as a covariate.

Analyses of response times on the positive and negative Stroop tasks within groups were conducted using paired-samples t-tests, as well as non-parametric Wilcoxon Signed-Rank tests to account for possible non-normal distribution of data.

In addition, regression analyses were examined with percent weight loss as the independent variable, response time on each of the positive and negative Stroop tasks as the dependent variables, and age, sex, and neutral response times as covariates.

4.4 QUALITATIVE METHODS

Specific Aim 3: To explore the types of interfering thoughts and potential sources of cognitive interference through a qualitative approach.

4.4.1 Description of Data

Brief (10-15 minute), semi-structured qualitative interviews were conducted with participants at the conclusion of their sub-study visit. The interviews were audio-recorded and transcribed verbatim by a trained transcriptionist. The purpose of the interview was to provide an opportunity for participants to explain their cognitive processes in their own words. The format of the interview was semi-structured and follow-up questions were dependent on the initial responses of the participant.

The interview script was refined during the Stroop pre-testing phase of the study. Those participants who completed the Stroop Words Pre-test (as opposed to the computer-based Stroop tasks) were interviewed at the end of their sub-study visits.

These interviews were used to test and refine the interview script. For example, the initial key question/prompt for the interview was: "What thoughts go through your head when you are making a decision about a healthy behavior—such as whether to exercise or to eat a particular food?" However, the early interviews indicated that this question was not precise enough to elicit participant's specific thoughts in response to lifestyle change. In the final version of the script, participants were first asked what their challenges were with lifestyle change. Then they were asked: "In that situation [refer to challenging situation], when you are trying to make the decision between the healthier [specify healthier choice if described by participant] and less healthy [specify healthier choice if described by participant] choice, what thoughts go through your head? Follow-up questions included "What kinds of thoughts help you make the healthy decision?" and "What kinds of thoughts make it difficult to make the healthy decision?" The final version of the interview script (Appendix E) was used with all the Stroop-tested participants who participated in the interview.

4.4.2 Data Analysis

Two trained qualitative coders, including the principal investigator, conducted a careful reading of several of the interview transcripts to identify initial emerging themes related to cognitive interference. Sarason's Thought Occurrence Questionnaire (Appendix F)—which is designed to identify presence of interfering thoughts—was initially used for guidance in identifying phrases that might indicate cognitive interference (Sarason, Sarason, Keefe, Hayes, & Shearin, 1986). A grounded theory approach and an iterative process were ultimately used to develop the codebook.

The coders selected 2-3 transcripts and independently reviewed them to identify themes or use of language that seemed related to cognitive interference. They then met to discuss and explore the similar themes that had been identified by both coders. Preliminary "codes" were loosely defined from the themes that were most clearly recognized. The coders then selected another 2-3 transcripts, independently reviewed them for the preliminary codes as well as any other emerging themes, and then discussed the results of this review. This iterative process continued until the coders felt that the key themes from the documents had been captured, and that the definitions of the codes were sufficiently detailed so that the coders could reliably and independently identify the themes in the remaining documents, which occurred after review of approximately half of the interview transcripts. Once the primary codebook was developed, all the documents were independently coded (or re-coded) by both coders. During final review of the transcripts, the coders used a consensus process to determine the codes for the "master" version of the transcripts. The transcripts and master codes were then entered into Atlas ti 5.0 Scientific software.

Identified themes were explored for presence across participants and relevance to the overarching cognitive interference concept. Descriptive statistics were run to examine the distribution of the outcomes and covariates of interest for the interviewed vs. not interviewed participants. Independent-samples t-tests (for continuous variables) and χ^2-tests (for dichotomous variables) were used to examine group differences.

Number and percentage of interviews that included each code were reviewed and compared among engaged & unengaged and successful & unsuccessful groups using χ^2-tests, whereas the mean numbers of each code per interview were compared using ANOVAs.

5.0 RESULTS

5.1 EXPERIMENTAL RESULTS

5.1.1 Description of Sample

Subject characteristics are displayed in Table 10. In total, 41 participants completed the Stroop sub-study. However, one participant was withdrawn from the sample before analysis due to recent diagnosis of a brain tumor and inability to complete the Stroop task correctly with the provided directions. Of the remaining 40 participants, 25 were categorized as "engaged" and 16 were categorized as "successful," based on the criteria described in section 4.3.1 above. Reflective of the parent study, 80% of the sub-sample were female, 78% were white, and the mean age was 52.0 years old. The sub-sample was well-educated with 85% with greater than high school education, and 13% with limited health literacy. Thirty-three percent of participants reported at least some difficulty paying for basics.

Statistically significant group differences were found, as anticipated, between the percentage of engaged (56%) versus unengaged (13%) participants who were successful; and between the percentage of successful (88%) versus unsuccessful (46%) participants who were engaged. By definition, successful participants lost significantly more weight in both pounds (-26.6 ± 13.2 lbs) and percent of body weight (-12.1 ± 6.4%) than unsuccessful participants (0.2 ±

6.2 lbs; 0.1 ± 3.1%). In addition, engaged participants lost more weight in pounds (-14.1 ± 18.8 lbs) than unengaged participants (-4.5 ± 9.3 lbs), which is expected given the higher percentage of successful participants in the engaged group. Also as anticipated, based on the Eating Inventory measure, engaged (12.6 ± 4.8) and successful (14.5 ± 3.5) participants had higher levels of cognitive eating restraint (dieting) than their unsuccessful (12.6 ± 3.0) and unengaged (8.2 ± 3.9) counterparts.

Table 10: Demographic and weight characteristics of Stroop participants

	ALL N = 40	Engaged N = 25	Unengaged N = 15	Successful N = 16	Unsuccessful N = 24
Age in years [Mean (SD)]	52.0 (10.9)	50.9 (10.8)	53.9 (11.19)	51.6 (11.0)	52.3 (11.1)
% Female	80	84	73	88	75
% White	78	80	73	88	71
% Difficulty paying for basics	33	32	33	25	38
% Above high school education	85	84	87	88	83
% Limited health literacy[1]	13	16	7	19	8
% Depression[2]	15	8	27	6	21
% Successful	40	**56**	**13~**	--	--
% Engaged	63	--	---	**88**	**46~**
% High hunger at time of task[3]	54	50	60	50	57
Baseline BMI [Mean (SD)]	37.1 (5.5)	36.9 (5.8)	37.4 (5.0)	37.7 (6.9)	36.7 (4.4)
1-year BMI [Mean (SD)]	35.3 (6.0)	34.6 (6.2)	36.7 (5.6)	33.3 (7.4)	36.7 (4.6)
1-year weight change (lbs)	-10.5 (16.5)	**-14.1 (18.8)**	**-4.5 (9.3)^**	**-26.6 (13.2)**	**0.2 (6.9)***
1-year weight change (%)	-4.8 (7.6)	-6.3 (8.6)	-2.2 (4.7)	**-12.1 (6.4)**	**0.1 (3.1)***
Eating Inventory					
Restraint	11.2 (4.5)	**12.6 (4.8)**	**8.2 (3.0)***	**14.5 (3.5)**	**8.7 (3.9)***
Disinhibition	9.1 (3.5)	9.0 (3.4)	8.9 (3.2)	7.7 (3.3)	9.8 (3.4)
Hunger	4.8 (3.3)	4.8 (3.4)	4.9 (3.3)	4.8 (3.3)	4.9 (3.3)
Classic Stroop RT (Incongruent)	765.1 (107.9)	772.3 (119.2)	753.2 (88.3)	775.8 (124.3)	758.1 (97.6)

[1]Measured by Newest Vital Sign; [2]as determined by mental health component of RAND SF-36; [3]per self report
* p <.001, ~ p <.01, ^ p <.05

No statistically significant group differences were found for age, sex, race, socioeconomic status, education, smoking, marital status, health literacy, depression, or level of hunger at the time of the Stroop study visit, nor for the other two components of the Eating

Inventory (disinhibition & hunger). There were no significant differences between groups in response time on the incongruent classic Stroop task, which was conducted to assess overall ability for Stroop tasks, nor between the four Stroop task key conditions (placement of color stickers on different keyboard keys).

5.1.2 Differences in Stroop Performance

Differences in response times on the positive and negative Stroop tasks between sub-groups were assessed with independent-samples t-tests, with results shown in Table 11. After adjusting for neutral response times, no statistically significant differences in Stoop response times were observed between any of the sub-groups examined.

Table 11: Stroop response times by sub-groups (Estimated marginal means*)

			Positive Stroop		Negative Stroop	
Variable	Category	N	Median Reaction Time [Mean(SE)]	p	Median Reaction Time [Mean(SE)]	p
Age	< 50	15	724.2 (16.5)	.389	740.6 (15.4)	.328
	50 +	25	743.5 (12.2)		761.1 (11.5)	
Sex	Female	32	741.0 (10.1)	.311	759.4 (9.4)	.168
	Male	8	717.3 (20.5)		729.4 (19.0)	
Education	Above HS	34	734.1 (9.9)	.588	747.5 (9.0)	.099
	HS or less	6	748.2 (23.7)		787.1 (21.5)	
Ability to pay for basics	Not Hard	27	727.1 (11.0)	.159	750.7 (10.5)	.659
	Hard	13	755.4 (16.0)		759.1 (15.4)	
Race	White	31	730.1 (10.3)	.458	755.4 (9.8)	.876
	Black	8	757.9 (20.2)		744.8 (19.3)	
	Other	1	753.9 (57.3)		762.5 (54.7)	
Depression (MHC of RAND SF-36)	No	34	731.6 (9.7)	.224	751.9 (9.3)	.665
	Yes	6	762.6 (23.1)		762.3 (22.0)	
Self-report hunger at time of Stroop tasks	High	21	730.0 (12.6)	.436	755.6 (12.0)	.761
	Low	18	744.7 (13.7)		750.2 (12.9)	
Health literacy (Newest Vital Sign)	Adequate	35	737.3 (9.7)	.767	748.6 (8.9)	.138
	Limited	5	729.0 (25.9)		786.9 (23.6)	

*Covariate: Neutral response time

In addition, as displayed in table 12, no statistically significant differences in number of valid responses (out of 40 possible correct responses) on Stroop tasks were found between groups.

Table 12: Number of valid responses (out of 40) on Stroop tasks

Stroop Type	Engaged N = 25	Unengaged N = 15	Sig	Successful N = 16	Unsuccessful N = 24	Sig
Positive Stimuli [Mean(SD)]	39.5 (0.7)	39.4 (0.6)	.60	39.7 (0.6)	39.3 (0.7)	.11
Negative Stimuli [Mean(SD)]	39.4 (0.9)	39.7 (0.6)	.20	39.6 (0.5)	38.5 (0.9)	.47
Neutral Stimuli [Mean(SD)]	39.1 (1.5)	39.5 (0.5)	.27	39.1 (1.9)	39.4 (0.8)	.44

Response times for the Stroop tasks between engaged and unengaged participants are shown in Table 13 and displayed in Figure 4. After adjusting for neutral response time, sex, and age, negative Stroop response times were slower in engaged *vs.* unengaged participants, $F(1,35) = 4.115$, $p = 0.05$, partial $\eta^2 = 0.105$, whereas positive Stroop response times were slower in unengaged participants, $F(1,35) = 0.589$, $p = 0.45$, partial $\eta^2 = 0.017$. These results indicate that negative stimuli interfered more with processing for engaged participants, while positive stimuli interfered more with processing for unengaged participants.

Table 13: Stroop response times by engagement (Estimated marginal means*)

Stroop Type	**Engaged** N = 25 Mean (SE)	**Unengaged** N = 15 Mean (SE)	*p*-value
Positive Stimuli Median Response Time (nsec)	730.9 (11.3)	745.2 (14.7)	.448
Negative Stimuli Median Response Time (nsec)	766.0 (10.3)	732.41 (13.0)	.050

*Covariates: Neutral response time, age, sex

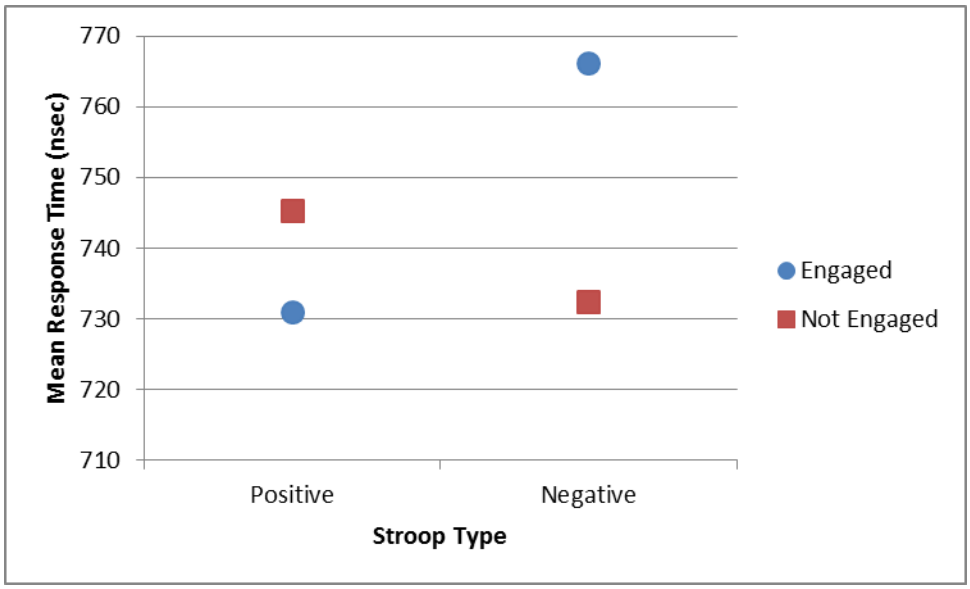

Figure 4: Stroop response times by Stroop type and engagement

Response times for the Stroop tasks between successful and unsuccessful participants are shown in Table 14 and displayed in Figure 5. After adjusting for neutral response time, sex, and age, positive Stroop response times were slower (more cognitive interference) in unsuccessful *vs.* successful participants, $F(1,35) = 3.818$, $p = 0.06$, partial $\eta^2 = 0.098$, whereas negative Stroop response times were slower in successful participants, $F(1,35) = 0.487$, $p = 0.49$, partial $\eta^2 = 0.014$.

Table 14: Stroop response times by success (Estimated marginal means*)

Stroop Type	**Successful** N = 16 Mean (SE)	**Unsuccessful** N = 24 Mean (SE)	*p*-value
Positive Stimuli Median Response Time (nsec)	715.7 (13.5)	750.0 (11.0)	.059
Negative Stimuli Median Response Time (nsec)	760.6 (13.1)	748.7 (10.7)	.490

*Covariates: Neutral response time, age, sex

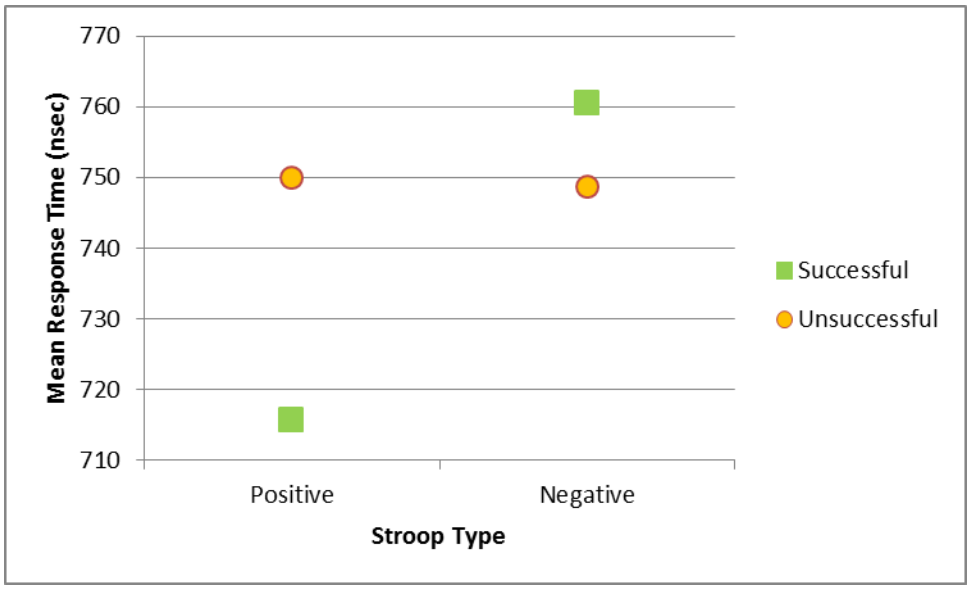

Figure 5: Stroop response times by Stroop type and success

Additional between-group analyses were run, adjusting for age, sex, and neutral response time, with the addition of one of the following variables: education, depression (as measured by the PHQ-8), self-report level of hunger at the time of the Stroop task, cognitive eating restraint, percent weight loss (for engaged comparison), weight loss in pounds (for engaged comparison), number of program lessons completed (for successful comparison), and number of days since the last login to the program (for successful comparison). However, none of the variables significantly impacted the results when added to the model.

Paired t-test analyses were run to compare response times between the positive and negative Stroop tasks within groups. Both successful and engaged participants responded significantly more quickly to the positive stimuli than the negative, as shown in table 15. No significant differences were found between positive and negative Stroop response times for unsuccessful or unengaged participants, or for the sub-sample overall. Non-parametric tests yielded the same results.

Although the study design included weight loss as a dichotomous variable, additional analyses were conducted examining it as an ordinal and continuous variable as well (see Appendix G for additional details).

Table 15: Stroop response times by Stroop type

	Positive Stroop Response Time Mean (SD)	**Negative Stroop Response Time** Mean (SD)	*p*-value
ALL Participants (N=40)	736.3 (107.6)	753.4 (106.4)	.111
Successful (N=16)	716.6 (98.1)	761.3 (112.6)	.011
Unsuccessful (N=24)	749.4 (113.7)	748.2 (104.3)	.927
Engaged (N=25)	725.1 (96.7)	759.9 (111.7)	.018
Unengaged (N=15)	754.9 (125.2)	742.6 (99.8)	.392

5.2 QUALITATIVE RESULTS

5.2.1 Description of Sample

Interviews were conducted with 26 of the 40 participants that completed the Stroop task. However, only 23 of these interviews are included in this analysis due to audio recording failures for the other 3 interviews. Characteristics of the 23 interviewed participants are displayed in Table 16. No statistically significant differences in demographics or weight characteristics were found between those who were interviewed and those who weren't.

Table 16: Demographic and weight characteristics of interview participants

	ALL (N=40)	Interviewed (N=23)	Not Interviewed (N=17)
Age [Mean (SD)]	52.0 (10.9)	53.22 (11.57)	50.41 (9.99)
% Female	80	78	82
% White	78	78	77
% Difficulty paying for basics	33	39	24
% Above high school education	85	83	88
% Limited health literacy	13	13	12
% Concerning MHC (depression)	15	17	12
% Successful	40	30	53
% Engaged	63	57	71
% High hunger at time of task	54	65	38
Baseline BMI [Mean (SD)]	37.1 (5.5)	37.7 (5.4)	36.3 (5.6)
1-year BMI [Mean (SD)]	35.3 (6.0)	36.2 (5.8)	34.2 (6.4)
1-year weight change (lbs) [Mean (SD)]	-10.5 (16.5)	-9.4 (16.2)	-12.1 (17.1)
1-year weight change (%)[Mean (SD)]	-4.8 (7.6)	-4.0 (6.8)	-5.9 (8.6)
Eating Inventory			
Restraint [Mean (SD)]	11.2 (4.5)	10.3 (5.1)	11.9 (4.1)
Disinhibition [Mean (SD)]	9.1 (3.5)	9.6 (3.4)	8.2 (3.5)
Hunger [Mean (SD)]	4.8 (3.3)	5.4 (3.9)	4.2 (2.2)
Classic Stroop RT (Incongruent) [Mean (SD)]	765.1 (107.9)	782.2 (98.8)	742.1 (118.1)

5.2.2 Qualitative Coding

The qualitative coding process described in section 4.2.2 above generated themes in three general areas: types of interfering thoughts; external factors in lifestyle decision-making; and level of conscious thought about lifestyle change (see Appendix H for final codebook). An overview of the qualitative coding is displayed in table 17.

Table 17: Summary of qualitative coding (N=23)

	Interviews Containing Code N (%)	Instances of Code per Interview Mean (SD)
Types of Interfering Thoughts		
Motivating Thoughts	19 (83)	2.4 (2.1)
Positive Motivating Thoughts	14 (61)	0.9 (1.2)
Negative Motivating Thoughts	11 (48)	0.7 (1.1)
Discouraging Thoughts	16 (70)	2.4 (2.3)
Positive Discouraging Thoughts	10 (44)	0.7 (0.9)
Negative Discouraging Thoughts	12 (52)	1.2 (1.4)
External Factors in Lifestyle Decision-Making		
General External Factors	23 (100)	3.5 (2.2)
Positive General External Factors	18 (78)	1.9 (1.6)
Negative General External Factors	21 (91)	1.7 (1.1)
Social External Factors	22 (96)	3.3 (1.9)
Positive Social External Factors	17 (74)	1.6 (1.3)
Negative Social External Factors	19 (83)	1.7 (1.3)
Level of Conscious Thought		
High Conscious Thought	13 (57)	1.4 (1.7)
Positive High Conscious Thought	13 (57)	1.3 (1.5)
Negative High Conscious Thought	3 (13)	0.1 (0.3)
No Conscious Thought	16 (70)	1.6 (1.4)
NCT for Healthy Decisions	7 (30)	0.5 (1.1)
NCT for Unhealthy Decisions	14 (61)	1.1 (1.0)
Change in Conscious Thought	22 (96)	2.4 (1.9)

5.2.2.1 Types of Interfering Thoughts

Codes related to types of interfering thoughts emerged primarily in the responses to the follow-up questions that were asked after participants identified their specific challenges with lifestyle change. For example, if a participant identified high-fat restaurant foods as a particular challenge, she would be asked: "When you are in a restaurant and trying to make the decision between the higher-fat and lower-fat choice, what thoughts go through your head?" Follow-up questions included "What kinds of thoughts help you make the healthy decision?" and "What kinds of thoughts make it difficult to make the healthy decision?"

Thoughts that participants identified as helping them make the healthier decision were coded as *motivating thoughts*, whereas thoughts that made it difficult to make the healthy

decision were coded as *discouraging thoughts*. In addition, the coders identified that these thoughts were most often framed in either a *positive* or *negative* way. Therefore, participant responses could be coded as *positive motivating thoughts* (PMTs), *negative motivating thoughts* (NMTs), *positive discouraging thoughts* (PDTs), or *negative discouraging thoughts* (NDTs).

Nineteen (83%) of the participant transcripts included at least one motivating thought, with a mean of 2.43 (SD = 2.13) motivating thoughts per interview. Fourteen (61%) interviews contained at least one PMT, while 11 (48%) contained at least one NMT. PMTs often included statements about how lifestyle change was good for the participants or would make them feel better. For example, one participant stated that what got her to exercise was "just knowing that I need to do it and it will be better for me and I'll feel better, and that's the reward in itself—just doing it." Statements coded as NMTs were often self-directed reprimands or thoughts focused on avoiding the negative consequences of being overweight. For example: "I think [my doctor] scared me...She put me to that point of, you know, this is life or death. This isn't, you know, you can't just eat three donuts on the way home because they're left over and you feel bad that they're going to be wasted."

Sixteen (70%) of the participant transcripts included at least one discouraging thought, with 10 (44%) containing at least one PDT and 12 (52%) containing at least one NDT. PDTs frequently included thoughts about how much easier or more enjoyable the unhealthy behavior was, such as "I can turn down dessert…but [sometimes] I'll eat it anyway 'cause I'll be like, that's my favorite." Statements coded as NDTs often included thoughts about how hard a healthy lifestyle was or the feeling that it was not worth it. One participant stated: "I know one time I wanted ice cream so badly…and I said the heck with it, I'm going to get some ice cream, and I did. It's like, this is the stupidest thing to do." Many NDT statements also included

sentiments such as "I don't feel like doing this," or "why should I even bother at all" in regards to healthier eating and activity behaviors.

5.2.2.2 External Factors in Lifestyle Decision-Making

Following the interview questions about the types of interfering thoughts participants had, they were asked what resources or support would make choosing the healthy option easier. Codes describing *external factors* emerged from responses to these questions, as well as from general statements participants made throughout the interview. External factors that the participants identified as affecting their lifestyle decision-making were coded according to whether they were *general* or *social* factors, as well as whether they were framed in a *positive* or *negative* way.

Overall, all participants identified at least one *external factor*, with a mean of 6.83 (SD=3.11) factors identified per interview. *General external factors*—including things such as access to healthy/unhealthy foods, access to exercise space and equipment, and presence of an externally-imposed structure (i.e. participation in a structured weight loss program)—were identified by all participants, with a mean of 3.52 (SD = 2.15) identified per interview.

Eighteen (78%) of the participants identified at least one *positive general external factor* that would help them make healthier choices. For example, one participant felt it would be helpful to have "closer, more convenient exercise places." She continued to say: "I think that's a big plus. I just heard the office that I used to work in…built a place to exercise and I'm like, darn, I wanna go back there… Or like a place to shower, you know, after exercise might be a good idea." *Negative general external factors* were identified by 21 (91%) of participants and included statements such as "If they didn't put a Dunkin Donuts in the same shopping center [as the gym], that would be good too," or "For whatever reason, I get thrown off, then I'm just eatin'

whatever I wanna eat… Especially at work, you know, you see all the stuff other people be eating or the stuff that we might get in from where I work."

Social external factors—including such influences as family and friends, or accountability to others—were identified by all but one (96%) of the participants, with a mean of 3.30 (SD = 1.92) factors per interview. Seventeen (74%) participants identified *positive social external factors*, such as "a partner or something who would walk with me at a set time," or "somebody who made me go a little bit further than what I want." *Negative social external factors* were identified by 19 (83%) of participants. One participant stated: "My husband's been very stressed. So his way of rewarding himself and to comfort himself has been food. So he kind of like took me down the rabbit hole with him."

5.2.2.3 Level of Conscious Thought

Another emerging theme from the transcripts was the varying level of conscious thought that was being described as part of the lifestyle decision-making process. While some participant statements indicated *high conscious thought* about lifestyle choices, others indicated little or *no conscious thought.* Many participants also identified things that led to a *change in conscious thought* level (CCT), such as their mood, a craving, or their level of fatigue.

Thirteen (57%) participants made at least one statement that indicated a *high conscious thought* (HCT) level—i.e. frequent or detailed thoughts—about making healthy lifestyle choices, with a mean of 1.43 (SD = 1.67) HCT statements per interview. For example, one participant stated: "It would be ideal if you went out to a restaurant they served only the right portions instead of loading your plate. Although that's not a problem for me anymore. I kind of, in my mind, divide out a portion and then I just keep the rest on the plate and take it home with me for

later." Another participant said "I can figure it all in my head now. Like…I can sit there and say, ok, this is how much I've had today, this is what I have left…and I stay within it… So if I've already, say I brought donuts to work and I had a donut and I know exactly how many fat [and] calories are in that donut, and the cookies are there later in the day, I probably won't have a cookie because I already had the donut."

No participants described HCT in regards to making an unhealthy decision. In general, as in the statements above, participants appeared to view this high level of conscious thought as a positive thing that assisted them with lifestyle change. The three (13%) participants who described HCT in a negative way indicated that this high level of conscious thought was burdensome: "I think it's, maybe old things die hard, old habits. I've noticed that along the way. Like I'll aim to do my 1500 calories and my 42 fat grams and I invariably go over and then I have to do this whole refresh my brain and start again tomorrow."

On the other hand, 16 participants made at least one statement that indicated that they had little or *no conscious thought* (NCT) about their lifestyle choices—i.e. a behavior was automatic or they felt compelled to do it—with a mean of 1.61 (SD = 1.44) NCT statements per transcript. Many participants (61%) made NCT statements that indicated that they used no conscious thought when making unhealthy choices, such as: "The night before I can think of what I'm going to [eat] the next day, but when that morning happens, it's all out the window. It's just gone. It's just, yeah, it's not there. I run too much on automatic pilot I think and I just…don't know what it is." In reference to making eating choices, one participant shared, "I don't have the ability prior to [eating the unhealthy food]. After the act I have the remorse and wish I could take it back. But I don't have it prior to actually consuming." Likewise, another participant

stated: “I hate to say this, but there’s no thoughts… You know, you’re upset, you automatically go pick up a bowl of ice cream or something like that.”

Fewer participants (30%) made statements that suggested they were putting no conscious thought into making the healthy choices. For example, “I’m more inclined to be out there [exercising] than not. And it’s amazing, today, like it’s more engrained for me to get up and do something than to sit there.” Another participant stated “To eat healthy, it’s just really keepin’ that mindset… ‘Cause even if I was eatin’ healthy and was to go out, you know, I have learned…things to do, you know, like automatically for takeout things only eat half of everything there, and maybe eatin’ off the more healthier side of the menu… It’s just me puttin’ it into my lifestyle and changin’ my mindset.”

Twenty-two (96%) of the participants made statements that indicated some factor *changed their conscious thought* level, with a mean of 2.43 (SD = 1.88) such statements per interview. One participant identified how her workday went as something that changed her thought level: “Sometimes I can make a healthy choice and go and have healthy things, and then a lotta the times I just don’t… It depends, sometimes I just won’t do it or something will prompt me not to do it. Like if I had a bad at work and I’ll just totally forget about the healthy thing and eat whatever I think makes me feel better.” Another participant explained how the online structured program affected her level of conscious thought: “I learned a lot from [the program]… In fact I was smiling on the way coming this morning because I was thinking about the things that have changed and how I look at food… [I’m] much more conscious about what I’m eating and I never really thought about what I was eating.”

5.2.3 Comparison of Codes between Groups

Number and percentage of interviews that included each code were reviewed and compared between engaged & unengaged and successful & unsuccessful groups. No statistically significant differences were found, as shown in Table 18. However, there was a seemingly substantial (>25%) difference between successful and unsuccessful participants in identification of positive social factors (100 vs. 63%), negative social factors (57 vs. 94%), no conscious thought for healthy decisions (57 vs. 19%) and no conscious thought for unhealthy decisions (43 vs. 69%).

Table 18: Number of interviews containing selected qualitative codes [N(%)]

	Successful N=7	Unsuccessful N=16	Engaged N=13	Unengaged N=10
Types of Interfering Thoughts				
Motivating Thoughts	6 (86)	13 (81)	11 (85)	8 (80)
Positive Motivating Thoughts	4 (57)	10 (63)	7 (54)	7 (70)
Negative Motivating Thoughts	4 (57)	7 (44)	7 (54)	4 (40)
Discouraging Thoughts	5 (71)	11 (69)	10 (77)	6 (60)
Positive Discouraging Thoughts	3 (43)	7 (44)	7 (54)	3 (30)
Negative Discouraging Thoughts	4 (57)	8 (50)	7 (54)	5 (50)
External Factors in Lifestyle Decision-Making				
General External Factors	7 (100)	16 (100)	13 (100)	10 (100)
Positive General External Factors	4 (57)	14 (88)	9 (69)	9 (90)
Negative General External Factors	6 (86)	15 (94)	11 (85)	10 (100)
Social External Factors	7 (100)	15 (94)	13 (100)	9 (90)
Positive Social External Factors	7 (100)	10 (63)	10 (77)	7 (70)
Negative Social External Factors	4 (57)	15 (94)	11 (85)	8 (80)
All External Factors	7 (100)	16 (100)	13 (100)	10 (100)
Positive External Factors	7 (100)	15 (94)	12 (93)	10 (100)
Negative External Factors	7 (100)	16 (100)	13 (100)	10 (100)
Level of Conscious Thought				
High Conscious Thought	5 (71)	8 (50)	7 (54)	6 (60)
Positive High Conscious Thought	5 (71)	8 (50)	7 (54)	6 (60)
Negative High Conscious Thought	2 (29)	1 (6)	2 (15)	1 (10)
No Conscious Thought	5 (71)	11 (69)	10 (77)	6 (60)
NCT for Healthy Decisions	4 (57)	3 (19)	5 (39)	2 (20)
NCT for Unhealthy Decisions	3 (43)	11 (69)	8 (62)	6 (60)
Change in Conscious Thought	7 (100)	15 (94)	13 (100)	9 (90)
Overall				
Positive Thoughts	7 (100)	16 (100)	13 (100)	10 (100)
Negative Thoughts	7 (100)	16 (100)	13 (100)	10 (100)

In addition, the mean numbers of each code per interview were compared between groups. No statistically significant differences were found between groups, as shown in Table 19, except that, on average, successful participants identified a significantly higher number of positive external social factors (2.6 ± 1.0) than unsuccessful participants (1.2 ± 1.3).

Table 19: Mean number of selected codes per interview [Mean(SD)]

	Successful N=7	Unsuccessful N=16	Engaged N=13	Unengaged N=10
Types of Interfering Thoughts				
Motivating Thoughts	3.1 (2.9)	2.1 (1.75)	3.0 (2.6)	1.70 (1.16)
Positive Motivating Thoughts	1.4 (1.9)	0.7 (.873)	1.0 (1.5)	0.80 (0.63)
Negative Motivating Thoughts	0.6 (0.5)	0.8 (1.33)	0.9 (1.4)	0.50 (0.71)
Discouraging Thoughts	2.1 (2.1)	2.5 (2.42)	2.7 (2.6)	2.00 (1.94)
Positive Discouraging Thoughts	0.7 (1.0)	0.7 (0.87)	0.9 (1.0)	0.40 (0.70)
Negative Discouraging Thoughts	1.1 (1.4)	1.2 (1.47)	1.2 (1.5)	1.10 (1.37)
Ext. Factors in Lifestyle Decision-Making				
General External Factors	3.3 (2.8)	3.3 (2.8)	3.1 (2.3)	4.10 (1.91)
Positive General External Factors	1.6 (1.9)	2.0 (1.4)	1.6 (1.6)	2.20 (1.55)
Negative General External Factors	1.7 (1.4)	1.6 (1.0)	1.5 (1.1)	1.90 (0.99)
Social External Factors	3.6 (1.5)	3.2 (2.1)	3.3 (1.9)	3.30 (2.06)
Positive Social External Factors	**2.6 (1.0)***	**1.2 (1.3)**	1.9 (1.5)	1.30 (1.16)
Negative Social External Factors	1.0 (1.2)	2.0 (1.3)	1.6 (1.3)	2.00 (1.63)
All External Factors	6.9 (2.7)	6.8 (3.4)	6.4 (3.2)	7.40 (3.06)
Positive External Factors	4.1 (2.1)	3.2 (2.2)	3.5 (2.3)	3.50 (2.12)
Negative External Factors	2.7 (1.3)	3.6 (1.8)	2.9 (1.2)	3.90 (2.13)
Level of Conscious Thought				
High Conscious Thought	2.3 (2.1)	1.1 (1.4)	1.4 (1.8)	1.50 (1.65)
Positive High Conscious Thought	1.9 (1.8)	1.0 (1.4)	1.2 (1.5)	1.40 (1.65)
Negative High Conscious Thought	0.3 (0.5)	0.06 (0.3)	0.2 (0.4)	0.10 (0.32)
No Conscious Thought	2.0 (1.9)	1.4 (1.2)	1.9 (1.5)	1.30 (1.34)
NCT for Healthy Decisions	1.1 (1.8)	0.3 (0.6)	0.8 (1.4)	0.20 (0.42)
NCT for Unhealthy Decisions	0.9 (1.2)	1.2 (1.0)	1.1 (1.0)	1.10 (1.10)
Change in Conscious Thought	2.7 (2.0)	2.3 (1.9)	2.5 (1.8)	2.40 (2.12)
Overall				
Positive Thoughts	6.3 (2.3)	4.6 (2.9)	5.4 (3.0)	4.70 (2.58)
Negative Thoughts	4.4 (1.9)	5.6 (3.2)	5.1 (3.2)	5.50 (2.64)

6.0 DISCUSSION

This study is the first to examine cognitive inference in response to general weight-loss related stimuli. emotional Stroop tasks comprised of positive weight-loss words, negative weight-loss words, and neutral words were developed to measure cognitive interference. In comparing successful versus unsuccessful weight-loss program participants, the Stroop results indicate that successful participants had faster response times in response to the positive stimuli compared either to their own response times to the negative stimuli or to their unsuccessful counterparts' response times to either the positive or negative stimuli, indicating that successful participants are able to process the positive weight-loss related stimuli more easily. In comparing engaged versus unengaged participants, the Stroop results indicate that engaged participants have slower response times in response to the negative stimuli compared either to their own response times to the positive stimuli or to unengaged participants' response times to either the positive or negative stimuli. In other words, engaged participants are more distracted and have higher cognitive interference in response to negative weight-loss related stimuli.

The results indicate that cognitive interference in response to weight-loss related stimuli may be related to success and engagement in a weight loss program, however the explanation for this relationship is more difficult to determine. Examining the line graphs of the results as shown in Figure 6 below, it appears that "typical" response times for both the positive and negative stimuli are around 740-750 nanoseconds, and that the response times to the positive

stimuli for the successful participants and negative stimuli for the engaged participants are the "anomalous" points (circled in the figure). However, because this is the first study to examine cognitive interference in response to weight-loss related stimuli, it is not possible to determine whether the circled points are the anomalous ones, or whether the "typical" points are. In other words, are the results indicating that successful participants have particularly fast response times for positive stimuli, or that others have particularly slow ones? Additional studies with larger sample sizes and control participants (e.g. normal weight individuals and/or individuals not participating in a weight loss program) would shed light on this question.

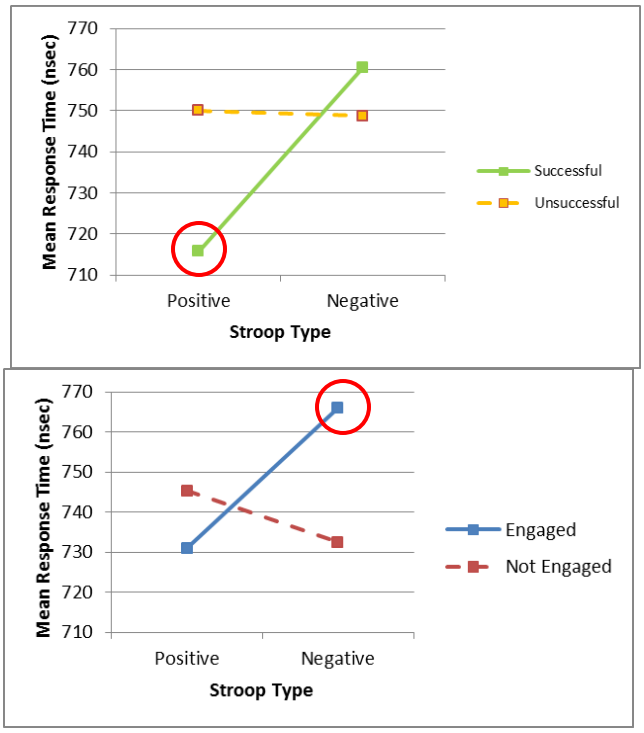

Figure 6: Line graphs of Stroop response times by Stroop type

If the circled points are indeed "anomalous," we could speculate on several possible explanations for why they are. For example, it may be that lower levels of cognitive interference in response to positive weight loss cues make it easier for individuals to embrace the guidelines

that promote healthier lifestyles, and therefore predict success in a weight loss program. However, given the current study design, it is not clear whether the differences in cognitive interference predict such outcomes, or whether success and/or engagement instead lead to a change in levels of cognitive interference in response to weight-loss related stimuli. It may be that as individuals succeed in their weight endeavors, they are less distracted by the stimuli that remind them of the process. To address this question, future studies should include random sampling and a before-after design.

In addition, there are many potential sources of cognitive interference, and some are considered to be specific to an individual's traits, such as tendency towards anxiety or depression, or ability to cope (Yee and Vaughn, 1996). Multiple studies have demonstrated that anxiety can lead to higher levels of cognitive interference, likely due to the focus on intrusive threat-related thoughts that occur frequently in anxious individuals (MacLeod, 1996). Depressed persons also report particular difficulty with cognitive functioning, such as poor concentration, forgetfulness, and intrusive negative thoughts (Gotlib et al. in 1996). Stress may also lead to cognitive interference. Given that individual differences can affect cognitive interference so substantially, it may be that some characteristics that predict weight loss success also predict lower cognitive interference in response to some types of stimuli. However, this study did not find differences in significance after controlling for depression, which indicates the results may supersede some of these individual differences. Measures of anxiety and stress would be useful additions to future studies.

Whatever the explanation of the Stroop results, these results are unique and indicate that there is something of interest on the cognitive level in regards to weight loss that deserves further attention. Determining who has greater interference in response to what type of stimuli may

allow public health practitioners to modify health behavior change interventions to make them less cognitively demanding. For example, if negative weight-loss related stimuli create higher levels of cognitive interference in people who are successfully losing weight and engaging in a weight loss program, then it may be particularly important to avoid usage of those stimuli in interactions with those individuals. Doing so may reduce their level of interfering thoughts and make continued success more probable.

A valuable contribution to understanding how cognitive interference may be affecting success with lifestyle change would be to measure it at the moment that health decisions are being made. Functional MRI (fMRI) technology has great promise for advancing understanding of brain mechanisms underlying cognitive interference, and would be invaluable in future studies. The qualitative findings of this study also suggest some possible cognitive interference mechanisms worthy of further examination. Participants were asked to imagine making healthy eating and physical activity decisions and to describe the thoughts that occurred to them at these times. A variety of types of thoughts with both positive and negative tonality were described—some that motivated the individuals to make healthy decisions and others that discouraged them from doing so. However, overall, it appeared that many of these thoughts were "interfering," and potentially distracted from the logical decision between the healthy and unhealthy choices. For example, one participant who was discussing her thoughts when she was deciding whether to cook healthily or not shared thoughts such as: "why even bother," "I'm no good at cooking," "it's just me [to cook for]," and "I might as well do what makes me happy." Distracting thoughts like these comprise cognitive interference and deplete cognitive resources that are needed to accomplish other tasks.

Yet cognitive interference is only one factor that impacts the level of cognitive—or attentional—resources that are available for people to accomplish tasks such as health behavior change. As mentioned in the review of the literature, individuals possess a fixed amount of attentional resources. Control processing uses most of an individual's attentional resource capacity, while automatic processing tasks require very little attentional capacity. However, it is also important to note that people can have considerable difficulty controlling and modifying their processing for automatic tasks (Schneider et al. 1984). For example, automatic processing is generally used when chewing and swallowing food. However, if an individual were asked to make sure that each bite of food was chewed 25 times, then the process of chewing would switch to a control processing task. The individual would have to focus on the chewing as well as the counting, and would likely be highly susceptible to distractions, which would cause the individual to revert the chewing back to automatic processing. Focusing on and changing automatic processes is actually quite difficult and consumes high levels of attentional resources. Therefore, it would be useful to know what cognitive modifications to automatic processing are involved in health behavior change and how this affects total cognitive resources.

The themes regarding conscious thought that emerged from the qualitative interviews provide insight into this phenomenon. Statements from participants that indicated little or no conscious thought (NCT) put into health behavior choices point to the automatic nature of these decisions. Participants were twice as likely to indicate NCT for unhealthy behaviors than healthy ones, and when NCT was identified for healthy choices, participants generally included a statement about how being able to make healthy choices automatically was a new development. In addition, the majority of participants indicated that during the lifestyle change process, making healthy decisions required a high level of conscious thought (HCT), while *no*

participants indicated that making unhealthy decisions did so. These results point to three suppositions. First, unhealthy behaviors are often automatic. Second, changing unhealthy behaviors to healthy ones can have high cognitive demands. And third, healthy behaviors can be automatized with practice.

Finally, the external factors that participants identified in the interviews point to the importance of the social and built environment in influencing health behavior choices. General external factors—including things such as access to healthy/unhealthy foods, access to exercise space and equipment, and presence of an externally-imposed structure (i.e. participation in a structured weight loss program)—were identified as affecting health behavior choices by all participants. Social external factors—including such influences as family and friends, or accountability to others—were identified by all but one of the participants. Furthermore, all successful participants identified at least one positive social factor, compared to 63% of unsuccessful participants; and successful participants identified significantly more positive social factors per interview. Conversely, almost all unsuccessful participants identified at least one negative social factor, whereas only 57% of successful participants did. This suggests that the social environment is particularly influential in lifestyle decision-making.

Because so many unhealthy eating and inactivity behaviors are automatic, changes in the social and built environment that support healthier decisions would make the health behavior changes less cognitively demanding. The environment plays a key role in cognitive processing, as it contains stimuli that can trigger automatic behaviors. As described above, once a task is automatized, it is more difficult to control or change. Therefore environmental stimuli that trigger automatic behaviors can be key in determining behavioral choices, especially when the automatic behavior is counter to the healthy choice. This underscores the importance of a social-

ecological approach in addressing cognitively-demanding changes in health behaviors. In order to reduce consumption of unhealthy foods, for example, we should decrease the accessibility, visibility, or quantities of foods to which people are exposed. And because human beings appear to be very sensitive to small changes in the food environment, these modifications may not need to be large to be effective (D. Cohen & Farley, 2008).

7.0 CONCLUSION

This study set out to examine the relationship between cognitive factors and engagement and weight loss for obese individuals enrolled in a structured weight loss program, through both an experimental and qualitative approach. In response to specific aims 1 and 2, the experimental findings suggest that cognitive interference in response to weight-loss related cues may be related to success with and engagement in a weight loss program. In response to specific aim 3, the qualitative exploration revealed insights about the types of interfering thoughts that individuals experience, the cognitive factors involved in health behavior change and the aspects of the social and built environment that may influence an individual's ability to implement these changes.

Many studies have been conducted to examine the level of cognitive interference from food and body shape words among individuals with eating disorders, between restrained and unrestrained eaters, and between obese and normal weight individuals. However, levels of cognitive interference among obese individuals engaged in a structured weight loss program or in response to weight-loss related cues (rather than food cues) have not been explored. This study contributes to the literature through the development of weight-loss related Stroop tasks and the implementation of these tasks in a previously unstudied population. The instrument developed for this study could be used in future studies of other populations for further contribution to the literature. In addition, this study is unique due to the use of a weight-related

Stroop task in a sample with a higher mean age than most weight-related Stroop studies, and a higher percentage of men and African-American individuals than almost all similar studies (Dobson & Dozois, 2004; L. Johansson et al., 2005).

Furthermore, no literature has been identified that has explored cognitive factors and weight loss through a qualitative approach, particularly when combined with an experimental design. The qualitative findings in this study substantially enhance our understanding of how cognitive and environmental factors may be affecting the ability of individuals to change their health behaviors successfully, and provide examples of this in the individuals' own words.

The experimental portion of the current study was limited by the small sample size and cross-sectional design. Future studies would benefit from the use of random sampling, normal weight controls, and additional measures of individual characteristics such as stress and anxiety. Additional qualitative studies may include interviews with participants about their immediate reactions following completion of the Stroop task, to further illuminate the reasons for the differences in response times. Moreover, further insights into the cognitive processes involved in health behavior change could be gathered from more in-depth, open-ended qualitative studies. However, this study provides new findings and can serve as a strong base for future studies.

An implication of these findings is that both cognitive limitations and environmental influences should be taken into account when examining the need for health behavior change and designing interventions to address this need. A number of important, and possibly minimal, changes could be made to the built and social environments that would support healthy behavior choices and reduce the high cognitive demands required to change health behavior in a positive way. There is, therefore, a need for additional studies that examine the cognitive influences on health behavior change and their impact on public health practice.

APPENDIX A

EXAMPLES OF WORDS FROM STUDIES USING FOOD AND BODY STROOP INSTRUMENTS

Words Used in the Stroop Task (Shelley Channon & Hayward, 1990)

Food Stroop		Body-size Stroop	
Target	**Control**	**Target**	**Control**
Food	Hall	Large	Far
Dinner	Record	Figure	Morning
Baker	Ocean	Heavy	Easy
Sugar	Pencil	Weight	Source
Meal	Lane	Shape	Rose
Butter	Powder	Fat	Harbour
Cream	Clock	Stomach	Sky
Toast	Brass	Massive	Gentle
Picnic	Shower	Waist	Gift
Potato	Piano	Monstrous	Hopeful
Cake	Boot	Hips	Print
Sandwich	Luggage	Bulky	Carefree

Words Used in the Stroop Task (translated from Dutch) (Overduin et al., 1995)

Target Words		Neutral Words	
Eating	**Shape**	**Office**	**Life-style**
Bun	Balance	Desk	Ambition
Cake	Belly	Envelope	Appointment
Candy	Bikinis	Felt-pen	Bonus
Chips	Cheeks	File	Career
Chocolate	Fat	Paper	Dedication
Ice cream	Hips	Pen	Manager
Licquorice	Legs	Pencil	Promotion
Pie	Slim	Ruler	Study

Pudding	Thighs	Scissors	Success
Tart	Thin	Tape	Working

Neutral Words		**High-Calorie Words**		**Low-Calorie Words**	
valley	flower	sausage	donut	radish	spinach
building	tree	bacon	pie	apple	fruit
stone	mountain	cake	hotdog	corn	melon
sweater	waterfall	brownie	caramel	berries	celery
telephone	carpet	cheeseburger	Ice cream	vegetables	peppers
picture	clock	candy	cheese	carrot	rice
door	paper	chips	milkshake	peas	yogurt
table	magazine	cheesecake	pepperoni	grapefruit	cucumber
envelope	basket	chocolate	French fries	banana	cherries
pencil	chair	cookie	steak	lettuce	pear
lamp	ceiling	fudge	pizza	squash	mushroom
window	notebook	cupcake	nachos	salad	oatmeal
calendar		hamburger		broccoli	

APPENDIX B

PHONE SCRIPT FOR RECRUITMENT

Note: Script was typically used over the phone after the participant had agreed to participate in the regular 12-month visit for the parent study.

Thank you for scheduling your 12-month visit! I wanted to make you aware of an additional opportunity to help us with some research about weight loss and the cognitive process—in other words, to examine the way your thoughts affect your weight loss efforts. As part of the OCELOT study, we are doing a brief experiment to study this topic. If you are interested in participating in this additional research effort, it would add about 45-60 minutes onto your study visit, and would consist of filling out an additional survey on paper, and completing a series of simple cognitive tests on the computer. We would also ask you to answer a few open-ended questions, and we would audio-record your responses to those questions. If you participate in this additional part of the study visit, you would be compensated an additional $20.00. Are you interested in participating?

If no: That's fine. We will look forward to seeing you at your regular study visit on [date].

If yes: Great! So after your regular study visit, you will meet with Tina, who is our project coordinator, and she will review a short consent form addendum with you. It should then take about 45-60 minutes to complete the additional tests and interview. If you have any questions about this additional research, you can contact Tina at 412-692-4852.

APPENDIX C

STROOP WORDS PRE-TEST

Participant ID: _____

Section 1

Given the scale below, please indicate how positive or negative you feel each of the following words is:

	Very Positive			Neutral		Very Negative
1. Activity	1	2	3	4	5	6	7
2. Calories	1	2	3	4	5	6	7
3. Desk	1	2	3	4	5	6	7
4. Chatting	1	2	3	4	5	6	7
5. Chair	1	2	3	4	5	6	7
6. Diet	1	2	3	4	5	6	7
7. Cup	1	2	3	4	5	6	7
8. Exercise	1	2	3	4	5	6	7
9. Computer	1	2	3	4	5	6	7
10. Eating	1	2	3	4	5	6	7
11. Fat	1	2	3	4	5	6	7
12. Fatigue	1	2	3	4	5	6	7
13. Binder	1	2	3	4	5	6	7
14. Goal	1	2	3	4	5	6	7

	Very Positive			Neutral		Very Negative
15. Food	1	2	3	4	5	6	7
16. Envelope	1	2	3	4	5	6	7
17. Gym	1	2	3	4	5	6	7
18. Ink	1	2	3	4	5	6	7
19. Lifestyle	1	2	3	4	5	6	7
20. Keyboard	1	2	3	4	5	6	7
21. Fruit	1	2	3	4	5	6	7
22. Intensity	1	2	3	4	5	6	7
23. Lamp	1	2	3	4	5	6	7
24. Lose	1	2	3	4	5	6	7
25. Gram	1	2	3	4	5	6	7
26. Minute	1	2	3	4	5	6	7
27. Letter	1	2	3	4	5	6	7
28. Hungry	1	2	3	4	5	6	7
29. Moderate	1	2	3	4	5	6	7

	Very Positive			Neutral		Very Negative
30. Marker	1	2	3	4	5	6	7
31. Obese	1	2	3	4	5	6	7
32. Monitor	1	2	3	4	5	6	7
33. Label	1	2	3	4	5	6	7
34. Physical	1	2	3	4	5	6	7
35. Mouse	1	2	3	4	5	6	7
36. Overweight	1	2	3	4	5	6	7
37. Measure	1	2	3	4	5	6	7
38. Notes	1	2	3	4	5	6	7
39. Steps	1	2	3	4	5	6	7
40. Paper	1	2	3	4	5	6	7
41. Pound	1	2	3	4	5	6	7
42. Ounce	1	2	3	4	5	6	7
43. Pen	1	2	3	4	5	6	7
44. Strength	1	2	3	4	5	6	7

	Very Positive			Neutral		Very Negative
45. Pencil	1	2	3	4	5	6	7
46. Scale	1	2	3	4	5	6	7
47. Pen	1	2	3	4	5	6	7
48. Portion	1	2	3	4	5	6	7
49. Stretch	1	2	3	4	5	6	7
50. Print	1	2	3	4	5	6	7
51. Tracking	1	2	3	4	5	6	7
52. Shredder	1	2	3	4	5	6	7
53. Serving	1	2	3	4	5	6	7
54. Stamp	1	2	3	4	5	6	7
55. Sweat	1	2	3	4	5	6	7
56. Unhealthy	1	2	3	4	5	6	7
57. Staple	1	2	3	4	5	6	7
58. Teaspoon	1	2	3	4	5	6	7
59. Tired	1	2	3	4	5	6	7

	Very Positive			Neutral		Very Negative
60. Tape	1	2	3	4	5	6	7
61. Weight	1	2	3	4	5	6	7
62. Stapler	1	2	3	4	5	6	7
63. Vegetables	1	2	3	4	5	6	7
64. Printer	1	2	3	4	5	6	7
65. Walking	1	2	3	4	5	6	7
66. Active	1	2	3	4	5	6	7

5

2. How strongly do you agree that each of the following words belong to the category **"weight loss"?**

	Strongly Agree					Strongly Disagree
1. Activity	1	2	3	4	5	6
2. Calories	1	2	3	4	5	6
3. Diet	1	2	3	4	5	6
4. Cup	1	2	3	4	5	6
5. Chafe	1	2	3	4	5	6
6. Eating	1	2	3	4	5	6
7. Exercise	1	2	3	4	5	6
8. Fatigue	1	2	3	4	5	6
9. Fat	1	2	3	4	5	6
10. Food	1	2	3	4	5	6
11. Gym	1	2	3	4	5	6
12. Goal	1	2	3	4	5	6
13. Fruit	1	2	3	4	5	6
14. Active	1	2	3	4	5	6
15. Intensity	1	2	3	4	5	6

6

	Strongly Agree					Strongly Disagree
16. Lifestyle	1	2	3	4	5	6
17. Gram	1	2	3	4	5	6
18. Minute	1	2	3	4	5	6
19. Lose	1	2	3	4	5	6
20. Hungry	1	2	3	4	5	6
21. Moderate	1	2	3	4	5	6
22. Obese	1	2	3	4	5	6
23. Label	1	2	3	4	5	6
24. Physical	1	2	3	4	5	6
25. Overweight	1	2	3	4	5	6
26. Measure	1	2	3	4	5	6
27. Steps	1	2	3	4	5	6
28. Pound	1	2	3	4	5	6
29. Ounce	1	2	3	4	5	6
30. Strength	1	2	3	4	5	6
31. Scale	1	2	3	4	5	6
32. Portion	1	2	3	4	5	6

7

	Strongly Agree					Strongly Disagree
33. Stretch	1	2	3	4	5	6
34. Tracking	1	2	3	4	5	6
35. Serving	1	2	3	4	5	6
36. Sweat	1	2	3	4	5	6
37. Unhealthy	1	2	3	4	5	6
38. Teaspoon	1	2	3	4	5	6
39. Tired	1	2	3	4	5	6
40. Weight	1	2	3	4	5	6
41. Vegetables	1	2	3	4	5	6
42. Walking	1	2	3	4	5	6

8

3. How strongly do you agree that each of the following words belong to the category **"dieting"**?

	Strongly Agree					Strongly Disagree
1. Calories	1	2	3	4	5	6
2. Cup	1	2	3	4	5	6
3. Diet	1	2	3	4	5	6
4. Fat	1	2	3	4	5	6
5. Food	1	2	3	4	5	6
6. Fruit	1	2	3	4	5	6
7. Gram	1	2	3	4	5	6
8. Hungry	1	2	3	4	5	6
9. Label	1	2	3	4	5	6
10. Measure	1	2	3	4	5	6
11. Ounce	1	2	3	4	5	6
12. Portion	1	2	3	4	5	6
13. Serving	1	2	3	4	5	6
14. Teaspoon	1	2	3	4	5	6
15. Vegetables	1	2	3	4	5	6

9

4. How strongly do you agree that each of the following words belong to the category **"exercise"**?

	Strongly Agree					Strongly Disagree
1. Active	1	2	3	4	5	6
2. Chafe	1	2	3	4	5	6
3. Exercise	1	2	3	4	5	6
4. Fatigue	1	2	3	4	5	6
5. Gym	1	2	3	4	5	6
6. Intensity	1	2	3	4	5	6
7. Minute	1	2	3	4	5	6
8. Moderate	1	2	3	4	5	6
9. Physical	1	2	3	4	5	6
10. Steps	1	2	3	4	5	6
11. Strength	1	2	3	4	5	6
12. Stretch	1	2	3	4	5	6
13. Sweat	1	2	3	4	5	6
14. Tired	1	2	3	4	5	6
15. Walking	1	2	3	4	5	6

10

5. How strongly do you agree that each of the following words belong to the category **"office"**?

	Strongly Agree					Strongly Disagree
1. Binder	1	2	3	4	5	6
2. Chair	1	2	3	4	5	6
3. Computer	1	2	3	4	5	6
4. Desk	1	2	3	4	5	6
5. Envelope	1	2	3	4	5	6
6. Ink	1	2	3	4	5	6
7. Keyboard	1	2	3	4	5	6
8. Lamp	1	2	3	4	5	6
9. Letter	1	2	3	4	5	6
10. Marker	1	2	3	4	5	6
11. Monitor	1	2	3	4	5	6
12. Mouse	1	2	3	4	5	6
13. Notes	1	2	3	4	5	6
14. Paper	1	2	3	4	5	6
15. Pen	1	2	3	4	5	6

11

	Strongly Agree					Strongly Disagree
16. Pencil	1	2	3	4	5	6
17. Print	1	2	3	4	5	6
18. Printer	1	2	3	4	5	6
19. Shredder	1	2	3	4	5	6
20. Stamp	1	2	3	4	5	6
21. Staple	1	2	3	4	5	6
22. Stapler	1	2	3	4	5	6
23. Tape	1	2	3	4	5	6

12

APPENDIX D

EATING INVENTORY

	Part I	True	False
1.	When I smell a sizzling steak or see a juicy piece of meat, I find it very difficult to keep from eating, even if I have just finished a meal.	T	F
2.	I usually eat too much at social occasions, like parties and picnics.	T	F
3.	I am usually so hungry that I eat more than three times a day.	T	F
4.	When I have eaten my quota of calories, I am usually good about not eating any more.	T	F
5.	Dieting is so hard for me because I just get too hungry.	T	F
6.	I deliberately take small helpings as a means of controlling my weight.	T	F
7.	Sometimes things just taste so good that I keep on eating even when I am no longer hungry.	T	F
8.	Since I am often hungry, I sometimes wish that while I am eating, an expert would tell me that I have had enough or that I can have something more to eat.	T	F
9.	When I feel anxious, I find myself eating.	T	F
10.	Life is too short to worry about dieting.	T	F
11.	Since my weight goes up and down, I have gone on reducing diets more than once.	T	F
12.	I often feel so hungry that I just have to eat something.	T	F
13.	When I am with someone who is overeating, I usually overeat too.	T	F
14.	I have a pretty good idea of the number of calories in common food.	T	F
15.	Sometimes when I start eating, I just can't seem to stop.	T	F
16.	It is not difficult for me to leave something on my plate.	T	F
17.	At certain times of the day, I get hungry because I have gotten used to eating then.	T	F
18.	While on a diet, if I eat food that is not allowed, I consciously eat less for a period of time to make up for it.	T	F
19.	Being with someone who is eating often makes me hungry enough to eat also.	T	F
20.	When I feel blue, I often overeat.	T	F
21.	I enjoy eating too much to spoil it by counting calories or watching my weight.	T	F
22.	When I see a real delicacy, I often get so hungry that I have to eat right away.	T	F
23.	I often stop eating when I am not really full as a conscious means of limiting the amount that I eat.	T	F
24.	I get so hungry that my stomach often seems like a bottomless pit.	T	F
25.	My weight has hardly changed at all in the last ten years.	T	F

26.	I am always hungry so it is hard for me to stop eating before I finish the food on my plate.	T	F
27.	When I feel lonely, I console myself by eating.	T	F
28.	I consciously hold back at meals in order not to gain weight.	T	F
29.	I sometimes get very hungry late in the evening or at night.	T	F
30.	I eat anything I want, any time I want.	T	F
31.	Without even thinking about it, I take a long time to eat.	T	F
32.	I count calories as a conscious means of controlling my weight.	T	F
33.	I do not eat some foods because they make me fat.	T	F
34.	I am always hungry enough to eat at any time.	T	F
35.	I pay a great deal of attention to changes in my figure.	T	F
36.	While on a diet, if I eat a food that is not allowed, I often then splurge and –eat other high calorie foods.	T	F

Part II

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

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

1	2	3	4
rarely	sometimes	usually	always

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

1	2	3	4
not at all	slightly	moderately	very much

39. How often do you feel hungry?

1	2	3	4
only at mealtimes	sometimes between meals	often between meals	almost always

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

1	2	3	4
never	rarely	often	always

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

1	2	3	4
easy	slightly difficult	moderately difficult	very difficult

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

1	2	3	4
not at all	slightly	moderately	extremely

43. How frequently do you avoid ‘stocking up’ on tempting foods?

1	2	3	4
almost never	seldom	usually	almost always

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

1	2	3	4
unlikely	slightly unlikely	moderately likely	very likely

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

1	2	3	4
never	rarely	often	always

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

1	2	3	4
unlikely	slightly unlikely	moderately likely	very likely

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

1	2	3	4
almost never	seldom	at least once a week	almost every day

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

1	2	3	4
unlikely	slightly unlikely	moderately likely	very likely

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

1	2	3	4
never	rarely	sometimes	at least once a week

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

0
Eat whatever you want, whenever you want it

1
Usually eat whatever you want, whenever you want it

2
Often eat whatever you want, whenever you want it

3
Often limit food intake, but often 'give in'

4
Usually limit food intake, rarely 'give in'

5
Constantly limiting food intake, never 'giving in'

51. To what extent does this statement describe your eating behavior? ‘I start dieting in the morning, but because of any number of things that happen during the day, by evening I have given up and eat what I want, promising myself to start dieting again tomorrow.’

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

APPENDIX E

INTERVIEW PROMPTS

1. How has the program been for you?
2. What do you feel are some of your biggest challenges when it comes to weight loss?
3. In that situation [refer to challenging situation], when you are trying to make the decision between the healthier and less healthy choices, what thoughts go through your head?
    a. What kinds of thoughts help you make the healthy decision?
    b. What kinds of thoughts make it difficult to make the healthy decision?
4. Repeat question for any other challenges reported
5. Do you have any challenges when it comes to food/physical activity/social support (if not reported in earlier challenges)?
6. When you are making decisions between healthy and less healthy choices, what kinds of things do you think would help you make the healthier decision more often?
    a. What resources would make these decisions easier?
    b. How could the program help support you in these situations?
7. Did you ever stop using the OCELOT program/strategies, or consider stopping?
    a. If so, what thoughts went through your head when you were deciding whether to continue using the program?
8. Where do you think weight loss and healthy lifestyle come in your priorities?
    a. Do you wish it would be a higher priority?
    b. What other priorities come before it?
9. What could be tweaked in the program so that it was more helpful to you specifically?

APPENDIX F

THOUGHT OCCURRENCE QUESTIONNAIRE

INSTRUCTIONS: This questionnaire concerns the kind of thoughts that go through people's heads when they have to concentrate on something, such as working, reading directions, or reading a book. The following is a list of thoughts, which, in your past experience, you may have had while working on various types of tasks. *Please estimate how often each thought has occurred to you by placing the appropriate letter to the left of each item.*

1 = Never
2 = Once
3 = A few times
4 = Often
5 = Very often

			Mean
__	1.	I think about how poorly I am doing.	2.53
__	2.	I think about what someone will think of me.	2.74
__	3.	I think about how I should be more careful.	2.73
__	4.	I think about how well others can do on what I am tying to do.	2.63
__	5.	I think about how difficult what I am doing is.	2.74
__	6.	I think about my level of ability	3.00
__	7.	I think about the purpose of what I am doing.	3.15
__	8.	I think about how I would feel if I were told how I performed.	2.39
__	9.	I think about how often I get confused.	2.08
__	10.	I think about other activities (for example, assignments, work)	3.05
__	11.	I think about members of my family.	2.48
__	12.	I think about friends.	2.85
__	13.	I think about something that makes me feel guilty.	1.92
__	14.	I think about personal worries.	2.81
__	15.	I think about something that makes me feel tense.	2.19
__	16.	I think about something that makes me feel angry.	1.98
__	17.	I think about something that happened earlier in the day.	2.81
__	18.	I think about something that happened in the recent past (for example, in the last few days).	2.69
__	19.	I think about something that happened in the distant past.	2.14
__	20.	I think about something that might happen in the future.	2.82
__	21.	I think about stopping.	2.42
__	22.	I think about how unhappy I am.	1.84
__	23.	I think about how hard it is.	2.54
__	24.	I think about how I can't stand it anymore.	2.02
__	25.	I think about quitting.	2.01
__	26.	I think about running away.	1.44
__	27.	I think about taking something (e.g., pills, a drink) to make it easier.	1.54
__	28.	I think about going to bed/or to sleep.	2.84

From Sarason, Sarason, Keefe, Hayes, and Shearin (1986, p. 226).

APPENDIX G

ADDITIONAL ANALYSES

ANCOVA analyses were run with weight change percentage as an ordinal variable. There were no significant differences between groups.

Table G-1: Stroop response times by percent weight change (categorized)

Stroop Type	**≤ -10.0%** N = 8 Mean (SE)	**-9.9 to -5.0%** N = 8 Mean (SE)	**-4.9 to 0.0%** N = 15 Mean (SE)	**≥ 0.0%** N = 9 Mean (SE)	*p*-value
Positive Stimuli Median Response Time (nsec)	723.6 (19.6)	707.5 (19.5)	753.2 (14.6)	744.9 (18.5)	.269
Negative Stimuli Median Response Time (nsec)	752.3 (18.9)	768.3 (18.9)	753.8 (14.2)	740.6 (18.0)	.767

* Covariates: Neutral response time, age, sex

A within-subjects ANOVA was run with weight change percentage as an ordinal variable. Individuals who lost between 5-9.9% of their body weight had significantly faster response times on the positive Stroop than the negative Stroop. No other significant differences were found.

Table G-2: Stroop responses by Stroop type

	Positive Stroop Response Time Mean (SD)	**Negative Stroop Response Time** Mean (SD)	*p*-value
ALL Participants (N=40)	736.3 (107.6)	753.4 (106.4)	.242
≤ -10.0% (N=8)	714.1 (79.9)	742.8 (80.1)	.263
-9.9 to -5.0% (N=8)	719.1 (119.2)	779.7 (141.3)	.019
-4.9 to 0.0% (N=15)	760.6 (106.8)	761.4 (109.4)	.965
≥ 0.0% (N=9)	730.7 (128.7)	726.2 (97.3)	.855

Weight change percentage was plotted against response times on the positive and negative Stroops. Positive Stroop response time was not correlated with percent weight change, $r(37) = .199$, $p = 0.244$. Negative Stroop response time was not correlated with percent weight change, $r(35) = .217$, $p = 0.196$.

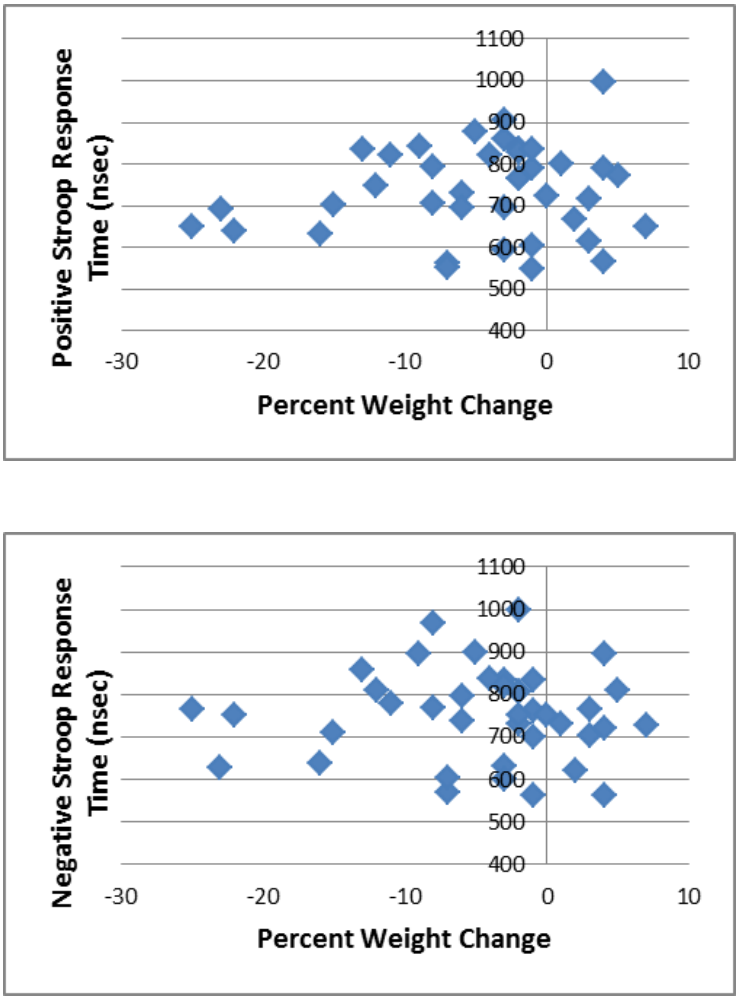

Figure G-1: Stroop response times by Stroop type and percent weight change

APPENDIX H

QUALITATIVE CODEBOOK

CONSCIOUS THOUGHT

NCT (No conscious thought): Any quotes that suggest that the participant does not put conscious thought or effort into making health behavior choices. (e.g. habit; not thinking about something, just doing it; feeling compelled to do something)

HCT (high conscious thought): Any quotes that suggest that the participant puts a high level of conscious thought or effort into making health behavior choices. (e.g. "It is always on my mind…")

CCT (change in conscious thought): Any mention of how the participant's level of conscious thought has changed as a result of some other factor. (e.g. CTC will be used if something obvious caused a change; can pertain to increased awareness, paying attention more, being more conscious about something)

*Other rules for all conscious thought codes:

Multiple conscious thought codes can be applied to one section of text (e.g. "The program really changed how I thought about my eating habits, especially the tracking (CTC). Now I always check the labels to see the ingredients in the foods that I buy at the grocery stores (HCT).")

THOUGHTS OTHER

PMT (motivating thoughts positive): Positive thoughts that motivate the participant to partake in healthy behaviors. (e.g. used only for text that is behavior specific (e.g. going for a run, going to the grocery store, tracking food, etc.) although can be "big picture" when it is relating to one specific behavior)

NMT (motivating thoughts negative): Negative thoughts that motivate the participant to partake in healthy behaviors. (E.g. "I have to eat healthy so I don't get diabetes.")

PDT (discouraging thoughts positive): Positive thoughts that discourage the participant from partaking in healthy behaviors. (E.g. "This tastes good so I'm going to eat it.")

NDT- (discouraging thoughts negative): Negative thoughts that discourage the participant from partaking in healthy behaviors. (E.g. "There is no point in trying to eat better because it's not going to make a difference.")

EXTERNAL INFLUENCES

ES+ (external positive social): Any mention of external social situations that have positive impact on the participant's health behaviors (e.g. family, social support, accountability (e.g. being able to check in with the doctor, weigh-ins, etc.)

ES- (external negative social): Any mention of external social situations that have a negative impact on the participant's health behaviors. (e.g. lack of social support, negative influences)

EG+ (external positive general): Any mention of the way(s) in which the environment in general contributes to positive health behaviors. (e.g. having a gym close to work, going to restaurants that have the calories for each dish listed in the menu, having a goal /structure)

EG- (external negative general): Any mention of the way(s) in which the environment in general contributes to negative health behaviors. (e.g. not having a gym close to home, only having fast food restaurants nearby)

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