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The Effects of a Yogic Breath Meditation Intervention on Attention Control and other Domains of Self-Control

A dissertation submitted in partial satisfaction of the requirements for the degree

Doctor in Philosophy in Psychology

by

Patricia Voege

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ABSTRACT OF THE DISSERTATION

The Effects of a Yogic Breath Meditation Intervention on Attention Control and other Domains of Self-Control

by

Patricia Voege

Doctor of Philosophy in Psychology

University of California, Los Angeles, 2014

Professor Gregory A. Miller, Chair

This study examined the effects of a 4-week yogic breath meditation intervention on physiological (blood glucose and cardiovascular) and psychological measures of self-control, particularly attention control via performance on the Stroop cognitive task. We recruited healthy participants from the University of California, Los Angeles campus. The final sample (N = 67) consisted of graduate (n = 1) and undergraduate (n = 66) students. Participants were randomized to an intervention or control group and assessed before and after the 4-week class series. There were no intervention effects on Stroop task performance, heart rate and blood pressure (all *ps* > .10). Participants in the control group exhibited a sharper decline in blood glucose in response to the Stroop task compared to participants in the intervention group at post-intervention (p = .07). In addition, participants in the control group exhibited lower positive affect levels than participants in the intervention group at post-intervention (p = .04) and a decline in acceptance based coping from pre- to post-intervention (p = .05). However, the difference in positive affect was mainly driven by feelings of pride (p = .06). Participants in the intervention group exhibited higher levels of spiritual coping (p = .01), emotional expression (p = .08) and acting with awareness (p = .03) than participants in the control group at post-intervention. There were no group differences in other domains of self-control such as health behaviors. While the intervention was not associated with an improvement in the primary outcome, attention control, the

results suggest that breath-based meditation might buffer the depleting effects of self-control, as measured by declines in blood glucose levels. Breathing-based meditation might further help to prevent a decline in adaptive coping behaviors and acting with awareness. The study was novel in that, to my knowledge, it was the first meditation intervention study that used different types of breathing techniques as the active intervention ingredient. Studying factors that determine when and how breathing-based meditations affect self-control efforts is an intriguing topic for future research studies.

The dissertation of Patricia Voege is approved.

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2002 – 2004	Long Beach City College (*LBCC*)
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2013 **Voege, P**., Bower, J.E., Stanton, A. L., & Ganz, P. A. *Motivations associated with physical activity in young breast cancer survivors.* Manuscript under review in Psychology, Health, and Medicine.

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2007 Manke, B., **Voege, P.**, & Eriksen, S. *How Children Cope with Type 2 Diabetes: A Study of Resilience.* Poster Presentation at 5th National Health Disparities Conference, Nashville, Tennessee.

2010 **Voege, P**., Bower, J.E., Stanton, A., & Ganz, P.A. *Motivations Associated with Regular Physical Exercise in Premenopausal Breast Cancer Survivors.* Poster presented at the Society for Behavioral Medicine Conference.

2012 **Voege, P**., & Robles, T. *The Effects of Acute Stress on Blood Glucose Metabolism.* Poster accepted for presentation at the 120th Annual Convention of the American Psychological Association, division Health Psychology.

2013 **Voege, P**., & Robles, T. *Acute Stress, Cortisol, and Blood Glucose in Healthy, Non-Fasting Adults.* Poster accepted for presentation at the 27th Annual Convention of the European Health Psychology Association.

Introduction

> *[…] But things that are pleasant and conducive to health or vigour he desires in a moderate way […] For the person who fails to abide by these limitations enjoys such pleasures more than they deserve; the temperate person is not like this, but enjoys them as correct reason prescribes.*
>
> Aristotle, the Nicomachean Ethics (2004, p. 57)

Background

Self-control theory. Self-control theory is based on the premise that people's behavior is reflexive and instinctual and therefore needs to be tightly regulated (Baumeister & Alquist, 2009). Self-control refers to consciously controlling and altering thoughts, emotions, and behaviors (Baumeister & Heatherton, 1996; Muraven, Baumeister, & Tice, 1999). It is often motivated by aligning oneself with societal norms and standards, such as refraining from engaging in any criminal behavior, pursuing an education and career and pursuing one's goals. The terms self-control and self-regulation are frequently used interchangeably (e.g., Gailliot et al., 2007; Baumeister & Alquist, 2009; Muraven, Tice, & Baumeister, 1998). However, the two differ in that self-control refers to any conscious effort to control behavior, thoughts, and emotions while self-regulation is an umbrella term that refers to conscious as well as unconscious efforts to control behavior, thoughts, and emotions. Given that my research will mainly deal with conscious behavior, I will use the term self-control.

The ability to self-control is limited and depletes over time. That means, engaging in a task that requires self-control impairs performance in subsequent acts of self-control (Gailliot et al., 2007). This suggests that self-control relies on a limited resource and there is some research evidence suggesting that blood glucose decreases in response to self-control efforts (Gailliot et al., 2007).

Self-control encompasses many types of behaviors, such as regulating emotions or abstaining from engaging in maladaptive health behaviors, and attention control is one basic form of self-control (Gailliot & Baumeister, 2007). The ability to self-control is not static and interventions have been successful at promoting and strengthening different domains of self-control such as attention (Baumeister, Gailliot, DeWall, & Oaten, 2006). One technique for strengthening self-control is meditation. Indeed, attention control in particular is a form of self-control that is utilized during the early stages of meditation.

Purpose of Dissertation Study

The aim of my dissertation study was to examine the effectiveness of a four-week yogic breath based meditation intervention on attention control in healthy undergraduate students. Participants were randomly assigned to either a weekly meditation class or a control condition. Attention control and other psychosocial and physiological measures pertaining to self-control were assessed before and after the intervention.

The aim of the following literature review is to introduce the reader to the literature on self-control, with a particular focus on studies pertaining to attention control. I will further review the literature on self-control and its relationship to blood glucose. For the second part of the introduction, I will review the literature on meditation practices as they pertain to self-control and how meditation lends itself as a technique for strengthening self-control, particularly attention control.

Theoretical background

Self-control involves *suppressing* an impulse that is largely automatic and deeply embedded in a person's behavioral, cognitive, and emotional pattern and not easily unlearned. Self-control is not equivalent to completing a challenging task such as solving a (simple) math problem, because solving a math problem relies on applying a learned skill and retrieving knowledge that is already deeply-rooted in one's thinking process (of course, the exception would be that one does not like math and does not want to spend the time solving the math problem) (Schmeichel, Baumeister, & Vohs, 2003; Muraven & Slessereva, 2003). In contrast, controlling an impulse, such as wanting to eat a piece of chocolate cake, requires effort and takes up mental and, as will be discussed later, physical energy.

Similarly, self-control is not equivalent to motivation although the two are closely intertwined (Baumeister, Heatherton, & Tice, 1994). For instance, a person can be highly motivated to adhere to a diet but lack the capacity to control the impulse of engaging in unhealthy eating. Likewise, motivation can strengthen self-control such that a person can be highly motivated to exercise which gives them more self-control strength. In a study with healthy undergraduate students, researchers exposed students to cookie plates and gave them the option of eating all cookies, yet emphasizing that not eating them would be most beneficial to the experimenter (Muraven, 2008). Participants' self-control, in the form of squeezing a handgrip, was assessed before and after cookie exposure. Squeezing a handgrip does not heavily depend on physical strength but can result in slight physical discomfort due to having to exert constant pressure. Hence, participants have to suppress and self-control the urge to let go of the handgrip. Students' motivations for not eating the cookies moderated their ability to self-control in that those students who were motivated to refrain from eating the cookies because they saw it as a challenge and even fun, were able to squeeze the handgrip longer after they were exposed to the cookies, compared to participants who did not eat the cookies for reasons such as not wanting to feel guilty. The study is among a few examining the interaction between self-control and motivations and further suggests that while motivation and self-control influence each other, they are distinct processes.

Attention control. Attention control refers to the process of concentrating on a particular stimulus in the internal (i.e., the self) or external environment (e.g., an object in one's environment), while disregarding stimuli that could potentially be interfering (Gray, 1994). Self-control theory postulates that it is a natural tendency for attention to shift to several stimuli in the environment at once (Gailliot & Baumeister, 2007) and overriding this automated reaction requires self-control. This becomes particularly evident during the early stages of meditation where much self-control is required in order to keep the mind focused, e.g. on the breath, and prevent it from becoming attached to other stimuli in the internal, e.g. thoughts, or external, e.g. sounds, environment.

Attention control is also important in the process of self-control itself and necessary in order to (1) detect that self-control efforts have gone astray and (2) stop further decrements in self-control. In the case of dieting for instance, individuals need to attend to their eating behavior in order to monitor whether they are following their diet to begin with.

Benefits of self-control. Good self-control has been associated with a variety of positive mental health outcomes such as more positive and stable relationships, better academic success, and less psychological pathologies (Baumeister & Alquist, 2009). The genesis of good self-control in adulthood can be traced back into childhood. In a seminal study by Mischel, Shoda, and Peake (1988), young children who were able to delay gratification by choosing to eat two marshmallows after waiting for a period of time, instead of eating one marshmallow right away, exhibited higher levels of cognitive and social competencies and more social and academic success in adulthood later on.

The benefits of self-control translate to attention control as well. In an innovative study, researchers used the iPhone for real-time sampling of thoughts and feelings as participants pursued their daily activities (Killingsworth & Gilbert, 2010). Participants whose mind wandered instead of being focused on the task at hand, even an unpleasant task, also reported being less happy (measured by participants' response to the question of how they felt at the moment which ranged from very good to very bad). The researchers suggest that "mind wandering" is the default mode from which most people go about their daily activities and infer that mind wandering compromises one's happiness and, consequently, health. From an Eastern perspective, this is of no surprise given that present moment awareness is a core pillar of happiness[1] (Kabat-Zinn, 1990).

Measuring self-control. There are several ways to measure self-control such as directly observing and recording a behavior or a response that requires self-control (Gailliot & Baumeister, 2007). For instance, a cognitive task that is frequently used as a measure of attention control is the *Stroop*. During this task, participants typically view a computer screen on which a color word is displayed.

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[1] Happiness defined here as a peaceful, non-euphoric, state of mind.

There are congruent and incongruent trials. During congruent trials, the word is displayed in its matching color (e.g., red is displayed in red) and during incongruent trials the word is displayed in a color that differs (e.g., red is displayed in yellow). The assumption is that incongruent trials are more challenging and require more self-control than congruent trials. Participants are asked to name the color that the word is displayed in and researchers typically measure the accuracy (error rate) and/or speed of their response (reaction time) during the incongruent trial. A faster reaction time and lower error rate are indicative of better attention control (e.g., Gailliot & Baumeister, 2007; Gailliot, Baumeister, DeWall, et al., 2007).

Besides the Stroop, there are other types of cognitive tasks to probe and measure attention control such as persistence at unsolvable anagrams (Baumeister, Bratslavsky, Muraven, & Tice, 1998; Gailliot & Baumeister, 2007) or performance on a video task. For the latter one, participants are required to focus their attention on a particular stimulus on the computer screen while disregarding stimuli that are displayed simultaneously on other parts of the screen and in order to keep attention on the target stimulus, participants have to exert self-control (Gailliot et al., 2007). Gailliot and colleagues (2007) used this measure in a series of seminal studies that were designed to examine blood glucose as a possible biological marker of self-control. The studies were prompted by past research which indicated that self-control relies on a limited source of energy (Gailliot & Baumeister, 2007; Muraven & Baumeister, 2000); this line of research lead to the emergence of self-control resource theory (de Ridder & de Wit, 2006).

Self-control relies on a limited energy source. Continuously exerting self-control is draining and impairs further self-control efforts (Baumeister et al., 2006). This process has also been referred to as ego depletion (Baumeister et al., 2006). In one study, for instance, one group of participants was asked to eat radishes instead of freshly basked cookies that were placed right next to radishes, a task that requires high levels self-control for most. The other group of participants was asked to actually eat the cookies. Following cookie exposure, participants were asked to complete unsolvable anagrams and those participants who were asked to resist eating the cookies gave up faster at solving the anagrams, than participants who had been allowed to eat the cookies (Baumeister et al., 1998). In another study (Muraven, Tice, & Baumeister, 1998), participants were asked to suppress thoughts by being instructed to not think of a white bear and work on unsolvable anagrams afterward. Participants who had been asked to suppress their thoughts quit sooner at solving the anagrams and rated the task as more difficult compared to participants who were allowed to think about the white bear.

Self-control efforts can also impair health behaviors. For instance, dieters who had to resist the temptation of eating cookies that had been placed right next to them, engaged in more unhealthy eating behavior afterwards than dieters who had been placed far away from the cookies and, as a result, did not have to control the temptation to eat the cookies as much (Vohs & Heatherton, 2000).

It is important to note that self-control in one domain impairs self-control performance in other domains. For instance, resisting the temptation to eat cookies impairs persistence at unsolvable anagrams (Baumeister & Alquist, 2009; Gailliot & Baumeister, 2007; Baumeister, Gailliot, DeWall, Oaten, 2006). This also applies to attention control in that self-control efforts, such as maintaining a positive self-image (Vohs, Ciarocco, & Baumeister, 2005) or even thinking and writing about a death related topic (Gailliot, Baumeister, & Schmeichel, 2006), can impair attention control (Schmeichel, Vohs, & Baumeister, 2003).

The studies discussed above, further suggest that self-control is fueled by a limited resource and there is research evidence for an actual physiological basis for this limited resource.

Self-control and glucose. The notion that controlling our impulse draws upon a limited resource can be traced back to the Victorian era of psychoanalysis and made a come back in the past two decades when models such as self-control resource theory were formulated (Baumeister & Alquist, 2009). Yet, early research on self-control used the term "limited resource" without any precise operational definition and relied on behavioral outcomes as a proxy for self-control strength since it was not clear where this energy source originated from and whether it had any physiological basis to begin with (Baumeister & Heatherton, 1996); as researchers began to examine biological mechanisms associated with psychological processes, a potential candidate that emerged was blood glucose (Gailliot & Baumeister, 2007). Glucose constitutes the primary fuel for much of the body's actions and can easily be measured in the blood stream. It is vital for executing mental and physical activities and the brain in particular relies heavily on glucose for its energy supply (Gailliot, 2008). Studies in healthy adults show that people who exert self-control, such as completing tasks that require attention control or even suppressing racial stereotypes, exhibit a decrease in blood glucose from before to after the task (Gailliot & Baumeister, 2007).

Attention control and glucose. Attention control in particular has been associated with decreases in blood glucose. For instance, a study exposed participants to either a difficult (100% incongruent) or easy (100% congruent) Stroop and measured blood glucose levels before, during, and after the task. Participants in the difficult Stroop condition had lower blood glucose levels during the actual task than participants in the easy Stroop version (Fairclough & Houston, 2004). Similarly, a study linked blood glucose to actual performance on the Stroop in that participants who experienced an increase in blood glucose prior to the task had faster reaction times (Benton, Owens, & Parker, 1994). In another experiment, study participants were instructed to either stay focused on a stimulus displayed on a computer screen while disregarding other incoming stimuli or to watch the computer screen without any restrain. Blood glucose levels of participants in the *restrained attention* group dropped from pre- to post-task while glucose levels of participants in the *no restrained attention* group remained stable (Gailliot, Baumeister, DeWall, Maner, Plant, Tice, Brewer, & Schmeichel, 2007).

Restoring self-control strength. A way of buffering the negative effects of self-control efforts has been to simply ingest a glucose load (Gailliot & Baumeister, 2007). One study had participants ingest a glucose or placebo drink followed by completing the video task described above. Briefly, half of the participants in each group (*glucose drink/placebo drink*) were instructed to watch a video with *no restrained attention* while the other half was asked to watch the video with *restrained attention*. Following the video, participants completed the Stroop task. Participants in the *restrained attention + placebo drink group* made more mistakes on the Stroop task than participants in the *no restrained attention + placebo drink group*. Interestingly, this group difference did not hold up for participants who had received a glucose drink. That is, participants in the *restrained attention + glucose* *drink* group did not make more mistakes on the Stroop task, than participants in the *no restrained attention* + *glucose drink* group. In line with these findings, a number of other studies have linked ingestion of a glucose load with reduced self-control depletion (e.g., Benton, Owens, & Parker, 1994; Martin & Benton, 1999; Gailliot & Baumeister, 2007). One might postulate that glucose mediates the relationship between self-control exertion and depletion, yet, empirical evidence that would identify glucose as the primary mechanism accounting for self-control depletion is lacking. It is because of this, among other reasons, that self-control resource theory has received a number of criticisms.

Criticism of self-control resource theory. Job, Dweck, and Walton (2010) assert that it is not self-control per se that is depleting, but instead people's expectations about whether or not self-control does indeed deplete their resources. To test this idea, Job and colleagues (2010) conducted a series of elegant experiments. In the first experiment, participants' expectancy beliefs about whether or not mental exertion is depleting were assessed before completing two consecutive self-control tasks. In the second experiment, participants' expectancy beliefs about self-control were manipulated with priming statements in line with a "nonlimited-resource theory" such as, "sometimes, working on a strenuous mental task can make you feel energized […]". In both experiments, participants who believed that they had an unlimited source of energy did not show self-control depletion.

Another factor that might play a role in buffering the negative effects of self-control efforts is the association between glucose and feelings of reward. This was illustrated in a study where trained cyclists were asked to only rinse their mouth with a glucose or placebo solution right before an exercise performance, followed by several neuroimaging tests (Chamber, Bridge, & Jones, 2009). Surprisingly, merely rinsing the mouth with glucose improved performance on the exercise performance test and activated brain reward centers. This was not the case when participants rinsed their mouth with a placebo solution.

Another major criticism of self-control resource theory is simply that not all studies show that self-control efforts are associated with a decline in blood glucose (e.g., Kurzban, 2010; Marcora, Statiano, & Manning, 2009). As such, other biological mechanisms might be at play. For instance, research participants who were exposed to a self-control task (a 10 minute Wisconsin Card Sort Task) did not exhibit a decline in peripheral blood glucose levels or change in blood flow coming in or out of the brain, thereby suggesting that brain metabolism was not affected by self-control efforts (Madsen et al., 1995). Gailliot (2008), however, suggests that self-control primarily relies on brain glycogen, which is *already* stored in the brain, and as such, capturing glucose flow in or out of the brain might not be an accurate way of measuring brain glucose consumption followed by self-control efforts. Notwithstanding, Kurzban (2010) addresses another important point namely that already present endogenous blood glucose levels in the periphery of the body can make it difficult to discern a decline in blood glucose that is *truly due* to self-control efforts, particularly given the small magnitude of change that is typically seen in studies. For instance, the body might still be metabolizing food remains in the digestive tract, thereby blurring effects on blood glucose that are due to self-control.

Despite this criticism, a recent meta-analysis of studies based on self-control resource theory found overall supportive evidence for the depleting effects of self-control, pointing out, however, that self-control is heavily shaped by moderating factors (Hagger and colleagues, 2010). For instance, when participants are exposed to two subsequent tasks that require self-control, ego depletion is stronger when two different experimenters, as opposed to the same experimenter, administer the tasks. Personality factors can also affect self-control. For instance, neuroticism tends to be associated with less, and conscientiousness with higher levels of self-control (e.g., Hooker, Choun, Mejia, Pham, & Metoyer, 2013).

Interventions to promote self-control. Given the association between glucose and self-control, the solution to self-control depletion might seem: just ingest more glucose (Gailliot et al., 2007)! However, considering the current obesity pandemic, relying on food as a means to boost self-control might not be the healthiest option in the long run. Instead, it would be more effective to target psychological processes. Indeed, self-control is a continuous, malleable process that can be strengthened through intervention efforts (Mischel, Shoda, & Peake, 1988; Baumeister, Gailliot, DeWall, & Oaten, 2006).

Automated behavior. Just as Muraven and Baumeister (2000) suggest that initially untrained muscles become tired after exertion, with repeated exercise they gain strength and endurance. Muraven and Baumeister (2000) infer that self-control works in a similar way in that it can be strengthened by simply exercising it, which internalizes the target behavior and makes it automatic.

Interventions based on self-control theory. For instance, participants in one study were asked to practice self-control for two weeks by either improving body posture, regulating mood, or maintaining a food diary without any specific mental processing (Muraven et al., 1999). After two weeks, participants exhibited a significant improvement in physical strength in the form of squeezing a handgrip, which is frequently used to assess self-control, compared to participants who had not practiced self-control. Furthermore, those participants who practiced the self-control exercises more often, as indicated by daily diaries, also showed the most improvement in self-control. Another intervention study had participants practice self-control by undergoing a four-month financial management training (Oaten & Cheng, 2007). Self-control, in the form of performance on a visual tracking task, was assessed at one-month intervals throughout the study and participants in the intervention group performed better at the task than participants who did not practice self-control during the study period. Another study by the same authors (Oaten & Cheng, 2006) assigned college students at the beginning of the semester to either an intervention (cohort 1), consisting of a study program that required students to adhere to study schedules and artificially imposed deadlines, or a waitlist control group (cohort 2). Participants' self-control strength (using the same visual tracking task as was mentioned previously) was assessed at the beginning and the end of the semester. After the semester break, the waitlist control condition (cohort 2) received the intervention as well and just as with cohort 1, their self-control was assessed at the beginning and the end of the subsequent semester. Given this elegant study design, the researchers were able to examine students' natural self-control pattern across a semester without the intervention (cohort 2 only) as well as the intervention's effect on self-control strength (cohort 1 and cohort 2); students in *both* cohorts showed improvements in performance on the visual tracking task, study habits, and other domains of self-control such as smoking less, drinking less coffee, and exercising more frequently *after* they had received the intervention.

Another way of improving self-control is physical exercise, based on the premise that most people who want to engage in exercise have to exert self-control in order to do so, particularly at the beginning stages (Oaten & Cheng, 2006). With this in mind, using the same visual tracking task as mentioned in previous studies, sedentary healthy participants were assigned to either a two-month exercise program or a waitlist control group. As was predicted, participants partaking in the exercise program showed better performance on the visual tracking task from before to after the exercise program and compared to the control group at post-intervention and also engaged in more positive health behaviors after participating in the program.

Potential processes accounting for the positive effects of self-control interventions*.* Despite the positive effects of interventions on self-control as mentioned above, it is unclear what processes account for the improvements. For instance, practicing self-control might *cultivate awareness* of one's behaviors in general. This heightened attention would enable people to detect whether self-control has gone astray to begin with. However, while self-control theory acknowledges that attention is an important part of self-control efforts, it makes no specification about how attention might be a way by which interventions can promote self-control. As such, the mechanisms by which interventions increase self-control are an important topic for future research. Attention, in particular, is an important component for cultivating not only *self-control* but also *awareness* and is one way by which self-control theory and Eastern meditation practices are intertwined.

Meditation

Background. It is difficult to define meditation given the many styles. In addition, meditation blends with other mind-body modalities such as Yoga and Tai Chi (e.g., Evans, Tsao, Sternlieb, & Zeltzer, 2009; Salmon, Lush, Jablonski, & Sephton, 2009). In a recent meta-analysis, Sedlmeier and colleagues (2012) listed three different types of meditation: (1) concentrative, (2) mindful, and (3) guided. According to Sedlmeier et al. (2012), *concentrative meditations* involve focusing on a stimulus such as a mantra or one's breath, *mindful meditations* include attention to the present moment while remaining alert and non-judgmental towards one's own thoughts, and *guided meditations* are very content specific. For instance, guided meditations can be focused on a mandala ("a complex picture, usually high in religious significance", p. 1141), a chant, or a universal experience such as death and suffering. Although concentrative, mindful, and guided meditations are distinct, there is also some overlap between them, and meditation practices typically consist of a combination of all three techniques. For instance, one could be meditating on one's breath, while simply taking note of thoughts and emotions as they arise, without reacting to them. A meditation as this could be labeled as concentrative and mindful.

Meditation in the West is mainly guided by Hindu and Buddhist philosophy (however, one can find meditation practices in other spiritual traditions, such as Judeo-Christian and Islamic, as well), and there has been much debate over how to integrate meditation into a Western psychological framework. One major obstacle is that meditation, in its original context, serves a much different purpose, namely to attain a higher state of consciousness, enlightenment, and liberation from all suffering (Sedlmeier et al., 2012). In contrast, within a Western paradigm, meditation is used primarily as a means to restore and maintain mental health and balance by dealing with thoughts and emotions (Wallace and Shapiro, 2006; in Sedlmeier et al., 2012). Applying meditation this way is supported by a number of research studies that link meditation to positive mental and physical health outcomes (e.g., Grossman, Niemann, Schmidt, & Walach, 2004; Sedlmeier et al., 2012). Self-control theory has been used in order to explain the benefits of meditation. Especially during the early stages of practicing meditation, beginners require a great deal of self-control in order to focus their attention on a particular stimulus while learning to remain unattached to any arising thoughts, emotions, and impulses (Lutz, Slagter, Dunne, & Davidson, 2008).

Meditation and self-control theory. Although meditation and self-control share commonalities, whether they represent the same construct is a current topic of debate (e.g., Brown, Ryan, & Creswell, 2007). This is particularly the case for mindfulness and its association with self-control. Similar to mindful meditation, Chambers and colleagues state that " […] a mindful state is characterized by full attention to, and awareness of, the internal and external experience of the present moment […] this awareness is employed equanimously, in that every thought and emotion that arises is acknowledged and examined without judgment, elaboration, or reaction (Chambers, Lo, & Allen, 2008). Mindfulness is a core pillar of meditation techniques and has been incorporated into widely known clinical interventions programs such as Mindfulness Based Stress Reduction (MBSR). Self-control theorists propose that mindfulness is a form of self-control, yet mindfulness scholars, while agreeing that mindfulness includes self-control, see it as a distinct process. Indeed, measures of dispositional mindfulness and self-control are only minimally correlated (Brown, Ryan, & Creswell, 2007). Furthermore, mindfulness and self-control theory diverge in their theoretical underpinnings, such as a different view of the Self, and the motivations that underlie mindfulness and self-control efforts (Brown, Ryan, & Creswell, 2007).

For example, mindfulness theorists propose that mindfulness operates from an "I self" concept, a self that is more fluid and undefined and openly integrates a person's experience without any constrains. Self-control theory, in contrast, operates from a "Me self" perspective, endorsing a self that is defined by cultural norms and values. This results in a more narrow view and constrained integration of a person's new experiences.

Mindfulness and self-control also differ in their motivations. For instance, behavior operating within a mindful context is guided by motivations that are in line with the "I self" and hence, are more in accord with one's "true self", a self that is not defined by external norms and standards, such as "I want to study in order to learn and grow". In contrast, behaviors carried out in a self-control context can be guided by motivations that aim at serving and meeting the "ego-involved" needs of the "Me self" (Brown, Ryan, & Creswell, 2007), e.g., I want to study diligently in order to get good grades and be acknowledged by my professor, classmates, and family. While self-control theory also acknowledges that people's behavior can be driven by motivations that serve the "I self", motivations that serve the "Me self" are a main component of the theory's framework.

Present moment awareness versus transcendence. Controlling attention is key for meditation practices and self-control efforts. Present moment awareness, in particular, is a key feature of meditation (e.g., Brown, Ryan, Creswell, 2007), yet antithetical to self-control theory. Broadly speaking, self-control theory proposes that in order to control arising impulses, it is essential to see the bigger picture of a situation by going beyond the present moment and attending to a larger set of held beliefs, goals, and values. This concept has also been termed *transcendence*. As Baumeister and Heatherton (1996) assert, "when attention slips off of long-range goals and high ideals and instead becomes immersed in the immediate situation[2], self-regulation is in jeopardy" (p. 4). It is important to note that becoming immersed in a thought or an emotion is not the goal of meditation either. However, the difference is that meditation aims at simply noting the event, thereby promoting non-judgment and open present moment awareness. This approach allows the person who is meditating to eventually "re-perceive" the situation (Shapiro, Carlson, Astin, & Freedman, 2006). Indeed, by cultivating non-judgment and present moment awareness, individuals will not feel that they have to control or override any urges. Instead, they are simply aware of the situation and accept it as it is while gently directing their attention back to the present moment (Brown, Ryan, & Deci, 2007a). With time, meditation practices become more internalized and require less self-control (Lutz, Slagter, Dunne, & Davidson, 2008).

[2] Although Baumeister and Heatherton do not state this directly, it can be inferred that they refer here to being immersed and driven by one's thoughts and emotions, mostly to gratify an incoming impulse.

Consolidating meditation and self-control theory. Although meditation requires some form of self-control, particularly during the early stages, self-control within a self-control theory framework differs in that the latter is predominantly driven by "Me self" centered motivations and values while the former is driven by "I self" centered motivations and values (see previous section for discussion of different motivations). As such, meditation and self-control within a meditation framework are thought to be more energizing and less depleting than self-control within a self-control theory context (Brown, Ryan, & Deci, 2007a); and there is some evidence for this which has already been reviewed above, namely: (1) self-control depletes resources as evident by decrements in subsequent acts of self-control and declines in blood glucose (e.g., Baumeister & Heatherton, 1996; Gailliot & Baumeister, 2007), and (2) self-control that is driven by "I-self" centered motivations (e.g., refraining from eating cookies because one sees it as a challenge and fun) is associated with better self-control (e.g., holding a handgrip longer) than behavior that is driven by "Me-self" centered motivations (e.g., not eating cookies because one does not want to be misjudged by the experimenter) (see study by Muraven, 2008 on p. 3).

For my paper, I will consolidate meditation and self-control theory and ground the rationale and arguments of my dissertation on the premise that meditation includes self-control efforts but within its own framework, such as maintaining present moment awareness, openness, and non-judgment. Self-control within a meditation framework is wider in cognitive focus and more energizing than self-control within a more limited self-control theory framework (see Figure 1 for a depiction).

Meditation and attention control. As has been discussed previously, directing attention and awareness is an integrative part of self-control (see page 15 for a discussion of this topic), and plays also a vital role during meditation. Indeed, all three types of meditation described by Sedlmeier (2012), concentrative, mindful, and guided, require attention to be either directed inward, such as observing thoughts and emotions, or outward, such as focusing on a chant or a mantra.

A number of intervention studies have demonstrated a clear link between meditation and improvements in attention control. For instance, participants undergoing a 10-day intensive meditation retreat performed better at a task requiring attention control, compared to a control group who did not receive any meditation training (Chambers, Lo, & Allen, 2008). A drawback of the study was its low external validity given that it is not feasible for most people to attend a 10-day intensive retreat. Another study showed that experienced meditators had a faster average reaction time than non-meditators on the Stroop task (Chan & Woollacott, 2007). Yet, among meditators, only the amount of time spent meditating each day, as opposed to total number of hours spent meditating over the lifetime, was associated with better performance on the Stroop task, suggesting that it is the regular practice of meditation that is linked to better attention control. As such, it might well be that a regular, daily meditation practice, even of short-duration, might be just as good, if not even better, than going on extensive retreats once in a while[3]. Indeed, even brief meditation interventions have been associated with improvement in attention control (e.g., Tang et al., 2007).

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[3] Of course, a combination of the two, as is done in the Mindfulness-Based Stress Reduction program (MBSR), could be the most beneficial.

When we begin to zone in on the interventions themselves, it is notable that although there is a great variety of meditation style and focus, what many, if not all of them have in common is their focus on the *breath*. Indeed, cultivating breath awareness is an important meditation tool that helps practitioners to stay anchored in the present moment. As Loizzo, Charlson, & Peterson (2009) point out:

Meditation aims at developing conscious regulation of the workings of the mind, nervous system, and physiology through control of attention, concentration, *breathing*, and posture (p. 11).

Breath-based meditation. Conscious breathing is a vital part of meditation and yoga (Brown & Gerbarg, 2009) and often used as a springboard into a more serious practice. Indeed, particularly for meditation beginners, focusing on the breath offers a simple way to stay anchored in the present moment, thereby giving participants immediate experiential benefits and motivating them to keep up (Brown & Cerbarg, 2009). As Jon Kabat-Zinn (1990), one of the founders of Mindfulness-Based Stress Reduction (MBSR), states: "the fundamental pulsations of the body [breath] are particularly fruitful to focus on during meditation because they are so intimately connected with the experience of being alive" (p. 48) and further elaborates that through our breath we can cultivate the sense of interrelatedness between us and our environment. Indeed, some argue that meditation enhances well-being by promoting a sense of oneness with ourselves, friends and family, society at large, and the entire life on the planet including all humanity, animals, and plants (Kabat-Zinn, 1990; Lehrer, Sasaki, & Saito, 1999).

Another postulation is that cultivating breath awareness creates an openess and "recepetivity to learning" and, as such, create the opportunity for a "teachable moment" where practitioners are particularly open to learning new skills such as coping with stress and other adaptive behaviors (Loizzo, Charlson, & Peterson, 2009). However, these ideas are mainly based on theoretical accounts and hard evidence is, to my knowledge, lacking. There are a few studies, however, that offer partial support which I will disuss in the subsequent section.

From a physiological point of view, Eastern philosophy suggests that our breath is closely interlinked with prana, a primal living force similar to Chi in Chinese medicine (Brown & Gerbarg, 2009). Incorrect unconscious breathing will result in disturbances in the distribution of prana throughout the body which can cause mental and physical health diseases (Brown & Gerbarg, 2009). Some research studies suggest that breath awareness can contribute to positive health outcomes. For instance, MBSR, which utilizes breathing meditation as an essential tool in order to cultivate mindfulness and present moment awareness, has been associated with better immune functioning (Davidson et al., 2003). However, it is difficult to tease apart the active ingredient of MBSR, as is the case with many other interventions, given its multiple components such as hatha yoga exercises, mindful eating practice, retreats, and social support through interacting with other intervention participants, just to name a few.

Out of the wealth of meditation studies that have accumulated in the last few years, some studies have examined the association between breath awareness and measures of physical and mental health. One study examined the association between breathing meditation and affect in women with fibromyalgia syndrome and found an association between practicing slow deep breathing and increased positive and reduced negative affect when these women were exposed to pain (Zautra, Fasman, Davis, & Craig, 2010). Another study compared the effects of mindful breathing, progressive muscle relaxation, and loving-kindness meditation on decentering in female undergraduate students (Feldman, Greeson, & Senville, 2010). Decentering refers to looking at thoughts with objectivity rather than identifying and becoming immersed with them. Participants were assigned to one of the three groups and listened to 15 minutes of guided instructions for one of the techniques. Decentering was assessed in several ways: directly through self-report measures and by examining participants' negative reaction to ruminative thoughts. Participants in the mindful breathing group showed higher levels of decentering than participants receiving progressive muscle relaxation and loving-kindness meditation instructions. It is of note that participants in the mindful breathing group also reported higher levels of ruminative thoughts than participants in the other two conditions. Yet, those receiving mindful breathing instructions *and* reporting high levels of decentering reacted less negatively to the ruminative thoughts than participants in the other two groups as well as participants receiving mindful breathing instructions and who reported low levels of decentering. The author's suggest that mindful breathing heightens awareness to thoughts, including negative ones, but as people learn to simply observe their thoughts with openness and non-judgment, they are also less affected by them.

Breathing-based meditation as a way of enhancing attention control. Besides being associated with creating awareness, a sense of openness, and non-judgment, breathing-based meditation has directly been associated with better performance on tasks requiring attention control (e.g., van de Hurk, Giommi, Gielen, Speckens, & Barendregt, 2010; Moore & Malinowski, 2009; van Leeuwen, Willer, & Melloni, 2009). For instance, in one study participants were assigned to an intervention that consisted of four meditation sessions aimed at cultivating breath- and present-moment awareness (Zeidan, Johnson, Diamond, David, & Goolkasian, 2010). Participants enrolled in the meditation class displayed improvements in attention control, as measured by performance on several standardized cognitive tasks, compared to the control group (Zeidan, Johnson, Diamond, David, & Goolkasian, 2010). Another brief meditation intervention, also utilizing breathing practices, had participants partake in daily 20-minute sessions over a 5-day period. Attention control was assessed before and after the intervention via the Attention Network Test which is a standardized test to measure attention control. Following the intervention, participants in the intervention group exhibited an improvement in test performance while participants in the control group did not show such change (Tang et al., 2007). An even shorter meditation intervention was conducted by Wenk-Sormaz (2005) who administered only one 20-minute breathing-based meditation session between two attention tasks (Wenk-Sormaz, 2005). Participants completed the Stroop task followed by a 20-minute meditation period and participants in the control group completed a learning task. After completing their tasks, participants took the Stroop task again and those in the meditation group had a faster average reaction time on the second Stroop than participants in the control group.

While the studies above have linked breathing-based meditation with better *performance* on tasks requiring attention control, parameters other than performance can also demonstrate the association between meditation and attention control. For instance, one study examined the effects of a 16-week long breathing-based meditation intervention on attention control via performance on the Stroop task in addition to brain activity in the form of event-related potentials (ERPs) in response to the Stroop task (Moore et al., 2012). ERPs are assessed by electroencephalography (EEG) and are a way of isolating electrical brain activity that is specific to one incoming stimulus of cognitive, motoric, or sensory nature, in the case of this study, the Stroop task. The intervention consisted of three hours of face-to-face class time, which were spread over three class meetings, in combination with 10 minutes of daily meditation home practice which consisted of a mindful breathing exercise. Participants in the control group were placed on a waiting list. The study's findings are of note because although participants in the meditation group did not show any improvement on Stroop task performance (error rate and reaction time), they did exhibit changes in ERPs in response to the Stroop task. These changes suggested that attention processing became less demanding for the brain as evident by less brain activity and resource allocation in brain regions associated with attention control. Hence, it can be inferred that the positive effects of breathing meditation can become apparent in measures of attention control other than performance on a cognitive task, such as brain activity during performance on a cognitive task.

Another important implication of the study's discussed above is that breathing meditation can be an effective means for promoting self-control. Intervention studies based on self-control theory have used techniques such as keeping a food diary or tracking money spend (Muraven et al., 1999; Oaten & Cheng, 2007), yet fostering self-control, such as attention, by means of meditation on the breath can be more conducive to cultivating present moment awareness, openness, and non-judgment, and can also include concentrative, mindful, and guided meditation. In addition, focusing on the breath is more in line with the "I-self" by not placing constraints on people's experience, while keeping a food diary and keeping track of money spend is more in line with a "Me self" that is defined by cultural norms and values (see page 17 for a discussion of this topic). Lastly, from a more practical point of view, cultivating breathing awareness can be carried out in a formalized meditation setting, but also informally at any time and place throughout the day as people go about their daily activities (see Figure 2 for a depiction of breathing awareness within a meditation context).

While I have gone over a few studies that have focused specifically on breathing meditation and attention control, to my knowledge, no research to date has examined the relationship between breathing meditation, attention control, blood glucose, and other domains of self-control. Furthermore, and perhaps most importantly, while breath awareness is part of most meditation practices, no intervention has made breathing meditation *the* main focus of the intervention. For instance, meditation interventions typically focus on simple breathing patterns such as deep belly breathing (e.g., Zeidan, Johnson, Diamond, David, & Goolkasian, 2010; Wenk-Sormaz, 2005; Valentine & Sweet, 2007; Chan & Woollacott, 2007; Moore & Malinowski, 2008; van den Hurk, Giommi, Gielen, Speckens, & Barendregt, 2010), yet, no intervention study has, for instance, utilized different types of breathing patterns in order to foster self-control, although meditation practices offer a plethora of breathing techniques (e.g., Brown & Gerbarg, 2009). Given that practicing more self-control makes one stronger at it, utilizing complex breathing meditation techniques might also be efficient in strengthening self-control. Research that examines the effects of *different* types of breathing meditations techniques on attention control, other domains of self-control, and blood glucose has yet to be conducted.

Dissertation Study

The primary aim of my dissertation study was to test the effects of a 4-week yogic breath meditation intervention on attention control and blood glucose levels in response to a cognitive task in healthy undergraduate students. I further examined the intervention's effects on cardiovascular function, as assessed by blood pressure and heart rate, as well as affect and stress appraisal. Lastly, I examined whether the intervention had any effects on other domains of self-control such as coping behavior and health behaviors. Undergraduate students were recruited from the psychology subject pool and by posting flyers throughout the UCLA campus. An outside member, who was not affiliated with the study, randomly assigned participants to the intervention or waitlist control group. While most meditation studies employ long deep breathing only, this study was novel in that it employed various types of breathing techniques. Using different breathing techniques for meditation is common in meditation and yogic practices (Brown & Gerbarg, 2009). For instance, in Zen Buddhism, Zazen meditation involves consciously altering respiration patterns such as inhaling and exhaling in particular segments (e.g., inhaling in four strokes and exhaling in one stroke) while cultivating awareness of one's breath (Lehrer, Sasaki, & Saito, 1999).

Hypotheses. I tested the following hypotheses; at post-intervention:

(1) participants in the intervention group will show improvements in *attention control*, as measured by performance on a cognitive task, compared to participants in the control group.

(2) participants in the intervention group will exhibit a lesser decline in *blood glucose* levels in response to performing a cognitive task, than participants in the control group.

(3) participants in the intervention group will show a lesser increase in *blood pressure* and *heart rate* in response to performing a cognitive task, than participants in the control group.

(4) participants in the intervention group will exhibit lower levels of *negative affect* and *perceived stress* and higher levels of *positive affect* after performing a cognitive task, than participants in the control group.

(5) participants in the intervention group will show improvements in *other domains of self-control,* particularly adaptive health behaviors, coping styles, mindfulness, thought control, and worry compared to participants in the control group.

Methods

Sample

Power analysis. 67 participants were recruited with 33 in the intervention and 34 in the control group. Power analyses showed that this sample size yields sufficient power (0.95) to detect a medium effect size (f = 0.45). In order to detect a large effect size, a sample of N = 32 would have been required, and for a small effect size, a sample of N = 328.

Participant selection. A trained research assistant screened potential participants for eligibility over the phone. Participants were excluded from the study if they had any health condition that might alter blood glucose or cardiovascular (i.e., heart rate and blood pressure) measures and/or indicated to take medications in order to treat any of those conditions which included: chronic infectious diseases, such as hepatitis or rheumatic fever in the last 6 months; any form of cancer or tumor; autoimmune disease such as lupus, rheumatoid arthritis or multiple sclerosis; severe immune disease such as HIV infection or AIDS; blood disease such as hemophilia or leukemia; endocrine disorders, such as a thyroid problem, Cushing's or Addison's disease; serious allergies or asthma as an adult; Chronic Fatigue Syndrome; cardiovascular condition during the last six months; skeletal fracture during the last six months; any metabolic disease such as type 1 or type 2 diabetes, hypoglycemia, or hyperglycemia. Participants were further excluded from the study if they reported that they had been diagnosed with a Diagnostic and Statistical Manual of Mental Disorders, 4th Edition – Text Revision (DSM-IV-TR) mental disorder (Diagnostic and statistical manual of mental disorders, fourth ed., text revision, 2000) in the past 6 months and/or if they indicated taking any prescription medication to treat a current DSM-IV-TR mental disorder in the past 6 months. Persons who reported to work regular night or rotating shift work were not eligible to participate in the study. In addition, health behaviors that excluded participants were using tobacco products, drinking more than 14 alcoholic drinks per week for women or 21 for men, drinking more than 6 alcoholic drinks in one sitting, excessive caffeine use (defined as drinking more than 8 caffeinated beverages per day), using marijuana daily or using any illegal drug (e.g., cocaine, heroin, methamphetamine) at least once in the last 6 months. Participants were eligible for participating in the study regardless of their prior yoga or meditation experience, both of which were assessed during the initial pre-intervention visit.

Participant compensation. Students received six course credits for participating in the study, equal to participating in a six-hour experiment. However, given that the total hours spent participating in the study exceeded six hours (two lab visits and four weekly meditation classes a 1.5 hours), participants also received a $10.00 Native Foods gift card. Although participants in the control group did not spend as many hours participating in the study as students in the intervention group, they also received a gift certificate.

Pre-Intervention Visit

Overview. Participants were scheduled for a pre-intervention visit at the health psychology laboratory during a 4-week window preceding the intervention. Given that I taught all meditation classes, only trained research assistants administered the pre- and post-intervention visits. Research assistants who carried out the pre- or post-intervention visits were not present at any of the meditation classes in order to prevent threats to internal validity.

At their pre-intervention visit, participants completed the consent form and a questionnaire containing demographic, health-related, and psychosocial measures, followed by assessment of attention control for which participants completed the Stroop, a widely used task for assessing attention control (Gailliot & Baumeister, 2007). Research assistants assessed participants' blood glucose levels, heart rate, and blood pressure before, during, and after the Stroop, affect levels before and after, and stress appraisal after the Stroop task.

Random assignment. Upon completing their pre-intervention visit, participants were randomly assigned to either the intervention or control group by an outside member of the research team. Participants were randomized at the beginning of each quarter within a few days following their initial laboratory visit. The study ran for three quarters and as a result there were three rounds of random assignment. Female students make up the majority of the psychology department's undergraduate student body and I had therefore planned to stratify participants on gender before randomly assigning them to the groups. However, experiments took place over a four-week window, preceding the beginning of the meditation classes. Given that students typically needed to know which group they were assigned to within a few days following their pre-intervention visit, it was not possible to stratify the group by gender. However, final analyses showed that males and females were distributed equally across both groups such that there were $n = 5$ males and $n = 28$ females in the control condition and $n = 4$ males and $n = 30$ females in the intervention group.

Procedure. Participants were scheduled for their pre-intervention visit to the health psychology laboratory during 8am and 2pm. On the day of their visit, participants were instructed to abstain from exercising and consuming alcohol and from eating any foods that are high in fat content, given their influence on blood glucose metabolism. We also asked participants to refrain from consuming any caffeinated beverages two hours, and beverages containing sugar as well as any food one hour before their scheduled appointment.

Upon arrival to the laboratory, participants provided consent after which a research assistant screened them for color blindness[4] and literacy. Participants were then asked to list all the food that they had consumed since they had gotten up that morning as well as any type of physical activity carried out. If we learned that participants did not follow the guidelines that they had been given (such as carrying out strenuous exercise or eating food high in fat content), we discontinued the study and rescheduled their appointment. Following this procedure, participants' anthropometric measures (weight, height, and wait circumference) were taken, followed by fitting them with a blood pressure cuff in order to assess heart rate and blood pressure.

Participants then filled out a questionnaire packet containing demographic, health-related and psychosocial measures, followed by a baseline resting period for which we asked them to sit quietly for 10 minutes while watching a video that was neutral in content (BBC's Planet Earth). After the resting period, we assessed baseline blood pressure and heart rate. For this, the blood pressure monitoring device took four readings in intervals of 2 minutes (= 8 minutes). We then assessed participants' blood glucose levels.

After the baseline assessment (= 8 minutes), participants completed the Stroop task. Throughout the Stroop, participants' blood pressure and heart rate was assessed in intervals of 3 minutes. After the first half of the Stroop, participants took a short break during which research assistants assessed their blood glucose levels, followed by the second half of the task. Once participants had completed the

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[4] One participant was screened as color blind. This participants was not included in any of the analyses pertaining to the Stroop task but was retained for all other analyses.

second half of the Stroop, research assistants undertook a final blood glucose, heart rate and blood pressure assessment. The latter two consisted of four readings in intervals of 2 minutes (= 8 minutes). Lastly, participants filled out a post-Stroop questionnaire, assessing positive and negative affect and stress appraisal.

Post-Intervention Visit

Overview. As the four-week intervention came to an end, a research assistant scheduled participants for their post-intervention visit to the health psychology lab. All research assistants who conducted the post-intervention visits were blind to participants' random assignment. Post-intervention visits took place within a two-week window after the four-week intervention class series had been completed.

As with the pre-intervention visit, participants were scheduled to come to the laboratory between 8am and 2pm. Pre- and post-intervention visits were identical. That is, participants filled out the baseline questionnaire, followed by the Stroop. Research assistants assessed participants' blood glucose levels, heart rate, and blood pressure before, during, and after the task as well as positive and negative affect levels before and after, and stress appraisal right after the Stroop. Participants were then debriefed and research assistants answered any remaining questions.

Intervention Classes. Participants assigned to the intervention group attended a 4-week yogic breath meditation class based on Kundalini Yoga as taught by Yogi Bhajan ®. The class was held once a week, lasted for about 90 minutes, with approximately 5-10 participants in each class. Two class sessions per week were held in order to give participants the option to make up a class in case they had missed one. The classes were lead by myself, the principal investigator of the study; I am a certified Kundalini Yoga as taught by Yogi Bhajan® instructor and have taught classes to groups and individuals in the past. The classes included all three meditation techniques, concentrative, mindful, and guided, as discussed by Sedlmeier and colleagues (2012) (p. 15). Each class had a didactic and experiential focus and the primary component of the intervention was meditations focused on the breath. For this, participants learned how to cultivate conscious and proper breathing and how to incorporate various breathing techniques into daily life.

At the beginning of each class, I briefly talked about the class's focus, followed by a light warm-up that consisted of simple yoga exercises. The class concluded with a longer meditation (about 10 – 15 minutes) and a relaxation period. All classes followed a set protocol that I had written up, which included a detailed, step-by-step description of the topic covered, and the yoga exercises and breathing techniques taught. Participants also received as short homework for which they were asked to practice the breathing meditation techniques covered in class for a given time period, typically 3-7 minutes, each day. Participants received a homework sheet, an mp3 recording with meditation instructions, and a weekly meditation diary in which they were asked to indicate whether they had completed the daily meditation exercise, how they felt during the meditation, and if they had practiced any of the meditation techniques throughout the day. Research assistants collected the homework diaries at the beginning of the each class period. We emphasized to students that the diaries served only the purpose to help students to keep track of their daily meditation practice and identify any challenges or difficulties that might arise during the week.

None of the research assistants, who assisted me in running the meditation classes, carried out any of the pre- or post-intervention laboratory visits.

Treatment fidelity. In order to ensure treatment fidelity, each class was coded and rated by research assistants following guidelines by Waltz and colleagues (Waltz, Addis, Koerner, & Jacobson, 1993). For this, research assistants received a rating sheet on which *essential*, *acceptable but not necessary*, and *proscribed* components of the class were listed. *Essential* components included the exercises and main points that should have been covered during the class; *acceptable* components consisted of the two items: 'self-disclosure' and 'asked if there are any questions/concerns'. *Proscribed* consisted of only one item, namely 'practicing assertion'. Research assistants checked off the items on the rating sheet while they listened to audiorecordings of the classes[5].

Control condition. Participants in the control group were offered to participate in a meditation workshop held on a weekend, which was a condensed version of the 4-week meditation class series and lasted for about 2 hours and 30 minutes, after they had completed the study.

Measures

Stroop task. The Stroop is a widely used task to assess attention control (Gailliot & Baumeister, 2007). For the task, participants were instructed to name the font color of a word, i.e. blue, green, red, and yellow, that was displayed on the computer screen. There are incongruent and congruent Stroop trials. During an incongruent Stroop trial, the font color of the word differs from the semantic meaning of the word. For instance, red is displayed in yellow. During congruent

[5] Only classes for the Fall 2012 and Winter 2013 quarter were rated.

trials, the font color of the word corresponds to the semantic meaning of the word e.g., red is displayed in red. Hence, during an incongruent trial, the correct response for the word ‘red’ with font color ‘yellow’, is ‘yellow’. The basic premise is that incongruent trials require participants to exert attention and self-control as most people’s initial response would be to state the word’s semantic meaning, e.g., state ‘red’ when it is displayed in ‘yellow’.

For my dissertation study, the Stroop task consisted of 75% incongruent and 25% congruent trials. All trials were presented in random order. The first cohort of students completed a total of 600 trials. Due to technical difficulties, I had to reduce the number of trials to 500 for the second and third cohort. In both cases, the task took approximately 40 minutes to complete. For the first cohort of participants, each trial was time sensitive in that participants had 1200 milliseconds until the computer automatically continued to a new trial, regardless of whether or not participants had responded. For the second and third cohort, response times were recorded such that participants could only continue on to the new trial once they had given a verbal response. In order to assess attention control, I obtained two Stroop outcome measures: (1) average reaction time which corresponded to how long it took participants to respond to each trial on average (only for cohort two and three), and (2) error rate, which corresponded to the number of incorrect responses for the Stroop task at pre- and post-intervention.

Blood pressure and heart rate. Research assistants assessed participants’ heart rate, systolic and diastolic blood pressure with a DinaMap Pro series v100 heart rate and blood pressure monitoring device. For this, participants were fitted with a blood pressure cuff right above their elbow. The device took participants’ heart rate and blood pressure in four 2-minute intervals during the pre-Stroop period (= 8 minutes), in 3-minutes intervals during the task period (approximately 45 minutes depending how quickly participants finished the Stroop), and in four 2-minute intervals during the post-Stroop period (= 8 minutes). For each assessment period, I took the mean of all readings in order to obtain an average measure.

According to the American Heart Association, a systolic blood pressure reading of less than 120 mm/Hg and a diastolic blood pressure reading of less than 80 mm/Hg is considered normal ("Understanding Blood Pressure", 2013). A heart rate considered normal for healthy adults is between 60 and 100 beats per minute, although a heart rate lower than 60 beats per minute is not necessarily due to a medical problem and could be the result of medications and/or high levels of physical fitness ("All About Heart Rate", 2012).

Blood glucose. Research assistants assessed participants' blood glucose levels with an OneTouch Ultra blood glucose meter and matching test strips (Milpitas, CA; LifeScan, Inc). Research assistants obtained three capillary blood samples through finger pricks at pre-Stroop, task period, and post-Stroop. Normal fasting blood glucose levels range from 70 to 99 mg/dL and blood glucose in response to a 75-gram glucose drink should be less than 140 mg/dL in healthy adults (Lab Test Online, 2013). All precautionary actions were taken in order to ensure maximum safety when research assistants dealt with the capillary blood samples.

Pre-Stroop questionnaires. Participants filled out a questionnaire containing demographic, health related, and psychosocial measures when they arrived to the laboratory. The psychosocial questionnaire administered during the pre-intervention visit was identical to the questionnaire administered during the post-intervention visit, except that I did not re-assess some of the participants' demographic information such as age and gender.

The psychosocial questionnaire contained the following measures:

Demographic information. Variables included age, gender, ethnicity, employment status, and family income. Items were taken from pre-established questionnaires that had been used in samples of breast cancer survivors and undergraduate students.

Medical history and health behaviors**.** Variables included medical history, health behaviors, current and past experiences with yoga and meditation practices. Items were taken from pre-established questionnaires that had been used in samples of breast cancer survivors and undergraduate students.

Coping. In order to assess how participants cope with stressful events *in general*, I combined items of two measures: the Cope (Carver, 1997) and the Emotional Approach Coping (EAC) Scales (Stanton, Kirk, Cameron, & Danoff-Burg, 2000). Instructions were adapted from Stanton and colleagues (2000) and responses ranged from *1 = I usually don't do this at all* to *4 = I usually do this a lot*. I calculated a mean composite score for specific subscales which were of interest for the study: active coping, planning, positive reframing, acceptance, venting, substance use, behavioral disengagement and self-blame from the COPE measure and emotional expression and processing from the EAC scale. The final score for each subscale ranged from 1 to 4, with a higher score being indicative of more frequent usage.

Cope. The COPE (Carver, 1997) consists of 28 items and measures 14 different coping styles: active coping, planning, positive reframing, acceptance, humor, religion, using emotional support, using instrumental support, self-distraction, denial, venting, substance use, behavioral disengagement, and self-blame. The brief COPE has adequate internal validity and reliability and is widely used in healthy and clinical populations (Carver, 1997).

Emotional approach coping. The EAC assessed participants' usage of emotional approach coping strategies and consists of two subscales, Emotional Expression and Emotional Processing (Stanton et al., 2000). In the expanded version, each scale contains 8 items. The EAC has good validity, with alphas for each subscale around .90, good test-retest reliability, and demonstrates convergent validity with other relevant constructs such as hope and better adjustment, and discriminant validity with other measures of coping.

Depressive symptoms. Participants' depressive symptoms over the previous week were assessed with the Center for Epidemiological Studies Depression (CES-D) scale. The CES-D consists of 20 items such as "I was bothered by things that usually don't bother me" or "I felt sad" (Radloff, 1977). Responses ranged from *0 = rarely or none of the time (< 1 day)* to *3 = some or all of the time (5-7 days)*. I created a composite score ranging from 0 to 60 with a higher score indicative of higher levels of depressive symptoms. The scale is designed to assess depressive symptoms in the general population and has been used in large scale epidemiological studies (Van Dam & Earleywine, 2011). It has excellent reliability and construct validity (e.g., Radloff, 1977; Van Dam & Earleywine, 2011).

Emotional states. In order to assess participants' momentary emotional state, I used a condensed version of the Positive and Negative Affect Schedule (PANAS-X) consisting of 20 items (Watson, Clark, & Tellegen, 1988). The scale assessed participants' momentary positive and negative affect with items such as feeling upset, excited, or alert which participants rated on a scale ranging from *1 = very slightly or not at all* to *5 = extremely*. The two major scales are positive and negative affect which can further be broken down into basic negative emotions (nervous, angry, dissatisfied with self, sad, irritable, alone, angry at self, jittery), general negative emotions (nervous, jittery, irritable), basic positive emotions with attention (happy, strong, alert, proud, attentive, excited), basic positive emotions without attention (happy, strong, proud, excited), and general positive emotions (alert, attentive, excited, relaxed, strong). In addition, there are several subscales such as attention (alert, attentive) and fatigue (tired, sleepy) which I included for my study. Furthermore, in order to assess emotional states that might be linked with self-control, I had to add the following items from the extended PANAS-X version: sleepy, tired, calm, and relaxed.

For each subscale, I summed up the responses and created a corresponding composite score. A higher score indicated higher levels of affect. Given that each scale had a different number of items, the following lists the composite score range for each subscale: basic negative emotions, 8 – 40; general negative emotions, 3 – 15; basic positive emotions with attention, 6 – 30; basic positive emotions without attention, 4 – 20; general positive emotions 5 – 25; attention, 2 – 10; and fatigue, 2 – 10.

The PANAS-X is one of the most widely used measures for assessing emotional states and has been used across a variety of populations and settings (e.g., Watson, Clark, & Tellegen, 1988; Watson & Clark, 1994). The brief PANAS-X measure that I used for this study has good convergent and external validity with other relevant measures of mood and well-being (Watson, Clark, & Tellegen, 1988).

Life events. The Life Events Scale is a 54-item scale that assesses events that might be potentially stressful for college students, e.g. not having enough money for extras such as social activities or having to juggle a school and a job (Towbes & Cohen, 1996). Participants indicated whether events listed in the scale happened to them over the past month and if so, how much the event bothered them. Responses ranged from *1 = just a little* to *3 = very much*. I created a composite score by adding up the responses of items that participants had indicated with a possible range from 0 to 162. A score of 162 would be a student who checked off every event on the list and indicated each event as having been very bothersome. The scale has good test-retest reliability and congruent validity (Towbes & Cohen, 1996).

Mindfulness. In order to assess participants' mindfulness, I used the Five Facet Mindfulness Scale Questionnaire (FFMQ) (Baer, Smith, Lykins, Button, Krietemeyer, Sauer, Walsh, Duggan, & Williams, 2008). The FFMQ assesses five components of mindfulness: observing ("I notice the smells and aromas of things"), describing ("I am good at finding words to describe my feelings"), acting with awareness ("I rush through activities without being really attentive to them"; this item is reverse coded), nonjudging of inner experience ("I tell myself that I shouldn't be thinking the way I'm thinking"; this item is reversed coded) and nonreactivity to inner experience ("I perceive my feelings and emotions without having to react to them"). Participants indicate how each statement applies to them by rating items on scale ranging from *1 = never or very rarely true* to *5 = very often or always true*. The observing, describing, acting with awareness, and nonjuding of inner experience subscales consisted of eight items while the nonreactivity to inner experience consisted of seven items. I calculated a composite score for each scale by creating a sum score which ranged from 8 – 40 for the scales with eight items and a sum score ranging from 7 – 35 for the nonreactivity to inner experience scale. With the exception of the "act with awareness" scale, all FFMQ components are positively associated with meditation experience and display good internal consistency with alphas ranging from .72 to .92. The FFMQ shows convergent validity with measures of well-being (Baer et al., 2008).

Perceived stress. Participants' perceived stress level over the past month was assessed with the 10-item Perceived Stress Scale (PSS) (Cohen, Kamarck, & Mermelstein, 1983). Participants indicated their responses on a scale ranging from *0 = never* to *4 = very often* to items such as "in the last month, how often have you felt difficulties were piling up so high that you could not overcome them" or "how often have you felt nervous and stressed". I created a composite score which ranged from 0 to 40, with a higher score being indicative of higher levels of perceived stress. The PSS has been used across a variety of settings, populations, and cultures (e.g., Schlotz, Zoccola, Jansen, & Schulz, 2011) and has high convergent validity with measures of health and good reliability (Cohen, Kamarck, & Mermelstein, 1983).

Thought control ability. Participants' ability to control their thoughts was assessed with the 25-item Thought Control Ability Questionnaire (TCAQ) (Luciano, Algarabel, Tomas, & Martinez, 2005). The TCAQ captures the degree to which participants can control any unwanted intrusive thoughts with items such as "I often cannot avoid having upsetting thoughts" and "I am usually unsuccessful when I decide not to think about something". Items were rated on a scale ranging from *1 = strongly disagree* to *5 = strongly agree*. I created a composite score, ranging from 25 to 75, with a higher score indicating a better ability to control thoughts. The measure displays high internal consistency and test-retest reliability (Luciano, Algarabel, Tomas, & Martinez, 2005).

Worry. Participants' dispositional worry levels were assessed with the Penn State Worry Questionnaire (PSWQ) (Meyer, Metzger, & Borkovec, 1990). The PSWQ is a frequently used scale with good discriminant validity and reliability. The questionnaire consists of 16 items such as "my worries overwhelm me" and "I am always worrying about something" which were rated on a scale ranging from *1 = not at all typical for me* to *5 = very typical for me*. I created a composite score ranging from 16 to 80 with a higher score indicating higher levels of worry.

Post-Stroop questionnaire. After participants completed the Stroop task, they filled out one more questionnaire containing the following measures:

Task impression. In order to assess how stressed and challenged participants felt after completing the Stroop task, I administered the *Task Impression Questionnaire (VAS)* (Gaab, Rohleder, Nater, & Ehlert, 2005). This measure is frequently used in research with the Trier Social Stress task, a widely used acute stressor. The questionnaire consisted of four items: "the past situation was stressful to me", "I found the past situation to be a challenge", "I knew what I had to do to influence the past situation", and "I was able to do something to influence the course of the past situation". Items were rated on a scale ranging from *1 = not true at all for me* to *4 = a lot true to me*. I created a composite score ranging from 4 to 16, with a higher score indicating higher levels of perceived challenge and stress associated with the task.

Emotional states. Participants filled out the same condensed version of the Positive and Negative Affect Schedule (PANAS-X), as described above, after completing the Stroop.

Analyses Plan

I conducted t-test and chi-square analyses in order to examine whether experimental groups differed on any demographic (e.g., family income, ethnicity), health related (e.g., BMI), and/or psychosocial variable (e.g., mindfulness) at pre-intervention. Stroop reaction time was winsorized at the 95^{th} and 5^{th} percentile. I examined all variables for normality, outliers and missing data points. I carried out a $\log_{10}$ transformation for positively or negatively skewed data. For missing values, I used intention to treat analyses. More specifically, for missing values at post-intervention, I used the "last observation carried forward method", and imputed participants' pre-intervention value (Sainani, 2010). For missing values at pre-intervention, I followed "global average value for numerical attributes (GMC-GA)" guidelines and imputed the grand group mean (Grzymala-Busse, Goodwin, Grzymala-Busse, & Zheng, 2005). I conducted the appropriate tests, e.g., t-test and ANOVA, in order to examine any group difference at pre-intervention for all relevant outcome variables as well as BMI and waist-to-hip ratio. I examined several variables as potential covariates: BMI, waist-to-hip ratio perceived stress, stressful life events, as well as current and past yoga and meditation experience, which I controlled for in the main analyses when applicable.

Hypotheses

I conducted the following analyses to test my hypotheses:

Hypothesis 1: Participants in the intervention group will show improvements in attention control. I tested this hypothesis with a repeated measures ANOVA with group (intervention, control) as the between-subjects factor, and Stroop error rate and reaction time at pre- and post-intervention as the within-subjects factor and ran two separate analyses for error rate and reaction time.

Hypothesis 2: Participants in the intervention group will exhibit a lesser decline in blood glucose levels in response to performing a cognitive task, than participants in the control group. In order to test this hypothesis, I conducted a repeated measures ANOVA with group (intervention, control) as the between-subjects factor, and blood glucose levels at pre- and post-intervention as the within-groups factor. In order to examine a change in blood glucose levels in response to the Stroop task, I calculated a blood glucose difference score for pre- and post-intervention by subtracting pre-Stroop from post-Stroop blood glucose levels as in Neuman et al. (2004). A *positive score* is indicative of an increase in blood glucose levels from before to after the Stroop task with a higher positive score indicative of a sharper increase. A *negative score* is indicative of a decline in blood glucose levels from before to after the Stroop task and a higher negative score is indicative of a sharper decline.

Hypothesis 3: Participants in the intervention group will exhibit a

lesser increase in heart rate and blood pressure when performing a cognitive task than participants in the control group. I examined the effects on heart rate and blood pressure by calculating a heart rate and blood pressure reactivity index score for which I subtracted the mean pre-Stroop period score from the mean task score. I only focused on the change in cardiovascular activity from before to during the Stroop. As can be seen in Figure 3-5, participants exhibited an increase from before to during the Stroop on virtually all cardiovascular measures (HR, SBP, DBP). As in the previous hypotheses, I employed a repeated measures ANOVA with intervention and control group as the between-subjects factor and heart rate and blood pressure reactivity index scores as the within-group factors which I examined in separate analyses. A *positive reactivity index score* is indicative of an increase while a *negative score* is indicative of a decrease in heart rate and blood pressure from pre- to during the Stroop.

Hypothesis 4: Participants in the intervention group will exhibit lower levels of negative affect and stress and higher levels of positive affect after performing the Stroop than participants in the control group. I tested this hypothesis with a repeated measures ANOVA with group as the between-subjects factor and mean negative and positive affect scores and stress scores at pre- and post-intervention as the within-subjects factor.

Hypothesis 5: Participants in the intervention group will show improvements in other domains of self-control. In order to test this hypotheses, I examined several dependent variables: *health behaviors* (alcohol consumption, aerobic and anaerobic exercise, number of nights with less sleep than needed, fruit and vegetable consumption, and consumption of caffeine and sugary drinks), *coping strategies* (active coping, planning, positive reframing, acceptance, venting, substance use, behavioral disengagement, self-blame, spiritual coping, emotional expression, emotional processing), *mindfulness* (observing, describing, acting with awareness, nonjuding of inner experiences, nonreactivity to inner experience), *thought control*, and *worry*. As in the previous analyses, I used a repeated measures ANOVA with group as the between subjects factor and the mean score for each dependent variable at pre- and post-intervention as the within-subjects factor.

Results

Sample Characteristics

Demographic and health-related characteristics of study participants (N = 67) are displayed in Table 1 and 2. Figure 6 depicts participant flow and study retention. The sample (*N* = 67 participants; 58 female, 9 male) was mainly female and primarily composed of students identifying themselves as White or Asian/Pacific Islander American. Participants' weight and height ranged from 41.82 kg to 84.14 kg and 1.49 m to 1.85 m and the BMI ranged from 17.42 to 29.94.

Group Equivalence

Groups did not differ on demographic variables (age, ethnicity, family income), except that there was a marginally significant group difference for relationship status, $x^2(1, N = 67) = 3.38$, $p = .08$, such that more participants in the meditation ($n = 32$) than control group ($n = 26$) indicated to be single. I therefore examined whether participants who were single ($n = 58$) differed from participants who were in a relationship ($n = 9$) on any of the outcome variables. There was no significant group difference except for general negative emotion ratings after the Stroop task at post-intervention such that participants in a relationship reported higher general negative affect ratings (*M* = 4.88, *SD* = 2.75) than participants who reported to be single (*M* = 3.77, *SD* = 1.36); although this effect was only marginally significant, $F(1, 65) = 3.75$, $p = .05$, $\eta^2 = .05$, I controlled for relationship status in the corresponding analyses with general negative emotions as the dependent variable. In addition, participants in a relationship reported to use venting as a coping strategy more frequently (*M* = 2.72, *SD* = 0.61) than participants who were single (*M* = 2.07, *SD* = 0.83), $F(1, 65) = 4.89$, $p = .03$, $\eta^2 = .07$, and I therefore also controlled for relationship status in the corresponding analyses with venting as the dependent variable when applicable.

Groups did not differ on any anthropometric measure (weight, height, BMI), whether they had practiced yoga or meditation in the past, their expectations of the meditation classes, or their health behaviors during the past seven days (alcohol consumption, aerobic and anaerobic exercise, eating breakfast, fruit and vegetable consumption, foods and drinks high in sugar intake, and consumption of caffeinated drinks) (all *p*s > .10). At pre-intervention, participants' rating of the day of the experiment ranged between that of *a typical day in terms of workload and stress levels* to *a day with a greater workload and stress levels*. At post-intervention, participants rated the day of the experiment on average as a *typical day in terms of workload and stress levels*.

Treatment fidelity. Overall, ratings of the two research assistants indicated that all essential, and no proscribed topics were taught in the meditation classes and acceptable components were incorporated equally.

Meditation class attendance. Participants in the intervention group were required to attend all four meditation classes. In order to give participants the opportunity to make up for a missed class, two classes per week were offered. In the event that a participant was not able to make it to any of the two classes, they had to withdraw from the meditation classes. Only one participant (n = 1) discontinued participating in the class series after the first class and six participants (n = 6) were not able to participate in the classes at all due to last minute time conflicts.

Covariates. I considered the following variables as potential covariates: *perceived stress (PSS), stressful life events, past and current yoga as well as past and current meditation experiences*, and examined the association between each potential covariate at pre-intervention and outcome variables at post-intervention. In order to avoid collinearity, I examined the correlation among those covariates that had the potential to be highly associated: past and current yoga experience ($r = .38$, $p = .00$), past and current meditation experience ($r = .53$, $p = .00$), current meditation and yoga experience ($r = .46$, $p = .00$), and past meditation and yoga experiences ($r = .23$, $p = .05$). Based on these correlations and given that the focus of the intervention were meditation techniques, I only picked current meditation experience as a covariate. I furthermore examined the association between perceived stress and life stress at pre-intervention. The two variables were highly correlated ($r = .58$, $p = .00$) and I therefore picked perceived stress only as a covariate. Groups' life stress ratings did not change from pre- to post-intervention $F(1, 54) = 0.29$, $p = .59$, $\eta^2 = .00$.

Hypothesis 1: Intervention Effects on Attention Control

I had hypothesized that participants in the intervention group will show improvements in attention control as measured by performance on the Stroop task (reaction time, error rate) (see Table 3 for descriptive statistics of raw values at pre- and post-intervention). The distributions for error rate at pre- and post-intervention were positively skewed and I therefore $\log_{10}$ transformed both. Results of analyses reported below are with $\log_{10}$ transformed error rates while means and figures[6] are based on raw values.

Groups did not differ in the errors they made on the Stroop at pre-intervention, $F(1, 64) = 0.63$, $p = .63$[7]. A repeated measures ANOVA indicated, albeit non-significant, a trend of time such that participants across both groups made more errors on the Stroop task at post- compared to pre-intervention, $F(1, 64) = 2.76$, $p = .10$, $\eta^2 = .04$ (see Figure 7). This trend disappeared when excluding outliers and participants with missing data, $F(1, 52) = 0.98$, $p = .32$, $\eta^2 = .01$. There was no significant group by time interaction, $F(1, 64) = 0.13$, $p = .71$, $\eta^2 = .00$. When examining Figure 7, it becomes apparent that the control group displayed a slightly higher error rate at post-intervention than participants in the intervention group. When controlling for pre-intervention error rate, there was no group difference at post-intervention $F(1, 63) = .31$, $p = .57$, $\eta^2 = .00$.

For reaction time, due to technical difficulties, data of the first cohort of participants ($n = 14$) was missing and analyses include data of the remaining two cohorts only ($n = 53$). Groups did not differ in their reaction time at baseline, $F(1, 51) = 1.76$, $p = .19$, $\eta^2 = .03$. There was no significant main effect of time, $F(1, 51)$

[6] The trend displayed in the figures with raw values does not differ from the results with $\log_{10}$ transformed values.

[7] The color-blind participant was not included in the analyses pertaining to Stroop error rate and reaction time.

= 2.01, p = .16, η^2 = .03, nor was there a significant group by time interaction F(1, 51) = 0.31, p = .57, η^2 = .00, (see Figure 8).

Hypothesis 2: Intervention Effects on Blood Glucose Levels

Results of a repeated measures ANOVA indicated a significant main effect of time for blood glucose levels F(1, 65) = 4.79, p = .03, η^2 = .06, such that there was a decrease in blood glucose difference score from pre- (M = - 2.74, SE = 1.29) to post-intervention (M = - 6.52, SE = 1.38)[8] (Table 4 for descriptive statistics). This is indicative of a more pronounced decline in blood glucose levels at post- compared to pre-intervention. This main effect was partially qualified by a marginally significant interaction, F(1, 65) = 3.37, p = .07, η^2 = .04. Simple main effects indicated that participants in the control group had a more pronounced drop in blood glucose levels from before- to after the Stroop, at post- compared to pre-intervention, F(1, 65) = 7.99, p = .00. See Figure 9 for a depiction of change in blood glucose difference scores at pre- and post-intervention. Note that a lower difference score is indicative of a higher drop in blood glucose from before to after the Stroop task. For instance, a participant with blood glucose levels 100 mg/dl at pre-Stroop and 96mg/dl at post-Stroop, would have a difference score of -4: 96 – 100 = -4, and exhibit a steeper decline than a participant with 100 mg/dl at pre-Stroop and 98mg/dl at post-Stroop, who would have a difference score of -2: 98 – 100 = -2.

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8 *Task- and pre-Stroop blood glucose at pre-intervention*, and *post-Stroop blood glucose at post-intervention* were $\log_{10}$ transformed. However, not all blood glucose data points were $\log_{10}$ transformed, i.e. post-Stroop blood glucose. I therefore ran the analyses with the $\log_{10}$ transformed values as well as the raw values. Results were the same and in order to keep all dependent measure constant, I only report the results of the analyses with the raw values here.

The interaction became non-significant when I excluded four participants who exhibited slightly elevated blood glucose levels before the Stroop task at pre- (126 mg/dl[9] and 121 mg/dl[10]; participants were in the control and meditation group, respectively) and post-intervention (144 mg/dl[11] and 132 mg/dl[12]; participants were in the meditation and control group, respectively)[13], $F(1, 61) = 2.62$, $p = .11$, $\eta^2 = .04$ while the main effect became marginally significant, $F(1, 61) = 3.18$, $p = .07$, $\eta^2 = .05$. When excluding participants who had dropped out from the study ($n = 11$) the main effect remained significant, $F(1, 54) = 4.75$, $p = .03$, $\eta^2 = .08$, and the interaction marginally significant, $F(1, 54) = 3.30$, $p = .07$, $\eta^2 = .05$.

The blood glucose difference score was not significantly associated with any of the outcome measures (all *p*s > .10). Among the covariates, perceived stress was negatively associated with task blood glucose ($r = -.30$, $p = .01$) and post-Stroop blood glucose ($r = -.24$, $p = .04$). When controlling in the analyses above for perceived stress the main effect of time became non-significant, $F(1, 64) = 1.23$, $p = .27$, $\eta^2 = .01$, while the interaction remained marginally significant, $F(1, 64) = 3.23$, $p = .07.$, $\eta^2 = .04$. Participants who were currently practicing meditation ($n = 4$) reported lower pre-Stroop blood glucose levels at post-intervention ($M = 59.89$, $SD = 4.87$) compared to participants with no current meditation experience (n = 58), ($M = 63.82$, $SD = 5.70$), $F(1, 60) = 3.16$, $p = .08$, $\eta^2 = .05$ although this effect was only marginally significant. Controlling for current

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[9] Participant was about three standard deviations away from the group mean (95.24).

[10] Participant was about two and a half standard deviations away from the group mean (94.38).

[11] Participant was about three and a half standard deviations away from the group mean (97.94).

[12] Participant was about two and a half standard deviations away from the group mean (102.27).

[13] None of these participants had eaten any suspicious food, such as food high in fat and/or sugar content. It should also be noted that while these values are slightly elevated compared to the group mean, they are within a clinically normal range.

meditation experience in the analyses above rendered the interaction non-significant $F(1, 59) = 2.75$, $p = .10$, $\eta^2 = .04$ while the main effect remained marginally significant $F(1, 59) = 3.90$, $p = .05$, $\eta^2 = .06$.

Hypothesis 3: Intervention Effects on Cardiovascular Measures

Heart rate. Participants difference scores did not significantly change from pre- to post-intervention, $F(1, 65) = 0.18$, $p = .66$, $\eta^2 = .00$, nor was there a significant interaction, $F(1, 65) = 0.00$, $p = .92$, $\eta^2 = .00$ (see Figure 10 and Table 4 for descriptive statistics). Participants in both groups exhibited an increase in heart rate while completing the Stroop task and this was the case both at pre- and post-intervention (see Figure 3 for a depiction of change in heart rate at pre-intervention).

Diastolic blood pressure. As with heart rate, there was no significant change in diastolic blood pressure difference score across both groups from pre- to post-intervention, $F(1, 65) = 0.44$, $p = .50$, $\eta^2 = .00$, nor was there a significant interaction, $F(1, 65) = 0.01$, $p = .91$, $\eta^2 = .00$[14] (see Figure 11 and Table 4 for descriptive statistics).

Participants who were currently practicing meditation exhibited lower task diastolic blood pressure than participants in the control group ($M = 60.54$, $SD = 5.53$ compared to $M = 66.94$, $SD = 5.11$), $F(1, 60) = 5.80$, $p = .01$, $\eta^2 = .08$ but controlling for current meditation experience in the above analyses did not change the results (all *p*s > .10).

[14] Pre-Stroop diastolic blood pressure at baseline and post-Stroop diastolic blood pressure at post-intervention were $\log_{10}$ transformed. Given that results remained the same whether using the transformed or untransformed values, I only report results with the untransformed values here.

Systolic blood pressure. The results for systolic blood pressure were the same as for diastolic blood pressure. That is, there was no significant change in systolic blood pressure difference score from pre- to post-intervention, $F(1, 65) = 0.02$, $p = .87$, $\eta^2 = .00$[15], nor was there a significant interaction, $F(1, 65) = 0.73$, $p = .39$, $\eta^2 = .01$, (see Figure 12 and Table 4 for descriptive statistics).

The results for blood pressure and heart rate stated above remained the same when excluding outliers ($n = 2$ for diastolic blood pressure; $n = 7$ for systolic blood pressure; $n = 3$ for heart rate) and participants who had dropped out from the study ($n = 11$) (all *p*s > .10).

Perceived stress at pre-intervention was positively associated with pre-Stroop systolic blood pressure ($r = .23$, $p = .06$), and post-Stroop systolic blood pressure, ($r = .24$, $p = .04$), however, when controlling for perceived stress, the effects for systolic blood pressure remained as stated above (all *p*s > .10).

I furthermore examined any group difference in heart rate and blood pressure difference score at post-intervention while controlling for the corresponding pre-intervention difference score. Results indicated no significant main effect or interaction when controlling for pre-intervention difference score (all *p*s > .10).

Hypothesis 4: Intervention Effects on Negative and Positive Affect and Reported Stress Levels following the Stroop Task

Negative affect. There was no main effect of time for any of the post-Stroop negative affect ratings nor was there an interaction: *basic negative emotions*, $F(1, 65) = 1.01$, $p = .31$, $\eta^2 = .01$, and $F(1, 65) = 0.67$, $p = .41$, $\eta^2 =$

[15] Systolic blood pressure during the Stroop was $\log_{10}$ transformed. Given that results remained the same whether using transformed or untransformed values, I only report analyses with untransformed values here.

.01, respectively; *general negative emotions*, $F(1, 65) = 0.92$, $p = .33$, $\eta^2 = .01$, and $F(1, 65) = 0.18$, $p = .66$, $\eta^2 = .00$, respectively. The effects remained the same when controlling for pre-intervention negative affect ratings prior to taking the Stroop task ($p > .10$).

Given the association between relationship status and general negative affect as was mentioned above (participants who were in a relationship reported higher levels of negative affect than participants who were single at pre-intervention), I controlled for relationship status in the analyses pertaining to general negative affect, yet the effects remained the same such that there was no main effect or interaction when controlling for relationship status as was the case when controlling for relationship status and pre-intervention negative affect ratings prior to taking the Stroop task (all *p*s > .10).

Perceived stress was associated with post-Stroop general negative emotions ($r = .26$, $p = .03$) and post-Stroop basic negative emotions ($r = .37$, $p = .00$). When controlling for perceived stress in the corresponding analyses, results remained the same as stated above (all *p*s > .10).

Positive affect. As with negative affect, there was no main effect of time or interaction for *positive affect ratings that included attention* after completing the Stroop task, $F(1, 65) = 2.03$, $p = .15$, $\eta^2 = .03$, and $F(1, 65) = 2.50$, $p = .11$, $\eta^2 = .03$, respectively. However, when controlling for pre-intervention positive affect ratings prior to taking the Stroop that included attention, there was a marginally significant interaction $F(1, 64) = 3.30$, $p = .07$, $\eta^2 = .04$ (see Figure 13 for a depiction of the interaction). When following up with simple main effects analyses, it became apparent that groups differed in their positive affect ratings at post-intervention, in that participants in the control group had lower positive affect ratings following the Stroop task than participants in the intervention group *F*(1, 64) = 6.86, *p* = .01 (see Table 5 for descriptive statistics).

Similarly, for *positive affect ratings without attention levels* after completing the Stroop task, there was a main effect, *F*(1, 65) = 4.31, *p* = .04, η^2 = .06, which was qualified by a significant interaction, *F*(1, 65) = 4.06, *p* = .04, η^2 = .05. When controlling for pre-intervention positive affect ratings without attention levels prior to taking the Stroop, the main effect became non-significant *F*(1, 64) = 1.12, *p* = .29, η^2 = .01, while the interaction remained significant, *F*(1, 64) = 4.63, *p* = .03, η^2 = .06. Simple main effects indicated that participants in the control group reported lower positive affect levels after completing the Stroop task following the intervention than participants in the intervention group, *F*(1, 64) = 7.42, *p* = .00 (see Figure 14 for a depiction of the interaction).

In order to examine positive emotions that are more in line with Yogic and Buddhist values, I created a new composite score for *positive affect ratings that include attention* and *positive affect ratings without attention levels* excluding the two items: *proud and excited.* When excluding these two items, the interaction for both positive affect ratings became non-significant, *F*(1, 65) = 1.10, *p* = .29, η^2 = .01 and *F*(1, 65) = 1.53, *p* = .22, η^2 = .02, respectively. I then examined each item, proud and excited, separately. While there was no main effect or interaction for *excited*, *F*(1, 65) = 1.74, *p* = .19, η^2 = .02 and *F*(1, 65) = 0.70, *p* = .40, η^2 = .01, respectively, there was a marginally significant interaction for *proud*, *F*(1, 65) = 3.52, *p* = .06, η^2 = .05. This interaction became significant when I controlled for pre-Stroop pride levels at pre-intervention, *F*(1, 65) = 4.53, *p* = .03, η^2 = .06.

Simple main effects indicated a group difference between participants in the control (*M* = 1.81, *SD* = 0.88) and intervention group following the intervention (*M* = 2.44, *SD* = 1.15), $F(1, 64) = 5.36$, $p = .02$, in that participants in the control group reported lower pride levels following the Stroop task than participants in the intervention group (Figure 15).

To contrast proud and excited, I chose two PANAS items more in line with yogic values, namely *calm* and *relaxed*, and examined any potential intervention effects. There was no main effect or interaction for *calm*, $F(1, 65) = 0.98$, $p = .32$, $\eta^2 = .01$ and $F(1, 65) = 0.19$, $p = .66$, $\eta^2 = .00$, respectively, or for *relaxed* $F(1, 65) = 0.15$, $p = .70$, $\eta^2 = .00$ and $F(1, 65) = 0.80$, $p = .37$, $\eta^2 = .01$, respectively.

Attention. There was no significant main effect of time for attention levels, such that participants' self-reported attention levels after completing the Stroop did not significantly change from before to after the intervention, $F(1, 65) = 0.05$, $p = .80$, $\eta^2 = .00$, nor was there a significant interaction, $F(1, 65) = 0.45$, $p = .50$, $\eta^2 = .00$. The effects remained the same when controlling for baseline pre-Stroop attention levels ($p > .10$).

Fatigue. There was no significant main effect of time on fatigue levels, $F(1, 65) = 1.75$, $p = .18$, $\eta^2 = .02$, nor was there a significant interaction, $F(1, 65) = 1.51$, $p = .22$, $\eta^2 = .02$. While the interaction remained non-significant when controlling for baseline pre-Stroop fatigue levels ($p > .10$), the main effect became marginally significant such that there was an increase in fatigue after completing the Stroop from baseline to post-intervention $F(1, 65) = 3.14$, $p = .08$, $\eta^2 = .04$, (see Figure 16 for a depiction of the main effect).

Perceived stress was positively associated with fatigue (r = .25, p = .03) and participants with a current meditation practice at pre-intervention reported lower levels of post-Stroop fatigue at post-intervention than participants without a current practice (M = 4.25, SD = 2.62 compared to M = 6.36, SD = 1.97), $F(1, 60)$ = 4.10, p = .04, η^2 = .06. Both main effect and interaction remained non-significant when controlling for perceived stress and current meditation experience, (all *p*s > .10).

Post-Stroop stress ratings. While there was no significant main effect of time for post-Stroop stress ratings, $F(1, 65)$ = 1.99, p = .16, η^2 = .03, there was a significant interaction $F(1, 65)$ = 6.54, p = .01, η^2 = .09, (see Figure 17). Simple main effects indicated that this interaction was driven by a significant group difference at pre-intervention in that participants in the control group reported higher stress levels following the Stroop than participants in the intervention group (see Table 4 for descriptive statistics) $F(1, 65)$ = 5.52, p = .02. Following the intervention, there was no significant group difference. Furthermore, participants in the control group exhibited a decline in stress ratings from before to after the intervention, $F(1, 65)$ = 7.92, p = .00, while there was no significant change from before to after the intervention in the intervention group, $F(1, 65)$ = 0.62, p = .43.

Given that the VAS consists of four items only, I examined any potential group difference for each item separately. There was a main effect for *how stressful participants perceived the Stroop task to be*, $F(1, 65)$ = 5.23, p = .02, η^2 = .07, which was qualified by a significant interaction, $F(1, 65)$ = 7.37, p = .00, η^2 = .10. Simple main effects showed that participants in the control group had higher stress ratings at pre-intervention than participants in the intervention group, $F(1, 65)$ = 3.26, p = .07.

All main results mentioned above remained the same when excluding dropouts.

Hypothesis 5: Intervention Effects on other Domains of Self-control.

I had hypothesized that participants in the intervention group will also show improvements in other domains of self-control such as health behaviors and adaptive coping strategies.

Health behaviors. As is illustrated in Table 6, there was no main effect of time or interaction for any of the following health behaviors: *alcohol consumption, aerobic exercise, anaerobic exercise, days that ate breakfast, days that consumed fruits, days that consumed vegetables, days that consumed sugary drinks*. Results remained the same when I excluded those participants who had dropped out (n = 11) and/or who had a missing data point due to non-responding (n = 2) and when controlling for perceived stress and current meditation experiences (all *p*s > .10). There was a main effect of time for average hours of sleep that participants got over the last seven days such that participants reported more number of hours of sleep at pre- (M = 6.80, SD = 0.97) than at post-intervention (M = 6.43, SD = 1.09). The interaction was non-significant. For number of nights with less sleep than needed, there was no main effect or interaction. However, when I excluded participants who had dropped out, there was a significant main effect, $F(1, 65)$ = 4.68, p = .03, η^2 = .08, such that participants reported more number of nights with insufficient sleep at post- (M = 3.28, SD = 2.07) than at pre-intervention (M = 2.76, SD = 1.73). Results remained the same when excluding drop-outs (n = 11) and when controlling for perceived stress (all *p*s > .10)

Perceived stress was negatively associated with aerobic exercise (r = -.24, p = .04), average hours of sleep per night during the past seven days (r = -.44, p = .00), and positively associated with number of nights in the past seven days with less sleep than needed (r = .23, p = .05). When controlling for perceived stress in the analyses with aerobic exercises as the dependent variables, results remained the same (ps > .10) as was the case with average hours of sleep that participants got over the last seven days and number of nights with less sleep than needed.

Participants who were currently practicing meditation at pre-intervention reported marginally significant more days during the past seven days where they ate fruits (M = 6.75, SD = 0.50) than participants who were not practicing any meditation currently (M = 5.06, SD = 1.91), $F(1, 60) = 3.01$, p = .08, η^2 = .04, and also reported less days where they consumed foods or drinks high in sugar content (M = 1.00, SD = 1.41 compared to M = 3.41, SD = 2.06), $F(1, 60) = 5.27$, p = .02, η^2 = .08. When controlling for current meditation experience in the pertaining analyses, the effects remained the same in that both main effect and interaction remained non-significant (ps > .10).

Coping Strategies. There was no significant main effect of time or interaction for *active coping, positive reframing, venting, substance use, behavioral disengagement,* and *emotional processing* (see Table 7 for main effect and interaction statistics). Since participants who were in a relationship indicated to use venting as a coping strategy more often than participants who were single, I examined the effects of the intervention on venting while controlling for relationship status. Results remained the same (p > .10 for the main effect and interaction).

As can be seen in Table 7, there was a marginally significant interaction for *acceptance*. Simple main effects analyses indicated that participants in the control group exhibited a significant decline in acceptance based coping from pre- to post-intervention $F(1, 65) = 4.16$, $p = .04$ (see Figure 18). Similarly, there was a significant interaction for *spiritual coping* and simple main effects analyses indicated that participants in the intervention group exhibited an increase in spiritual coping from pre- to post-intervention $F(1, 65) = 8.03$, $p = .00$ (see Figure 19). In addition, there was a marginally significant interaction for *emotional expression* with simple main effects analyses indicating that participants in the intervention group exhibited a marginally significant increase from pre- to post-intervention $F(1, 65) = 2.83$, $p = .09$ (see Figure 20). Lastly, there was a significant main effect of time for *self-blame* such that participants in both groups exhibited a decline in self-blame from pre- ($M = 2.28$, $SD = 0.85$) to post-intervention ($M = 2.04$, $SD = 0.75$).

All effects remained the same when excluding participants who had dropped out (n = 11) and/or participants who had missing data (venting: n = 1; self-blame, n = 1).

There was a negative association between perceived stress and active coping ($r = -.22$, $p = .06$) and positive reframing ($r = -.34$, $p = .00$), and a positive association with substance use ($r = .22$, $p = .06$), and self-blame ($r = .46$, $p = .00$). The results above remained the same when controlling for perceived stress (all *p*s > .10).

Participants with a current meditation practice reported higher levels of positive reframing ($M = 3.50$, $SD = 0.57$), acceptance ($M = 3.50$, $SD = 0.40$), and spiritual coping ($M = 3.25$, $SD = 0.64$), than participants without a current meditation practice, (M = 2.80, SD = 0.78), (M = 2.70, SD = 0.77), (M = 1.94, SD = 0.94), respectively; $F(1, 60) = 3.00$, $p = .08$, $\eta^2 = .04$, $F(1, 60) = 4.09$, $p = .04$, $\eta^2 = .06$, and $F(1, 60) = 7.23$, $p = .00$, $\eta^2 = .10$, respectively. However, the effect for positive reframing was only marginally significant, $p = .08$. When controlling for current meditation experience in the analyses pertaining to positive reframing, both main effect and interaction remained non-significant (ps > .10), while the marginally significant interaction for acceptance became non-significant ($p > .10$). The interaction for spiritual coping remained significant when controlling for current meditation experience ($p = .01$, $\eta^2 = .09$).

Mindfulness. As can be seen in Table 7, there was no significant main effect of time or interaction for observing and nonreactivity to inner experience*.* There was a significant interaction for acting with awareness, and simple main effects analyses indicated that participants in the intervention reported higher levels of acting with awareness at post-intervention than participants in the control group $F(1, 60) = 6.12$, $p = .01$; in addition, participants in the intervention and control group exhibited a significant increase in acting with awareness from pre- to post-intervention, $F(1, 65) = 11.27$, $p = .00$ and $F(1, 65) = 42.68$, $p = .00$, respectively (see Figure 21).

Given that there was a significant interaction *for awareness based coping* and *acting with awareness*, and given that both constructs seem to be related in that they both require a widening in cognitive scope, I examined the correlation between the two constructs across both groups at pre- and post-intervention as well as for each group separately. Results indicated that the two constructs were not significantly correlated at pre-intervention across both groups ($r = .12$, $p = .33$), and neither in the control (*r* = .03, p = .85) or intervention group (*r* = .18, p = .30), separately. However, at post-intervention, awareness based coping and acting with awareness were highly correlated in the intervention (*r* = .39, *p* = .02) but not control group (*r* = .07, *p* = .68).

Lastly, there was a significant main effect for describing, such that participants in both groups exhibited an increase from pre- (*M* = 23.87, *SD* = 7.38) to post-intervention (*M* = 26.58, *SD* = 6.39), as well as nonjuding of inner experience, such that participants in both groups exhibited an increase from pre- (*M* = 23.37, *SD* = 10.97) to post-intervention (*M* = 28.13, *SD* = 8.88). There was no significant interaction for describing and nonjudging of inner experience. All effects remained the same when excluding participants who had dropped out (n = 11).

There was a negative association between perceived stress and nonjudging of inner experience (*r* = -.39, *p* = .00), and acting with awareness (*r* = -.33, *p* = .00). The main effect and interaction for non-judging of inner experience remained non-significant when controlling for perceived stress (all *p*s > .10) while the interaction for acting with awareness remained significant as described (*p* = .03, η^2 = .06).

Thought control. There was a significant main effect of time for thought control, such that participants across both groups exhibited an increase from pre- (*M* = 80.51, *SD* = 12.97) to post-intervention (*M* = 83.75, *SD* = 14.52) while the interaction was non-significant. All effects remained the same when excluding participants who had dropped out (n = 11).

Perceived stress was negatively associated with thought control (*r* = -.51, *p*

= .00). When controlling for perceived stress in the above analyses, the main effect became non-significant ($p > .10$) and the interaction remained non-significant ($p > .10$).

Worry. Similar to thought control, there was a significant main effect of time for worry, such that participants across both groups exhibited a decline in worry from pre- ($M = 52.31$, $SD = 10.46$) to post-intervention ($M = 49.89$, $SD = 11.04$) while the interaction was non-significant. All effects remained the same when excluding participants who had dropped out (n = 11).

Perceived stress was positively associated with worry ($r = .46$ $p = .00$) and when controlling for perceived stress in the above analyses, the main effect became non-significant while the interaction remained non-significant (all *p*s > .10).

Ancillary Analyses.

In order to examine whether regular meditation practice would be associated with better Stroop performance, I examined whether participants who used the meditation techniques more frequently would perform better at the Stroop task than participants who used the meditation techniques less frequently. There was no main effect of group on Stroop reaction time at post-intervention such that participants who indicated to use the techniques more often did not differ from participants who used the techniques less often, $F(1, 17) = 1.15$, $p = .33$, $\eta^2 = .12$ Groups did not differ on Stroop error rate either, $F(1, 25) = 0.61$, $p = .54$, $\eta^2 = .04$.

Lastly, given the decline in feelings of pride in participants in the control group (see page 56), I examined the association between pride and performance on the Stroop task at post-intervention. Self-reported pride levels were not associated with Stroop reaction time at post-intervention, (β = - 0.11, p = .42); overall $F(1, 51) = 0.63$, p = .42, R^2 = .01. This was also the case when controlling for pre-intervention pride levels and Stroop reaction time (β = - 0.01, p = .90) while Stroop reaction time at pre-intervention was significantly associated with Stroop reaction time at post-intervention in this model (β = 0.76, p = .00), overall $F(3, 49) = 22.77$, p = .00, R^2 = .76. Furthermore, self-reported pride levels were not associated with Stroop error rate at post-intervention, (β = - 0.07, p = .56); overall $F(1, 65) = 0.33$, p = .56, R^2 = .00 and this held up when controlling for pre-intervention pride levels and Stroop error rate, (β = - 0.0, p = .98); overall $F(3, 63) = 15.09$, p = .00, R^2 = .41 while Stroop error rate at pre-intervention was significantly, and pre-intervention pride levels marginally significant associated with Stroop error rate at post-intervention in this model, (β = 0.64, p = .00, and β = -0.21, p = .08, respectively).

Discussion

This study examined the effects of a four-week yogic breath meditation intervention on attention control, blood glucose and cardiovascular measures, in addition to changes in other domains of self-control. There were no intervention effects on the main outcome of interest, attention control, as was the case for heart rate and blood pressure.

The intervention was associated with changes in blood glucose depletion in that participants in the control group exhibited a sharper decline in blood glucose levels after completing the Stroop task at post-intervention compared to participants in the intervention group. In fact, for participants in the intervention group, the decline in blood glucose levels in response to the Stroop task remained fairly stable from before to after the intervention. In addition, participants in the control group reported lower levels of positive affect after completing the Stroop task at post-intervention compared to participants in the intervention group, however, this group difference was mainly driven by feelings of pride. Lastly, there were group differences in other domains of self-control such as acceptance and spiritual based coping and emotional expression and the mindfulness domain of acting with awareness, which are discussed in more detail below.

Hypothesis 1: Intervention Effects on Attention Control

Contrary to my hypothesis, the intervention did not have any impact on participants' attention control. Participants in both groups made more errors during the post-intervention than pre-intervention visit and there were no improvements for reaction time from before to after the intervention. This is contrary to a number of meditation studies which have linked meditation practice to better Stroop performance, e.g., faster reaction time (e.g., Moore, Gruber, Derose & Malinowski, 2012; Wenk-Sormaz, 2005); yet, it should be pointed out that most studies focus on improvements in Stroop reaction time while only a few focus on error rates (e.g., Gailliot et al., 2007). One possible reason for the increase in error rates in participants in this study might have been that post-intervention visits were scheduled around final exam time where participants might have experienced a decline in overall self-control. This would be somewhat consistent with Gailliot et al.'s study (2007), where participants completed the Stroop task before and after a video task that required self-control. Those participants who received a glucose drink after the task did exhibit a slight, albeit non-significant, increase in error rates and participants who received water only, made significantly more errors on the

Stroop following the video task. As such, self-control depletion seems to be associated with higher error rates on the Stroop task. This explanation remains speculative, however, given that I did not assess overall self-control strength.

The null findings for attention control are contrary to some Western theoretical frameworks which propose that meditation has its positive effects on mental health by altering cognitive processes such as shifting attention inwards and away from distracting stimuli thereby preventing emotional reactions (Sedlmeier et al., 2012). Although, Sedlmeier and colleagues (2012) found in their meta-analysis that meditation does affect attention control, the effects are relatively small compared to meditation effects on emotional states such as anxiety. However, Sedlmeier and colleagues (2012) add that one should be cautious in interpreting the findings because "small causes sometimes can have huge effects; that is, small changes in cognition might yield huge changes in emotional variables" (p. 1159). Although the intervention described here did not show any effects on measures of attention control, it would be premature to conclude that meditation does not improve attention at all. Instead, there might be other factors explaining how and when meditation practices translate into improvements in attention control.

Duration of the meditation practice might be one such factor. Indeed, a number of studies that show positive effects on attention control are interventions of long duration, such as three months, which consist of an intensive daily meditation regiment (e.g., Slagter et al., 2007; MacLean et al., 2010). In one study, long time practitioners participated in a three-month long retreat while participants in the control group received a one-hour meditation class and were instructed to meditate 20 minutes per day during the week preceding the post-intervention assessment (Slagter et al., 2007). As expected, participants undergoing the three-month long retreat showed improvements in attention control (measured by the attentional blink task) while participants in the control group did not show any improvement. Similarly, in another study participants took part in a three-month long retreat which included a five hours per day meditation regimen and as in the previous study, participants exhibited improvements on measures of attention control (MacLean et al., 2010).

Yet, there are also interventions of shorter duration that were associated with improvements in attention control. In one study (discussed in the introduction on p. 24), participants completed the Stroop task right after undergoing a 20-minute meditation exercise (e.g., Wenk-Sormaz, 2005). That is, participants practiced a breathing meditation for 20 minutes right after the Stroop task followed by retaking the Stroop a second time and compared to the control group, participants who had completed the breathing meditation exhibited a faster average reaction time on the Stroop. The results are remarkable given the short duration of the intervention, yet factors such as priming and practice effects might account for the positive findings. Yet, other intervention studies with a more moderate duration of ten-, five-, and four-days only, have also been associated with improvements in attention control (Chambers, Lo, & Allen, 2008; Tang et al., 2007 and Zeidan et al., 2010). What sets these interventions apart from the longer meditation interventions (Slagter et al., 2007; MacLean et al., 2010) is that participants were complete meditation novices. Indeed, *meditation experience* might contribute to interventions' positive findings as experienced meditators perform better on the Stroop task (reaction time) than novices (Chan & Woolcolt, 2007). As such, perhaps there is more room for improvement in absolute meditation novices. Given that my sample consisted of novices and participants with meditation experience, I examined meditation experience as a potential covariate, yet groups did not differ on any of Stroop performance measures as a function of meditation experience. The degree to which interventions have different effects on experienced meditators compared to novices is a relevant topic for future research studies.

Yet, another important factor to take under consideration is that daily meditation practice time, as opposed to total hours spend meditating, has been associated with better Stroop performance (Chan & Wolacolt, 2007). While daily meditation practice was not associated with Stroop performance in this sample, it should be noted that the assessment of daily meditation practice was rather limited. More specifically, participants simply indicated whether they had used any of the meditation techniques during the morning, midday, or evening. In addition, participants did not receive specific instructions when to record the use of daily meditation techniques. It is therefore possible that participants over- or underestimated their daily meditation time. In order to get the most reliable and valid measurement of participants' daily use of meditation techniques, a methodology such as ecological momentary assessment would be more appropriate.

How *attention is operationalized and measured* is another important factor when examining the effects of meditation on attention control. For example, there are various tasks in order to assess attention control besides the Stroop, such as the attention network test (Tang et al., 2007) or the attentional blink test (Slagter et al., 2007). In addition, attention control can be assessed at multiple levels, such as brain activity and performance on cognitive tasks combined (e.g., Tang et al., 2007). Indeed, assessing performance on cognitive tasks only, can leave valuable findings undetected. A good example for this is Moore et al.'s (2012) study where participants undergoing a meditation intervention showed improvements in brain activity related to attention control but not actual Stroop performance. This points to one of the shortcomings of my study, namely that the assessment of attention control was very limited, i.e., performance on the Stroop task only, and it is therefore difficult to completely rule out any intervention effects on attention control.

Hypothesis 2: Intervention Effects on Blood Glucose Levels

A notable finding of this study was the sharper decline in blood glucose from pre- to post-intervention in participants in the control group. While the decline in blood glucose from before to after the Stroop remained constant in participants in the intervention group, it actually worsened in the control group[16]. One possible reason for this finding is that participants in the intervention group simply believed that their self-control was based on an unlimited "source of energy". Indeed, past research has shown that when people believe that their self-control is resistant to depletion (as opposed to believing that their self-control relies on a limited source of energy and as such could be depleted), they also exhibit better self-control (Job,

[16] This effect cannot be accounted for by food consumed on the day of the experiments. As mentioned on p. 31, participants in both groups were given specific food consumption instructions. We verified that all participants followed these instructions and that groups did not differ in the food that they had consumed on the day of the experiment.

Deck, & Walton, 2010). Hence, simply believing that one's self-control is unlimited can result in better self-control strength[17].

It is intriguing to think that the mere thought of having an unlimited capacity of self-control could bolster self-control in and of itself, and in the case of my dissertation study, prevent ego depletion as measured by a decline in blood glucose levels during a self-control task. Cultivating and restoring mental and physical energy through focus on the breath was a main topic during the intervention classes and as such, it is a possibility that participants' belief about their own self-control capacity had an influence on blood glucose levels throughout the Stroop task, particularly given the close link between blood glucose and self-control efforts (Gailliot & Baumeister, 2007).

Hypothesis 3: Intervention Effects on Cardiovascular Measures

There were no intervention effects on participants' cardiovascular measures, namely blood pressure and heart rate. Findings of past meditation studies and their effects on cardiovascular measures have been mixed. For instance, a study in healthy undergraduate students with a family history of hypertension, did not find any effects of a brief mindfulness intervention on cardiovascular reactivity and recovery in response to a cold pressor task (Grant, Hobkirk, Persons, Hwang, Danoff-Burg, 2013). This was also the case for a few brief meditation interventions in healthy adults, where, for instance, a mindfulness body scan was not associated with improvements in cardiovascular functioning in response to a stressful task (Ditto, Eclache, & Goldman, 2006) as was the case for a three-week mindfulness

[17] This was the case for dispositional beliefs and experimentally induced beliefs about self-control in Job, Deck, and Walton's, 2010 study.

intervention, consisting of two mindfulness sessions each week, in healthy adults (Kingston, Chadwick, Meron, & Skinner, 2007).

However, intervention studies of a longer duration, such as two or three months, have found a relationship between meditation and more adaptive cardiovascular functioning at rest (Barnes, Pendergrast, Harshfield, & Treiber, 2008) and in response to an acute laboratory stressor (Barnes, Treiber, & Davis, 2001). In addition, other studies have found an association between meditation and more adaptive cardiovascular functioning during and the time period following breathing-based meditation in long-time practitioners (Lehrer, Sasaki, & Saito, 1999) and for mantra-based meditation in yoga novices (Bernardi et al., 2001). As is the case for attention control (discussed above), intervention duration and meditation experience are two important factors that should be examined more closely in future studies, examining the effect of meditation on mental and physical health.

Hypothesis 4: Intervention Effects on Negative and Positive Affect and Reported Stress Levels following the Stroop Task

At post-intervention, participants in the control group displayed lower positive affect levels after the Stroop task compared to participants in the intervention group. This finding was somewhat surprising given the meta-analysis by Sedlmeier et al. (2012) and other intervention studies which show that meditation has positive effects on emotion (e.g., Chambers et al., 2008; Zautra et al., 2010). For instance, a brief laboratory based study, which consisted of a 10-minute breathing intervention, was associated with higher levels of positive affect following a film clip with positive content, in addition to lower negative affect and difficulties regulating emotions after watching a film clip with mixed emotional content, as well as higher levels of decentering compared to the control group (Erisman & Roemer, 2010).

Other studies have observed an increased ability in decentering from negative emotions following a meditation intervention (e.g., Feldman, Greeson, & Senville, 2010; see intro). Indeed, decentering from unpleasant and disturbing emotions is a main objective of meditation practices. However, participants in this intervention study did not show any change in decentering as was measured by nonreactivity to inner experiences on the Five-Facet Mindfulness Scale Questionnaire (Baer et al., 2008) (the studies mentioned above assessed decentering using different scales) nor did they show any change in negative affect ratings.

However, it is of note that while participants in the control group displayed a decline in positive emotions, participants in the intervention did not show much change. As such, one speculation could be that the intervention served as a buffer against a potential decline in positive emotions which might have occurred as a natural result of stress associated with the quarter in participants in the control group. Indeed, according to Buddhist philosophy, destructive emotions are at the core of human suffering which one can overcome by learning to "eliminate emotions that afflict the mind", and cultivate happiness[18] (Dalai Lama, p. 20; Goleman, 2003).

Yet, it is important to distinguish happiness from pleasure. For instance, as the famous Buddhist monk Matthieu Ricard states (in the context of a talk that he gave at a Mindlife conference): "happiness is understood here to refer to a deep

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[18] It is important to note that destructive and constructive emotions cannot necessarily be differentiated by their face value. For instance, desiring peace for all human beings constitutes a constructive emotion as it contributes to the happiness of all sentient beings, a core value of (Tibetan Buddhism), while being happy as a result of seeing someone being hurt would constitute a destructive emotion.

sense of fulfillment, accompanied by a sense of peace and a host of positive qualities such as altruism. Pleasure depends upon the place, the circumstances, and the object of its enjoyment" (Goleman, 2003, p. 85). As such, the aim is not to attain a state of euphoria and pleasure, but instead a content, positive state of peace and well-being.

With this in mind, I re-examined the positive affect items of the PANAS subscales. I deemed particularly two items, *proud* and *excited,* to be not fully consistent with the Buddhist and Yogic view on constructive emotions as both are dependent on context and place and are high in activation and arousal, particularly *excited*. Emotions high in activation and arousal have been associated with negative health outcomes (Pressman & Cohen, 2005). In contrast, I deemed the two items *calm* and *relaxed* to be in line with the Buddhist and Yogic view on constructive emotions. While there were no intervention effects for calm, relaxed, or excited, the lower positive affect levels in the control group seemed to be mainly driven by feelings of pride. However, pride was not associated with performance on the Stroop task. Although I deemed pride to be an emotion that is less consistent with Buddhist and Yogic values, pride is not necessarily a destructive emotion. For instance, for a student who has repeatedly received low grades due to a learning disability, a sense of pride in response to a well-deserved good grade, can be an adaptive emotion that restores hope. Indeed, pride has been associated with a sense of 'self-worth' and 'feeling good about oneself' (Cavanaugh, Cutright, Luce, & Bettman, 2011). For this study, pride was assessed right after performance on the Stroop task. As such, perhaps meditation served as a buffer against a decline in pride in participants in the intervention group. Whether pride can serve an adaptive function within a meditation context, is a topic for future research.

Hypothesis 5: Intervention Effects on other Domains of Self-Control

Besides the above mentioned effects, there were group differences in other domains of self-control as well, most notably acceptance-based coping which has been linked to improvements in mental health in HIV-positive men (Carrico et al., 2006). That is, participants in the control group exhibited a decrease in acceptance-based coping from before to after the intervention, while participants in the intervention group did not exhibit any change.

Participants in the intervention group also showed an increase in emotional expression and spiritual based coping from before to after the intervention. While the intervention did not include any explicit spiritual or religious topics, one could argue that certain topics covered during the classes were intrinsically spiritual, such as using the breath to calm the mind, using the breath to stay anchored in the present moment, cultivating a sense of oneness by connecting to the breath, just to name a few. In addition, the spiritual coping subscale included whether or not participants had been praying or meditating as a way of coping. Hence, given that participants received a daily meditation homework as part of the intervention, the increase in spiritual coping is not surprising.

The emotional expression scale consisted of items such as *I take time to express my emotions, I let me feelings come out freely,* and *I feel free to express my emotions*. However, it is difficult to conclude whether the increase in emotional expression that was associated with the intervention is adaptive. While emotional expression has been associated with a number of positive mental and physical health outcomes in populations who are faced with stress, such as couples coping with infertility, women with breast cancer, and women who have been sexually assaulted (in Stanton & Low, 2012), whether emotional expression promotes positive outcomes depends on a variety of factors. According to Stanton and Low (2012), emotional expression is most adaptive during (a) situations that are relatively uncontrollable, (b) when used by individuals who are dispositionally inclined to experience emotions intensely and express their emotions frequently, and (c) when emotion expression is welcomed by close others. According to a mindfulness framework, emotional expression could be adaptive as long as one remains non-judgmental and unattached towards the emotion (Shapiro, Astin, & Freedman, 2006), however, the utility of emotional expression within a meditation context warrants further investigation.

Participants in both groups exhibited an increase in describing and non-judging of inner experience. Similarly, participants in both groups exhibited an increase in thought control and a decline in worry from before to after the intervention. Why participants in the control group experienced such changes is unclear. The fact that the sample consisted of UCLA students might have been a contributing factor. For instance, it might well be that participants developed more thought control as a function of coursework (e.g., completing homework, exams, term papers etc.) and/or that students were exposed to meditation techniques through campus activities and services. The decline in worry that participants in both groups exhibited might have been due to the timing of the post-intervention visits which were scheduled around the end of the quarter when students finished up their coursework and final exams and, as such, perhaps experienced a sense of relief.

Yogic Breath-Based Meditation: a Way for Promoting Self-Control?

Findings of this study suggest that using breath-based meditation might help to promote physiological resistance to self-control as measured by less glucose depletion in response to a challenging cognitive task. However, based on this study we cannot conclude that a four-week breath based meditation intervention promotes attention control as measured by performance on the Stroop task and self-control in the form of health behaviors. It is also important to consider that the null findings might be a function of some of the study's limitations such as the lack of measuring attention control at multiple levels, which I had discussed earlier (e.g., Moore et al., 2012) and assessing health behaviors through retrospective self-reports only.

A main assertion of this study was that meditation promotes self-control and a more fluid self-concept (see *Introduction* for an in-depth discussion of this topic; and Brown, Ryan, Creswell, 2007a). There might be some evidence for this in that participants in the intervention group reported higher levels of spiritual based coping and emotional-expression after, compared to before, the intervention. In addition, participants did not exhibit a decline in acting with awareness and acceptance based coping, as did participants in the control group after the intervention.

Possible mechanisms. It is worth discussing why breathing-based meditation would be a useful way for promoting self-control and I would like to propose a few possibilities that might offer fertile ground for future research.

Creating psychological flexibility. A main topic of the intervention classes was to use the breath in order to create psychological flexibility, mental space, and acceptance. Some examples are: "*the movement of our breath is connected to the movement of our thoughts and emotions*", "*we want to use the breath to stay fully in the present moment with our mind and remain fairly unaffected by any thoughts and emotions that might come up in a situation*", "[…] *when we constantly react and attach ourselves to our surroundings we constantly activate our negative and positive mind and end up in emotional turmoil […] What we have to do is connect to our neutral mind. We can think of the neutral mind as our center. Our neutral mind is the 'whatever' in us. It doesn't make us aloof. In fact, the neutral mind enables us to open up ourselves fully to the world […] The way we can access this center, our neutral mind, is our breath. It is what connects our inside with the outside […]".*

This aspect of the intervention shares some similarities with Acceptance and Commitment Therapy (ACT), which has been an effective therapy for work-related stress and problems associated with weak self-control such as nicotine addiction (Hayes, 2004). Indeed, a core feature of ACT is to deal with recurring negative thoughts by creating a psychological space within which one cultivates acceptance and mindfulness of occurring thoughts and emotions instead suppressing them. Similarly, during the intervention, the goal was to "soften" mental confines that had been created by cognitive processes, e.g., I should not think this thought, I should not feel this emotion, and instead create a psychological space of acceptance and mindfulness. There is some research evidence that links breath and emotions (e.g, Brown & Gerbarg, 2009). As such, perhaps breathing meditations are one tool for cultivating a calm and relaxed attitude when faced with challenging thoughts and emotions, thereby creating psychological flexibility. Through this psychological flexibility, breathing meditations might offer a window for change, where practitioners are particularly open to learning new adaptive skills for coping with challenging situations (Loizzo, Charlson, & Peterson, 2009).

Creating physiological flexibility. Besides psychological flexibility, breathing meditation might also promote physiological flexibility. Indeed, at a very basic physiological level, the breath is associated with the autonomous nervous system, specifically the parasympathetic and sympathetic nervous system. Altering one's breathing pattern is associated with changes in autonomous nervous system activity as measured by resting heart rate variability (HRV) and respiratory sinus arrhythmia (RSA) which are indices of sympathetic (SNS) and parasympathetic nervous system (PNS) activity (in Brown & Gerbang, 2009). Yogic breathing in particular has been linked to more adaptive HRV and RSA rates (Brown & Gerbang, 2009), which is of note as less adaptive HRV and RSA levels have been associated with a variety of negative mental and physical health outcomes such as depression and obesity (Carney, Saunders, Freedland, et al. 1995; Karason, Molgaard, Wikstrand, & Sjostrom, 1999).

Connecting the mind with the body. Focusing on the breath might be useful in bringing people more in tune with their bodies. Indeed, mental and physical health problems can be linked to viewing the body as an independent and separate entity from the mind. For instance, research has shown that people who are primed with the concept of 'body-mind dualism', i.e., seeing the body and mind as two separate entities, also report less adaptive health behaviors and less positive attitudes towards health behaviors than when they are primed with a message that conveys that mind and body are connected (Forstman, Burgmer, & Mussweiler, 2012). As such, seeing the body and mind as connected can facilitate health behaviors because one understands that in order to maintain a healthy mental and physical state, one needs to take care of the body. Perhaps focusing on the breath can help people connect their body with their mind (a topic that is commonly mentioned during meditation and yoga classes) by offering not only a conceptual frame, but also an experience, e.g., how does my breath feel like, what does it do to my body, what am I sensing, etc.

***Breath as an object of focus during meditation*.** At a very basic level, the breath simply offers a focus of attention during meditation. It is no accident that focusing on the breath is a gateway into a more serious meditation practice. That is because concentrating on the breath helps to focus attention and still the mind particularly during the early stages of a new meditation practice. As a result, simple breathing meditations (typically long deep belly breathing) are part of a number of meditation interventions (e.g., Jha, Krompinger, & Baime, 2007; Feldman, Greeson, & Senville, 2010; Tang et al., 2004; Lutz et al., 2004). However, to my knowledge, this was the first intervention study that used the breath as a primary focus. Indeed, while many intervention studies utilize breathing meditations to some extend, focusing on the breath is typically just a secondary focus.

Furthermore, a shortcoming of meditation studies thus far has been that a theoretical framework explaining why and how breath work might be beneficial to mental and physical health is lacking. Yet, in order to uncover mechanisms that help us understand the effects of breathing meditation on physical and mental health, a guiding theory is much needed[19].

Limitations

A few study limitations merit mention. First and foremost, the small sample size (*N* = 67) might have limited my power to detect any intervention effects. This might have been particularly true for reaction time given that I was not able to analyze data of the first cohort of participants (n = 14). While my sample yielded enough power to detect effects of a medium size, a larger sample would have been more beneficial to detect small effect sizes, particularly for the more intricate post-intervention analyses. Furthermore, the study included participants with and without current and prior meditation experiences. This might have influenced the way participants dealt with the cognitive task during the experiments and the way they assimilated the material of the intervention classes. However, participants with prior experience and novices were spread equally across groups, thereby minimizing the influence of meditation experience as an extraneous variable.

The retrospective self-reports might have limited response accuracy. For instance, in order to assess participants' *use of meditation techniques* throughout the day, participants were asked to indicate whether they had used any of the breathing techniques at (1) AM, (2) midday, and/or (3) PM. However, I did not specify to participants when to fill out their responses. As such, it might well be that participants waited until the end of the day, possibly giving a biased over- or underestimate of when they had used the techniques. For assessing attention

[19] It should be noted that Buddhist psychology actually offers a comprehensive theoretical framework that could help us understand the workings of the breath on the mind. Current efforts are on the way to integrate the Eastern and Western psychological approach as can be seen during meetings such as the *Mind & Life Conference*.

control, I used a computerized version of the Stroop task; yet, different Stroop versions, e.g., paper-pencil, might yield different effects (e.g., Moore, 2012).

About 18 percent of participants in each group were lost to follow-up. This rate includes participants who were not able to make it to the classes and/or the post-intervention visit and is comparable to other intervention studies (Moore et al., 2012; Condon, Desbordes, Miller, & DeSteno, 2013; Pace et al., 2009). However, it should be noted that only one participant (n = 1) actually discontinued the meditation classes, in this case after one class. All other participants (n = 27) participated in all four classes (not including six participants who did not participate in the meditation classes to begin with). Offering meditation classes during other times during the day could be one preventive measure in order to reduce drop out rates in future studies.

The study included only two data points, namely right before and after the intervention, and as such, possible intervention effects that might become apparent over time only, might have remained undetected. Regression to the mean, poses another possible explanation for some of my study findings, particularly the decrease in acceptance based coping and blood glucose levels from before to after the intervention in the control group.

Instructor characteristics could have further influenced study results. In order to reduce the effects of this potential covariate, future studies could have different teachers for each cohort. Lastly, the sample consisted of healthy participants only, thereby limiting generalizability of study results to clinical samples.

Notwithstanding these limitations, to my knowledge, this is the first randomized controlled trial that used different types of yogic breathing techniques as its key intervention ingredient. Although breathing meditation has been a central part of mind-body interventions, the focus is typically on deep belly breathing. This study, in contrast, used a much wider repertoire, starting with long deep belly breathing and adding more complex yogic breathing techniques such as segmented and paused breathing. In addition, the intervention was based on a strong theoretical basis which is an aspect that is often neglected in intervention studies that utilize meditation. Lastly, only one participant discontinued the intervention after one class, while all other students who began with the intervention (n = 27) participated in all four classes. As such, notwithstanding the study's limitations, examining the potential of different breathing meditation techniques in order to navigate the complex nature of the mind, is an exciting and intriguing topic for future research studies.

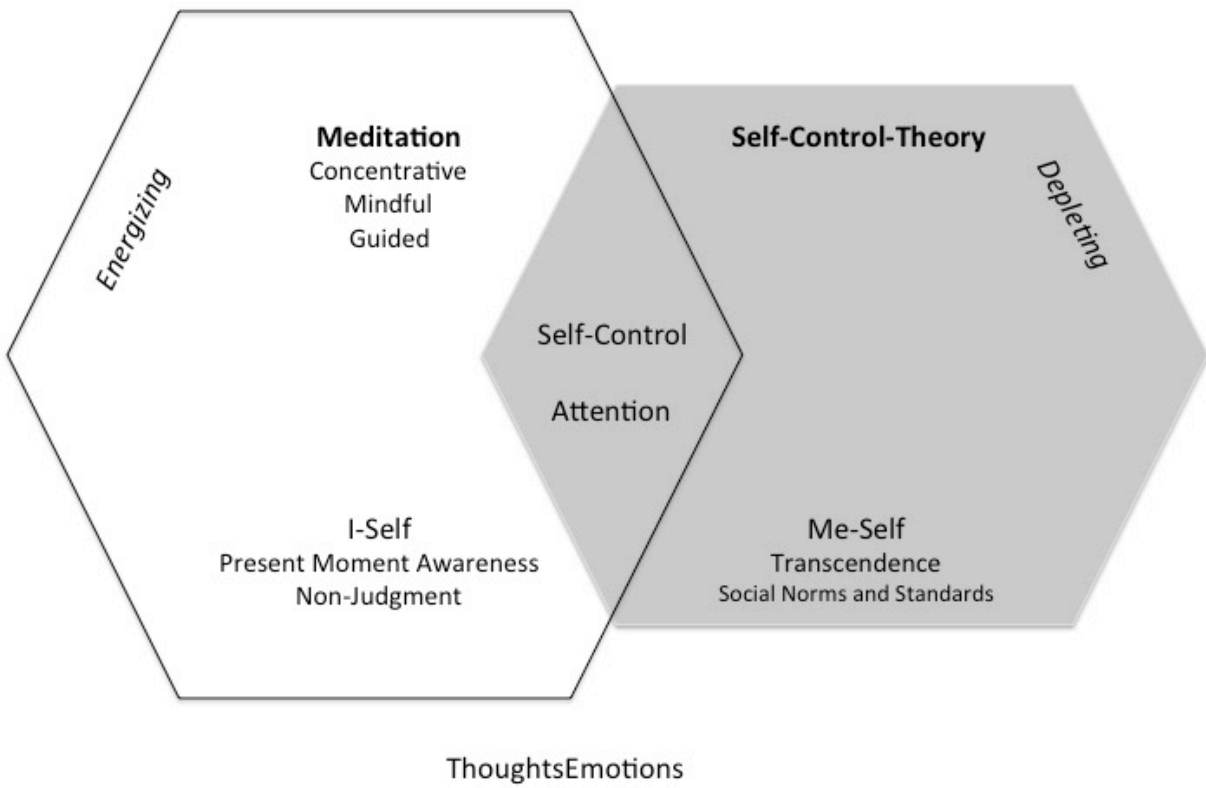

Figure 1. *Self-control within a meditation and self-control theory context.*

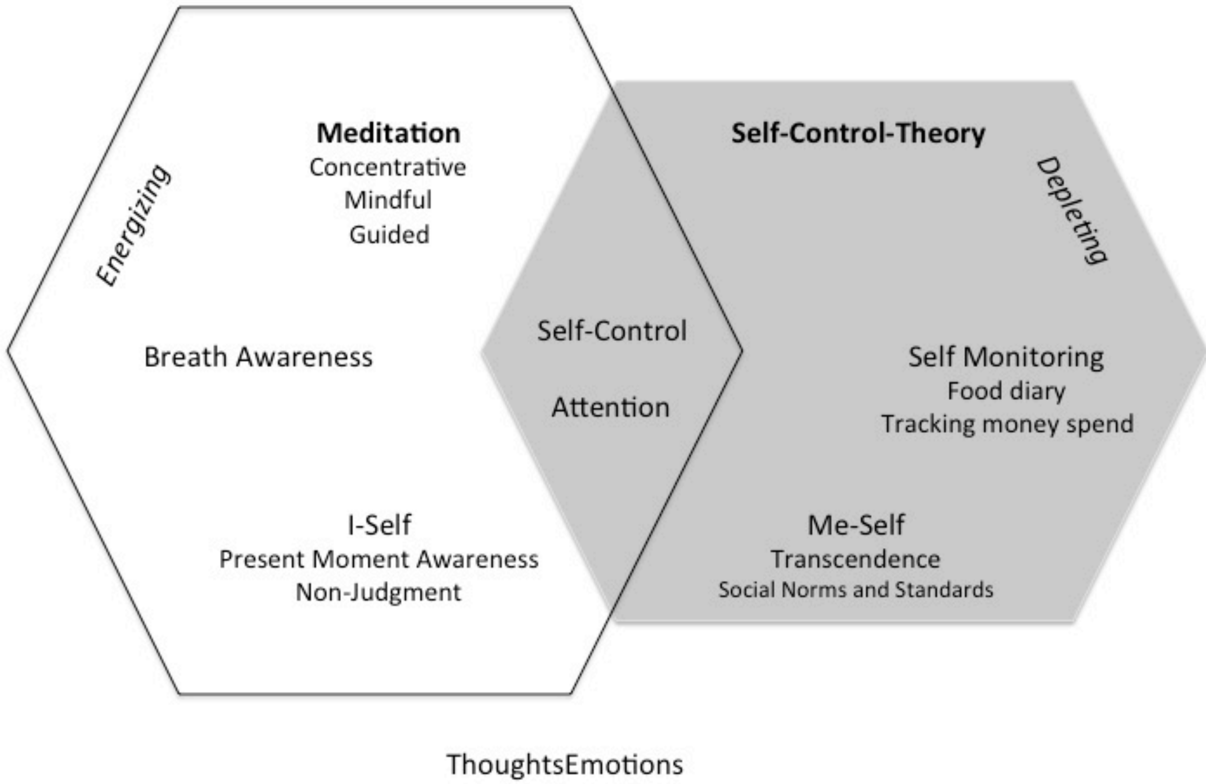

Figure 2. Breath awareness as a way of fostering self- and attention control.

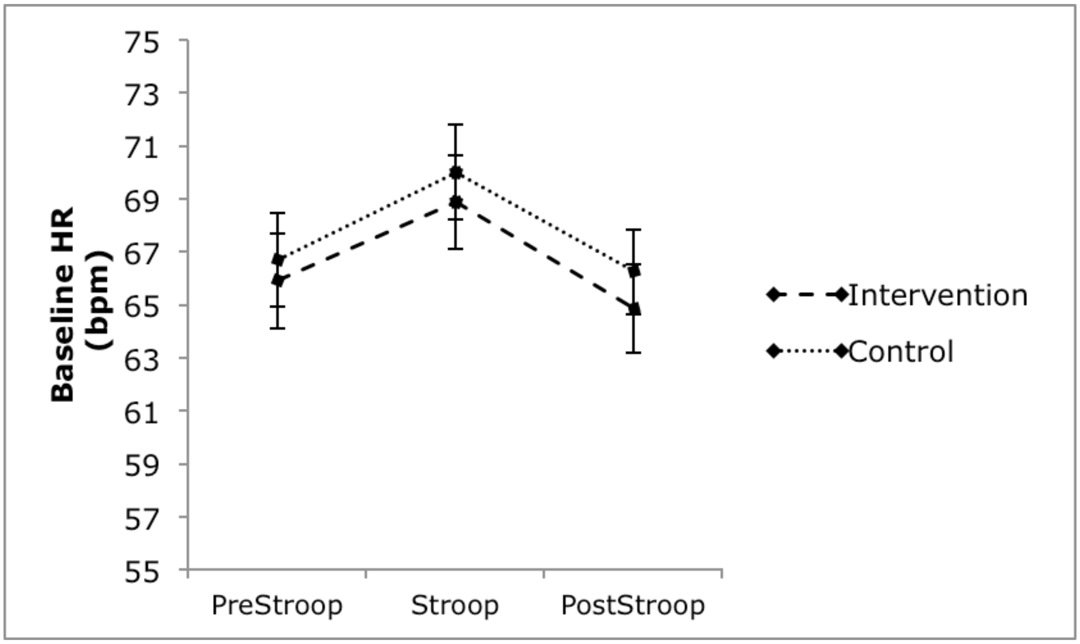

Figure 3. Heart rate at pre-intervention before, during, and after the Stroop task.

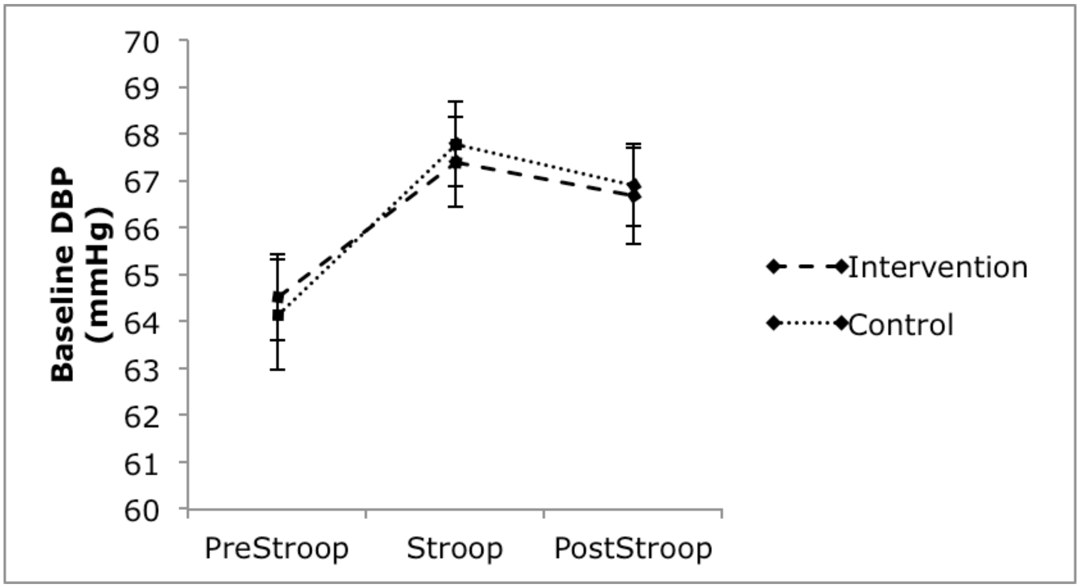

Figure 4. Diastolic blood pressure at pre-intervention before, during, and after the Stroop task.

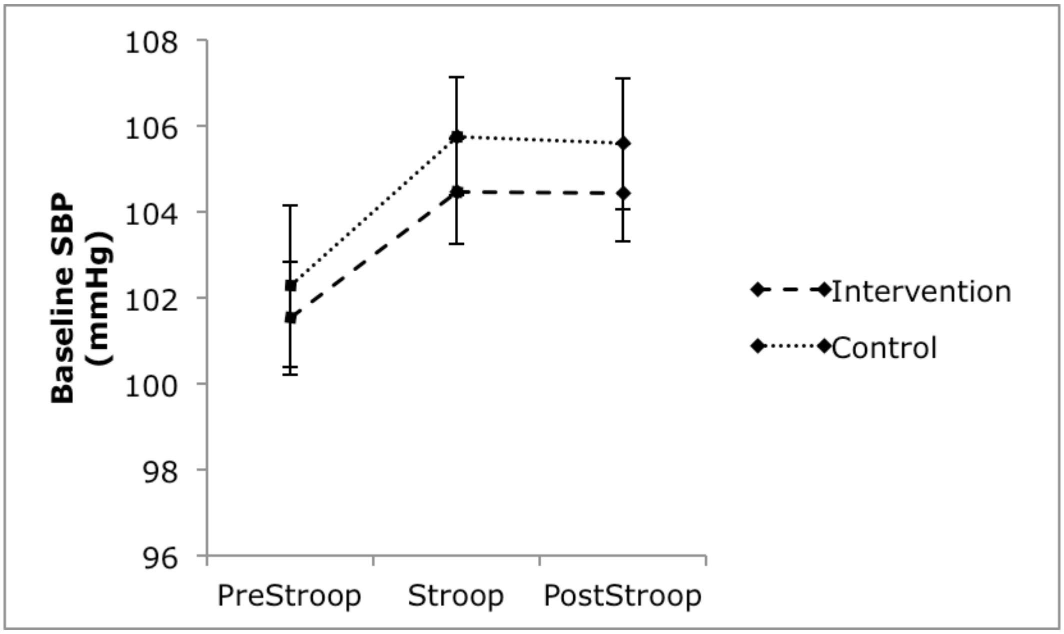

Figure 5. Systolic blood pressure at pre-intervention before, during, and after the Stroop task.

Table 1

Participant characteristics – Health Variables

	Intervention group (n = 34)		Control group (n = 33)	
Variable	Mean	SD	Mean	SD
Age	20.51	2.61	19.72	1.90
Height (m)	1.64	0.07	1.63	0.06
Weight (kg)	60.13	8.69	59.70	9.46
BMI	22.15	2.25	22.18	2.70
Variable	N	%	N	%
Smoked in past	3	8.82	1	3.03
Past diagnosis of depression	1	2.94	1	3.03
Meditation				
Practiced in the past	6	17.64	6	18.18
Still practicing	2	5.88	1	3.03
Practicing meditation as part of yoga class	1	2.94	1	3.03
Yoga				
Practiced yoga in the past	22	64.70	24	72.72
Still practicing yoga	10	29.11	6	18.18

Table 2
Participant characteristics

Variable	Intervention group (n = 34) N	%	Control group (n = 33) N	%
Males	4	11.76	5	15.15
Females	30	88.23	28	84.84
Ethnicity				
White	11	32.35	14	42.42
African American	1	2.94	0	0
Asian	12	35.29	12	27.50
Hispanic	6	17.64	6	18.18
Other	4	11.76	1	3.03
Full-time student	31	91.17	27	81.81
Employed part-time	3	8.82	5	15.15
Committed relationship	2	5.88	7	21.21
Single	32	94.11	26	78.78
Has children	0	NA	0	NA
Living with parents	8	23.52	11	33.33
Family income				
< $30,000	7	20.58	5	15.15
$30,001 - $75,000	10	29.41	8	24.24
$75,001 - $100,000	5	14.70	5	15.15
> = $100,001	11	32.35	11	33.33

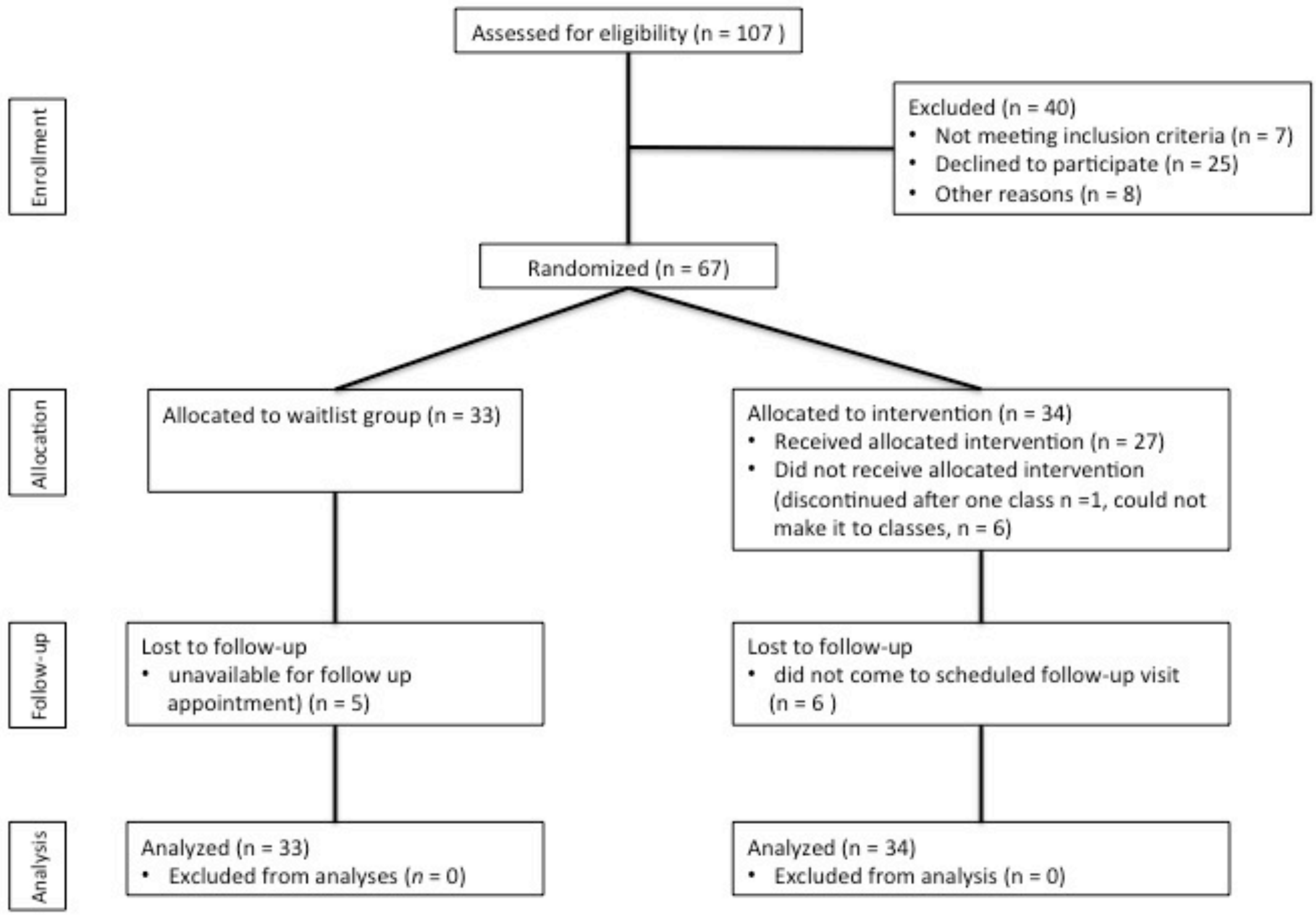

Figure 6. CONSORT trial participation flow diagram.

Table 3

Raw values of attention control at pre- and post-intervention

	Intervention group (n = 34)				Control group (n = 33)			
	Pre-intervention		Post-intervention		Pre-intervention		Post-intervention	
Variable	M	SD	M	SD	M	SD	M	SD
Stroop error rate[1]	17.22	16.38	18.68	13.97	14.73	12.03	19.66	20.42
Stroop reaction time[2]	1133.06	259.07	1162.93	297.18	1264.55	435.80	1333.36	393.08

[1]This data excludes one color blind participant.

[2]This data excludes the first cohort of participants (n = 14) as reaction time was not recorded as well as one color blind participant.

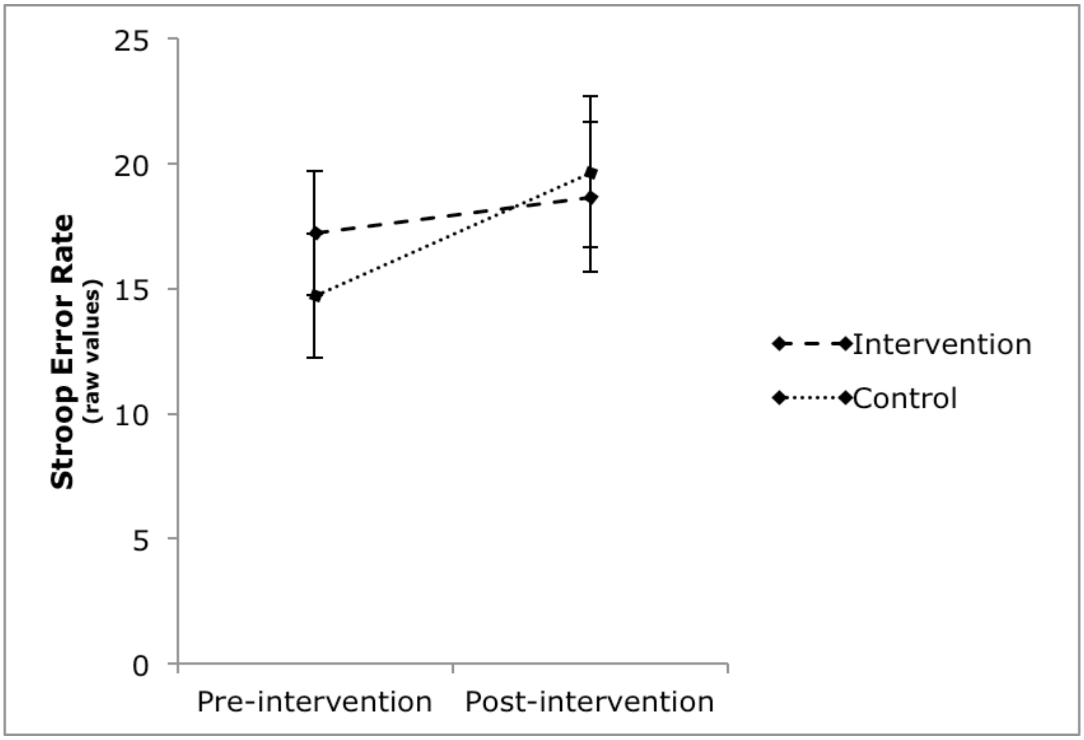

Figure 7. Average Stroop error rate at pre- and post-intervention.

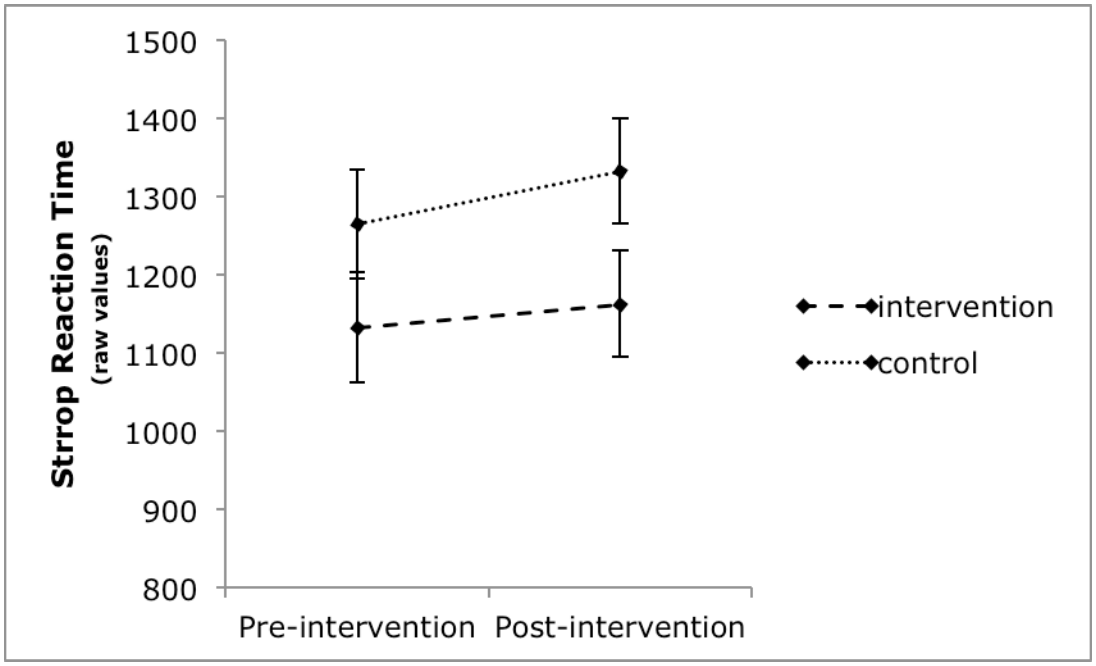

Figure 8. Average Stroop reaction time pre- and post-intervention.

Table 4

Raw values of blood pressure (SBP, DBP), heart rate (HR) and blood glucose (BG) before, during, and after the Stroop task

Before the Intervention

	Intervention (n = 34)			Control group (n = 33)		
	Pre-Stroop	Stroop	Post-Stroop	Pre-Stroop	Stroop	Post-Stroop
Variable	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
SBP	101.53 (7.68)	104.48 (7.22)	104.48 (7.22)	102.27 (10.90)	105.75 (7.95)	105.75 (7.95)
DBP	64.52 (5.31)	67.40 (5.62)	66.68 (5.99)	64.14 (6.73)	67.79 (5.18)	67.90 (5.06)
HR	65.89 (10.21)	68.88 (10.49)	64.86 (9.84)	66.71 (10.25)	70.02 (10.36)	66.25 (9.27)
BG	94.38 (12.09)	92.05 (11.65)	89.94 (9.22)	95.24 (9.85)	95.78 (8.84)	94.24 (10.86)

After the Intervention

	Intervention (n = 34)			Control group (n = 33)		
	Pre-Stroop	Stroop	Post-Stroop	Pre-Stroop	Stroop	Post-Stroop
Variable	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
SBP	101.29 (7.66)	103.68 (7.89)	104.93 (7.28)	100.81 (8.41)	105.13 (8.24)	104.69 (8.80)
DBP	63.90 (5.91)	66.49 (5.57)	66.50 (6.69)	63.15 (5.51)	66.39 (5.00)	66.88 (6.25)
HR	67.49 (10.66)	70.74 (10.18)	64.96 (9.97)	67.65 (10.03)	71.35 (8.75)	66.44 (9.02)
BG	97.94 (13.61)	96.14 (13.25)	92.88 (10.46)	102.27 (12.23)	95.48 (9.14)	94.24 (9.79)

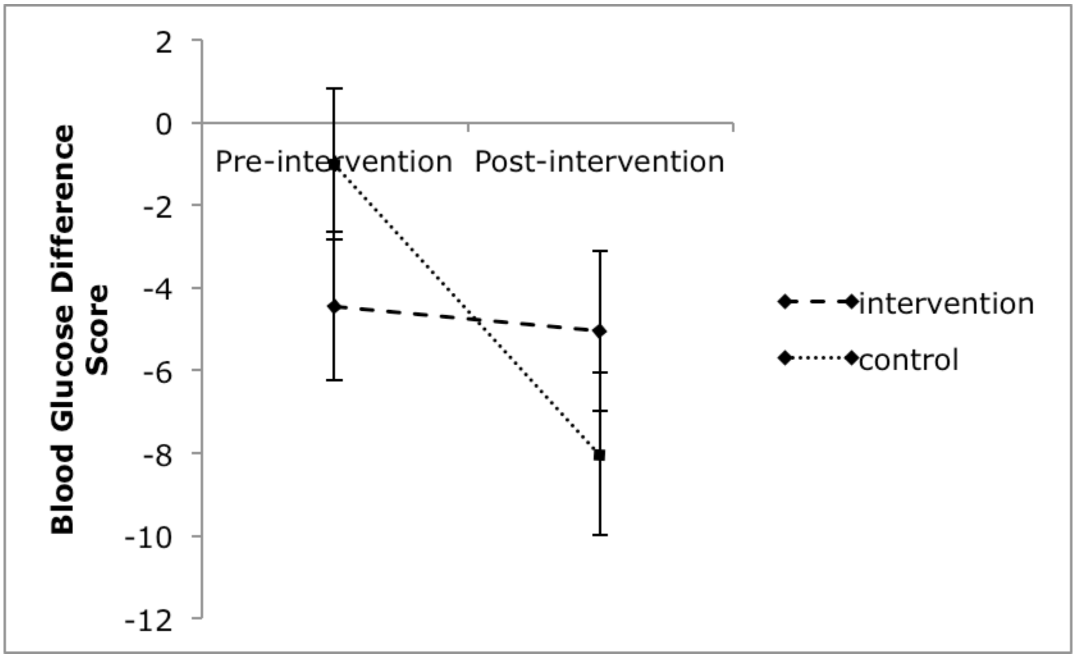

Figure 9. Blood glucose difference score (= post-Stroop - pre-Stroop blood glucose levels) at pre- and post-intervention.

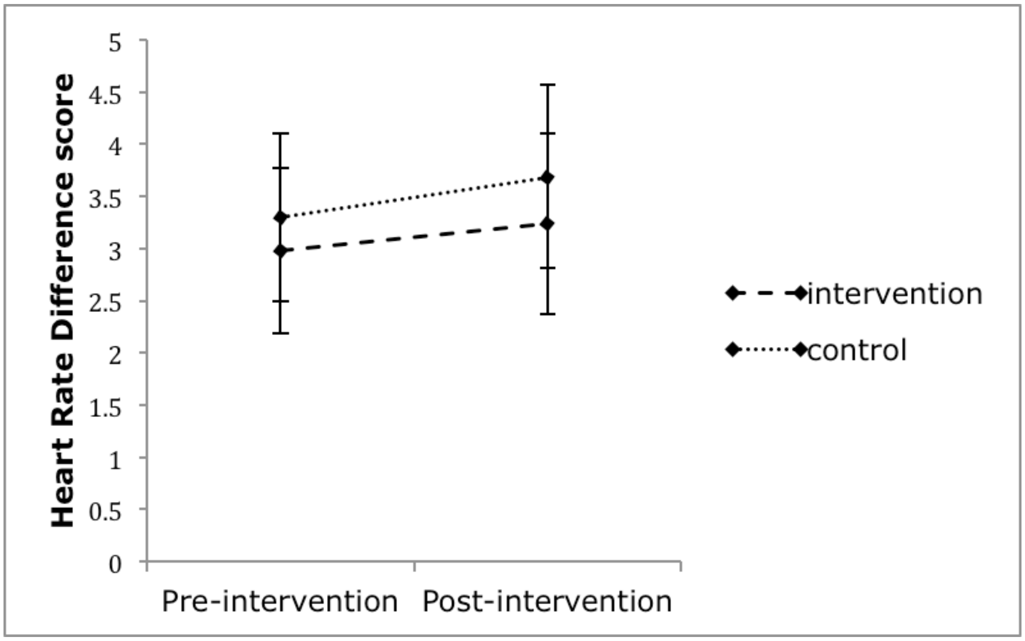

Figure 10. Heart rate difference score (= task score – pre-Stroop heart rate score) at pre- and post-intervention.

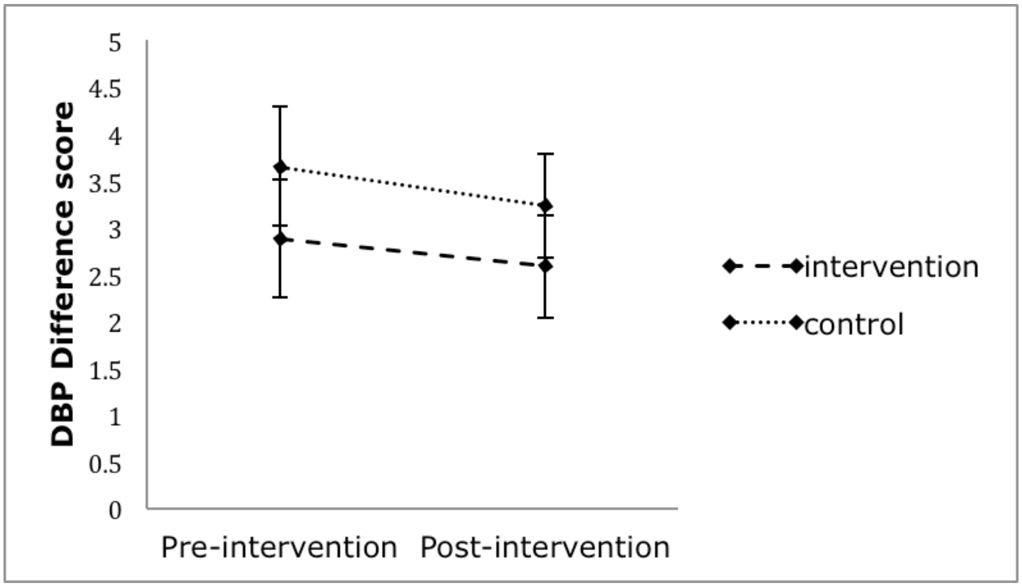

Figure 11. Diastolic blood pressure difference score (= task score – pre-Stroop DBP score) at pre- and post-intervention.

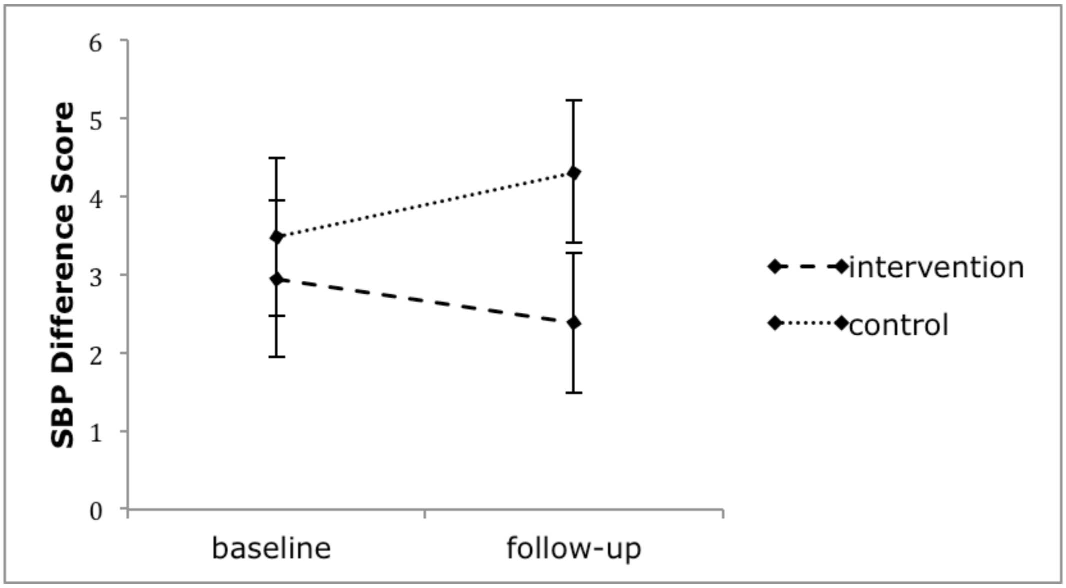

Figure 12. Systolic blood pressure difference score (= task score – pre-Stroop SBP score) at pre- and post-intervention.

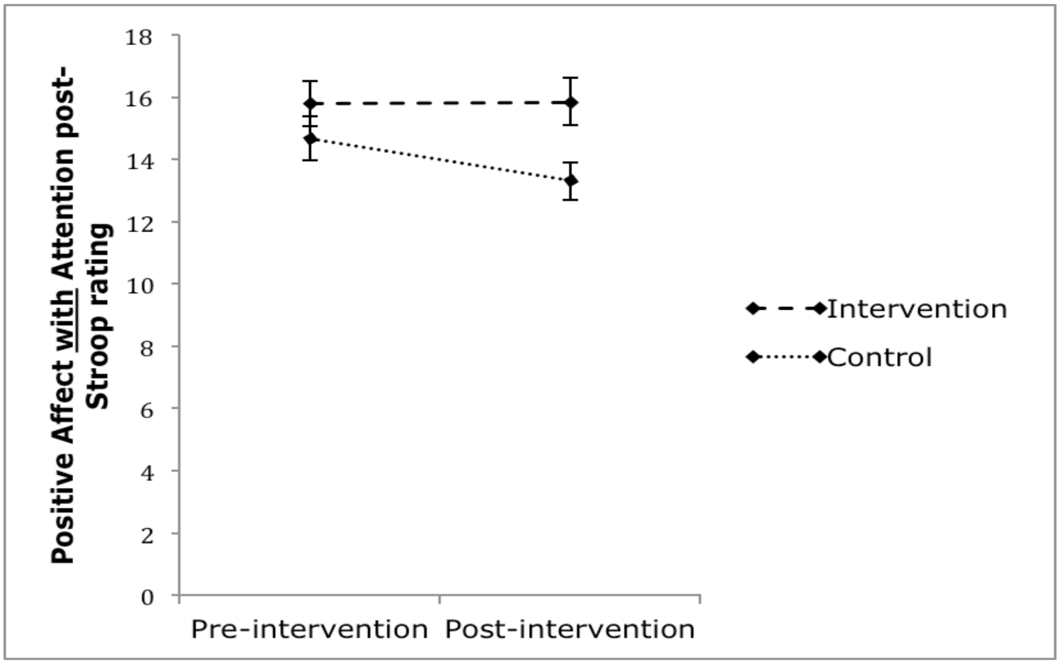

Figure 13. Post-Stroop positive affect with attention ratings at pre- and post-intervention.

Table 5

Affect and stress ratings after the Stroop task at pre- and post-intervention

	Intervention group (n = 34)							
	Pre-intervention				Post-intervention			
	Pre-Stroop		Post-Stroop		Pre-Stroop		Post-Stroop	
Variable	M	SD	M	SD	M	SD	M	SD
PANAS basic negative emotions	10.44	2.60	9.38	2.26	10.85	3.68	9.32	2.25
PANAS basic positive emotions with attention	17.11	4.78	15.79	4.24	15.58	4.58	15.85[a]	4.43
PANAS basic positive emotions without attention	10.97	3.40	10.14	3.12	9.85	3.42	10.11[b]	3.17
PANAS attention	6.14	1.98	5.64	1.99	5.73	1.76	5.73	1.86
PANAS fatigue	5.38	2.26	6.05	2.14	5.79	2.51	6.08	2.23
VAS			2.10	0.50			2.17	0.53

	Control group (n = 33)							
	Pre-intervention				Post-intervention			
	Pre-Stroop		Post-Stroop		Pre-Stroop		Post-Stroop	
Variable	M	SD	M	SD	M	SD	M	SD
PANAS basic negative emotions	10.75	2.81	10.66	3.75	10.72	2.49	10.12	3.58
PANAS basic positive emotions with attention	16.24	4.07	14.67	4.04	13.93	3.62	13.30	3.43
PANAS basic positive emotions without attention	10.57	2.93	9.67	3.19	9.24	2.78	8.33	2.64
PANAS attention	5.66	1.76	5.16	1.62	4.69	1.46	4.96	1.51
PANAS fatigue	5.60	2.44	5.27	2.22	6.45	2.03	6.39	2.06
VAS			2.37	0.40			2.14	0.41

[a] $p = .07$; interaction (intervention > control at follow up)

[b] $p = .03$; interaction (intervention > control at follow up)

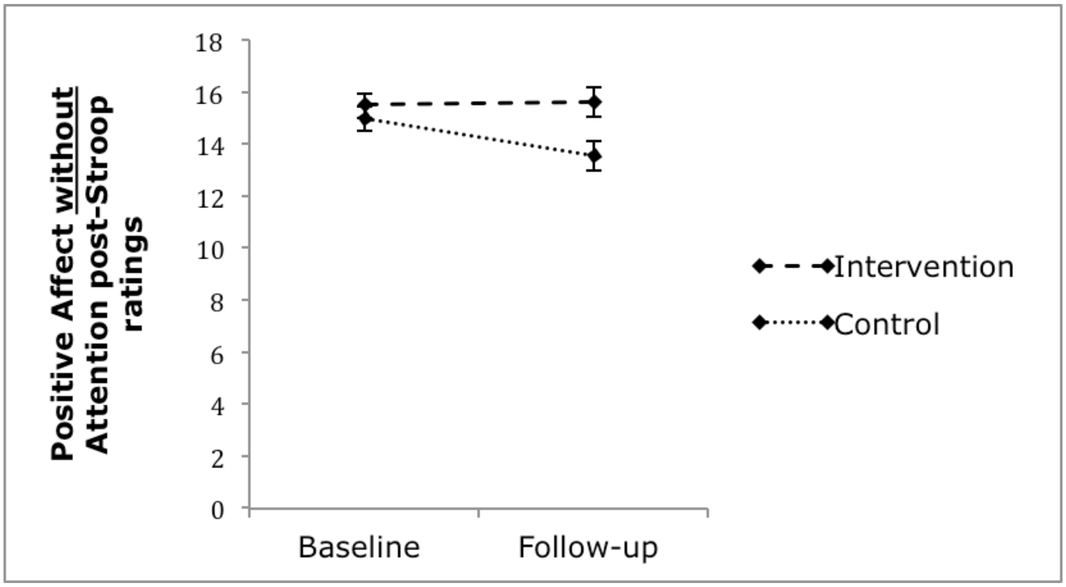

Figure 14. Post-Stroop positive affect ratings without attention at baseline and follow-up.

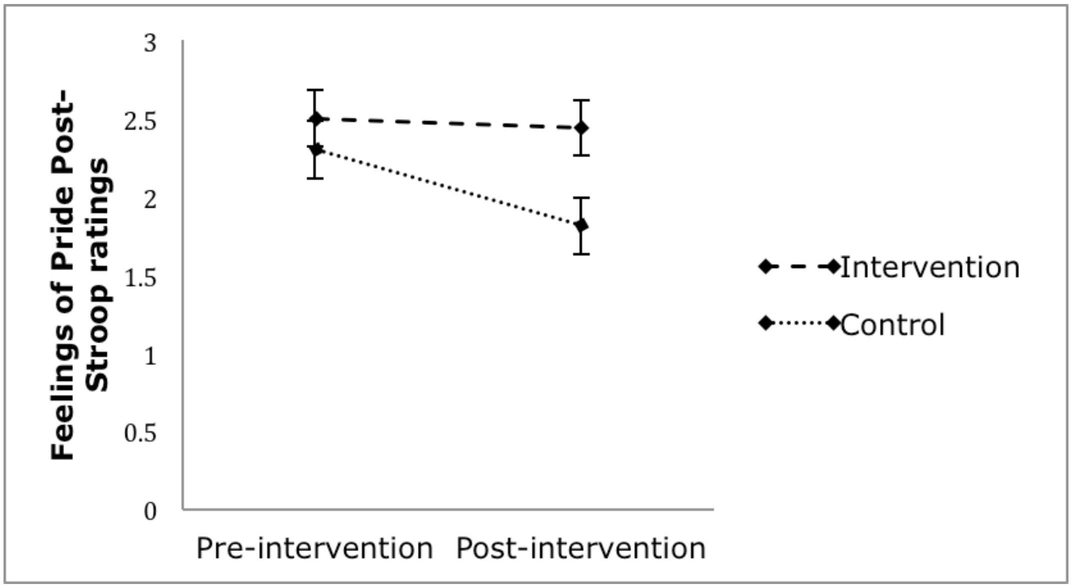

Figure 15. Post-Stroop feelings of pride ratings at pre- and post-intervention.

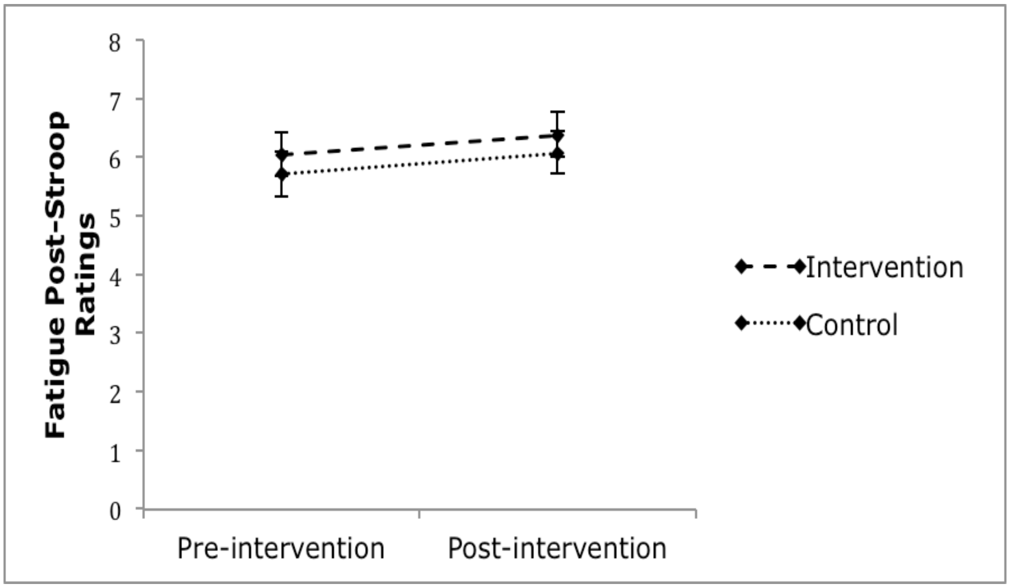

Figure 16. Post-Stroop fatigue ratings at pre- and post-intervention.

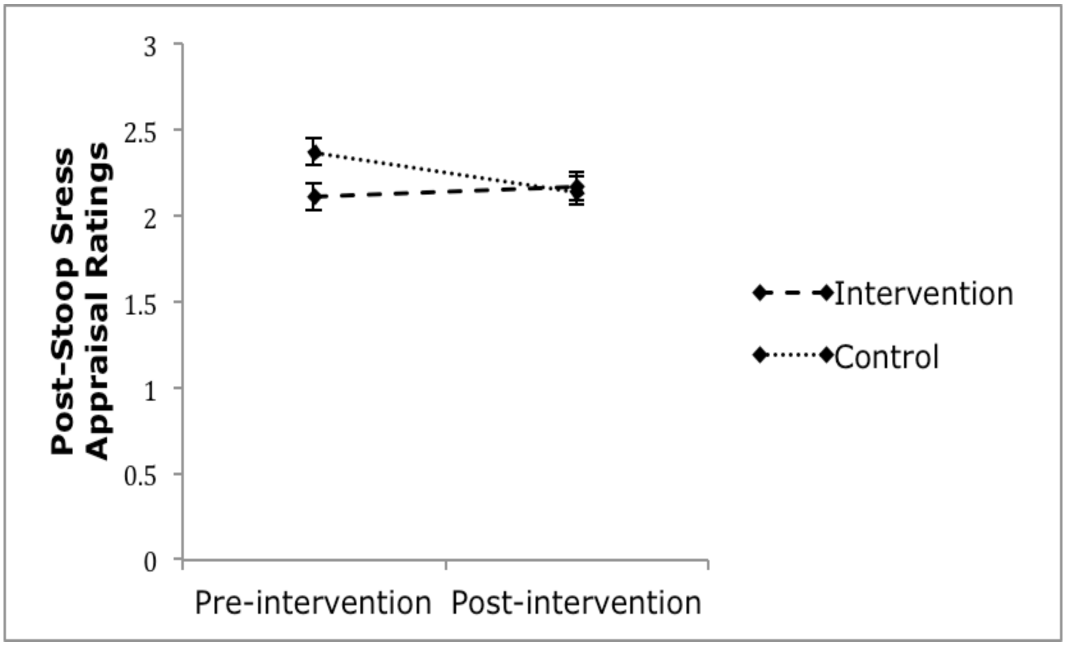

Figure 17. Post-Stroop stress ratings at pre- and post-intervention.

Table 6

Intervention effects on health behavior

	Main effect				Interaction			
Dependent variable	df	F	p	η^2	df	F	p	η^2
Alcohol consumption	1, 65	1.47	.22	.02	1, 65	0.00	.98	.00
Aerobic exercise	1, 65	0.08	.77	.00	1, 65	0.23	.63	.00
Anaerobic exercise	1, 65	1.37	.24	.02	1, 65	0.97	.32	.01
Days that ate breakfast	1, 65	0.01	.89	.00	1, 65	0.43	.51	.00
Days that consumed fruits	1, 65	0.29	.59	.00	1, 65	0.03	.86	.00
Days that consumed vegetables	1, 65	0.09	.76	.00	1, 65	0.01	.92	.00
Days that consumed sugary drinks	1, 65	0.77	.38	.01	1, 65	0.35	.55	.00
Average hours of sleep per night over last seven days	1, 65	15.12	.00	.18	1, 65	0.03	.85	.00
Number of night with less sleep than needed	1, 65	2.02	.16	.03	1, 65	0.16	.68	.00

Table 7
Intervention effects on coping, mindfulness, thought Control, and worry

	Main effect				Interaction			
Dependent variable	df	F	p	η^2	df	F	p	η^2
Coping method								
Active coping	1, 65	0.24	.62	.00	1, 65	0.53	.46	.00
Positive reframing	1, 65	0.48	.49	.00	1, 65	0.29	.59	.00
Venting	1, 65	0.54	.46	.00	1, 65	0.54	.46	.00
Substance use	1, 65	1.23	.27	.01	1, 65	0.75	.38	.01
Behavioral disengagement	1, 65	0.76	.38	.01	1, 65	0.88	.35	.01
Emotional processing	1, 65	1.77	.18	.02	1, 65	0.00	.98	.00
Acceptance					1, 65	3.92	*.05*	.05
Religious coping					1, 65	6.97	*.01*	.09
Emotional expression					1, 65	3.10	*.08*	.04
Self-blame	1, 65	8.88	.00	.12	1, 65	0.05	.82	.00
Mindfulness								
Observing	1, 65	0.00	.92	.00	1, 65	1.62	.20	.02
Nonreactivity to inner experience	1, 65	0.06	.80	.00	1, 65	1.21	.27	.01
Acting with awareness					1, 65	4.81	*.03*	.06
Describing	1, 65	15.73	.00	.19	1, 65	0.16	.68	.00
Nonjudging of inner experience	1, 65	26.10	.00	.28	1, 65	0.50	.48	.00
Thought control	1, 65	7.35	.00	.10	1, 65	2.08	.15	.03
Worry	1, 65	7.27	.00	.10	1, 65	1.80	.18	.02

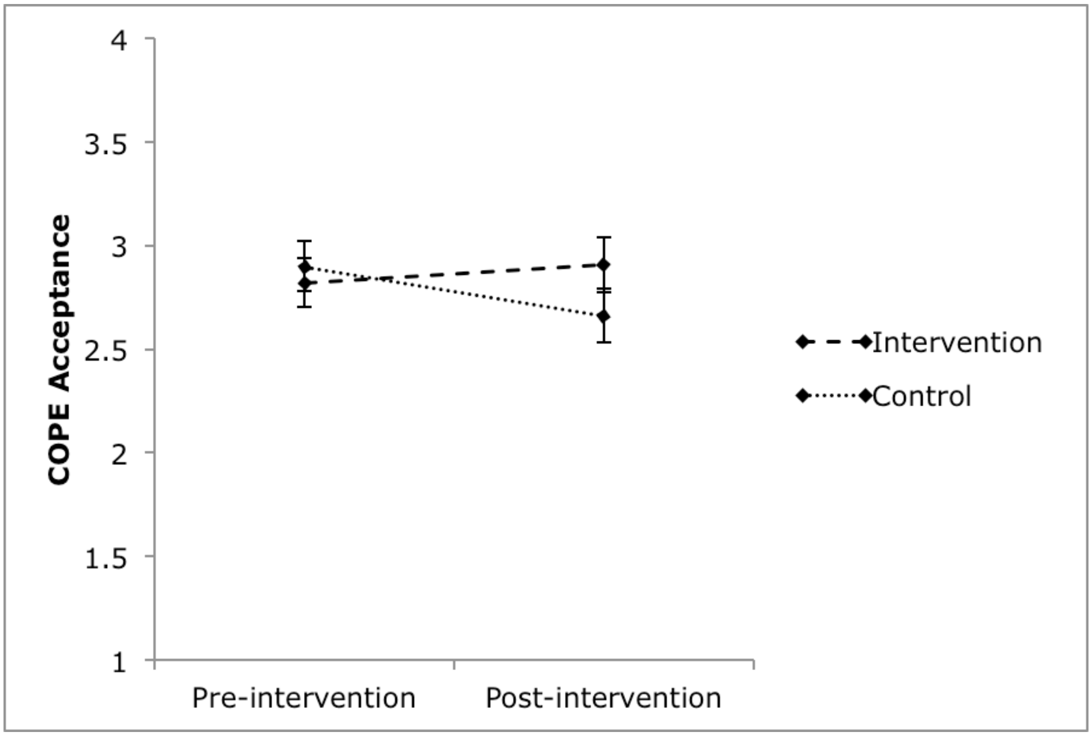

Figure 18. Acceptance based coping at pre- and post-intervention.

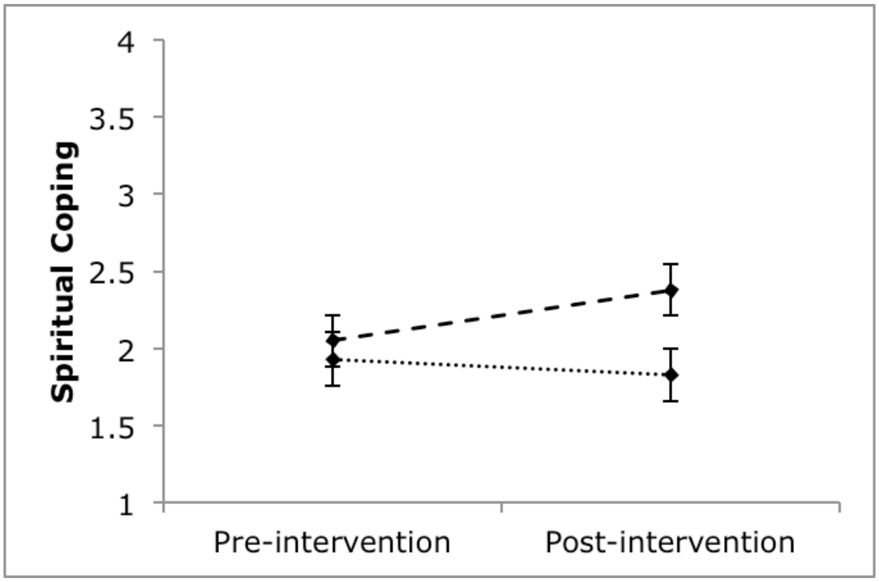

Figure 19. Spiritual coping at pre- and post-intervention.

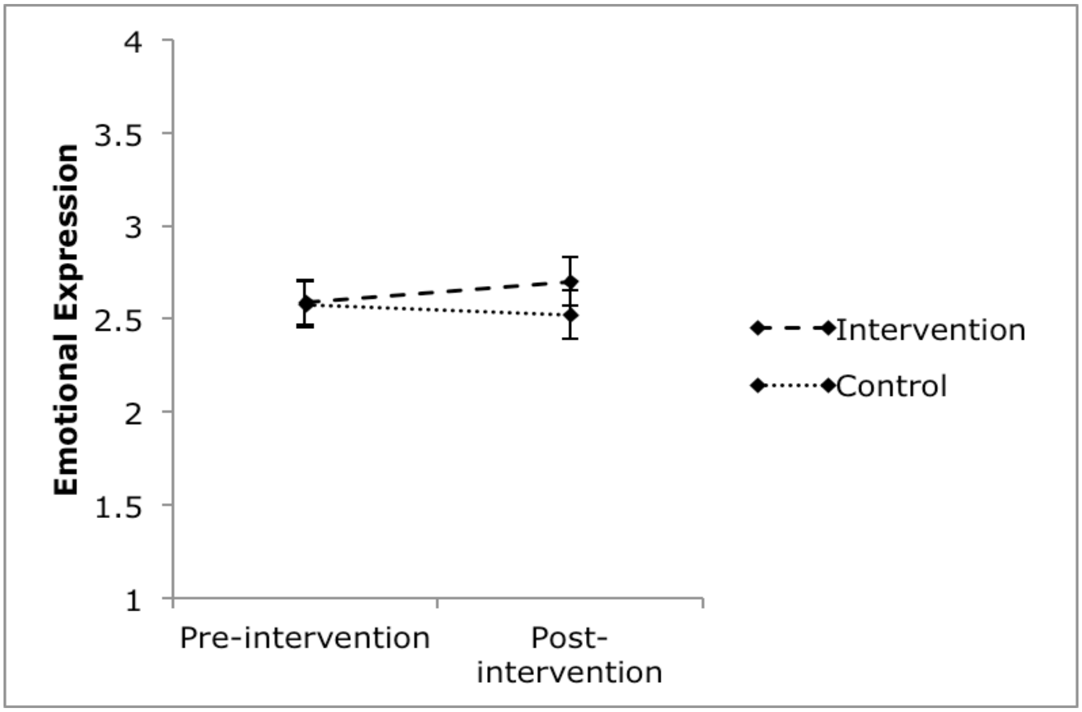

Figure 20. Emotional expression based coping at pre- and post-intervention.

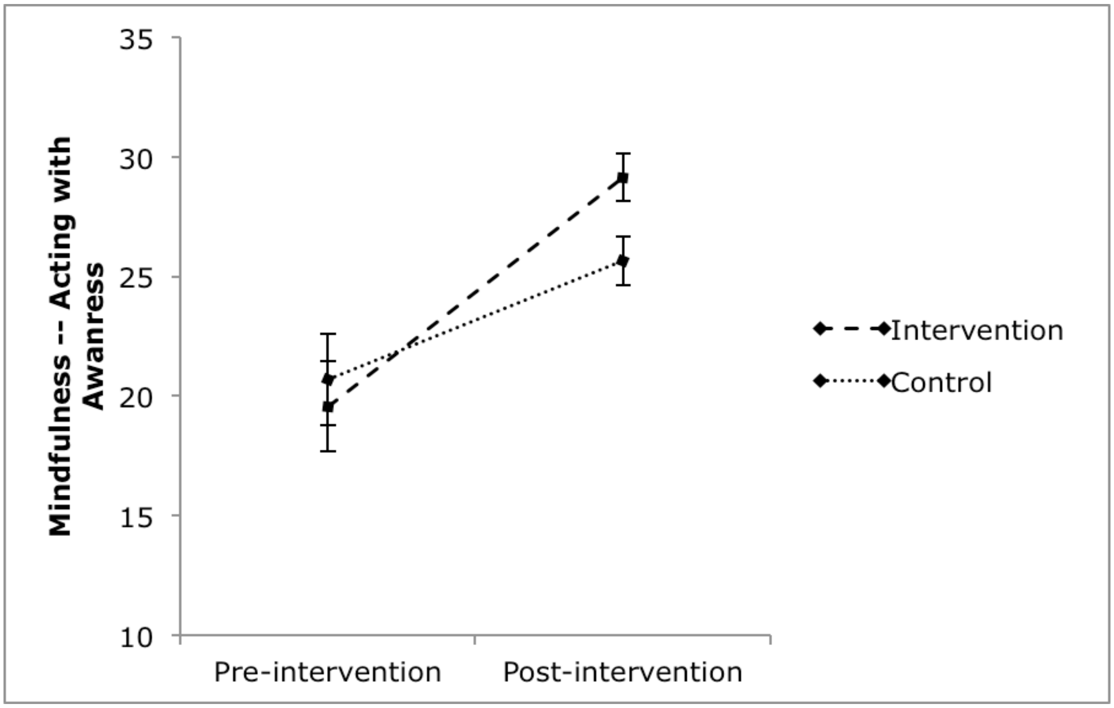

Figure 21. Acting with awareness at pre- and post-intervention.

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