Cardiovascular reactivity and recovery to stressful tasks following a mindfulness-analog in college students with a family history of hypertension

Christoffer Grant

University at Albany, State University of New York, christoffer.grant@gmail.com
Cardiovascular Reactivity and Recovery to Stressful Tasks Following a Mindfulness-Analog in College Students with a Family History of Hypertension

By

Christoffer A. Grant

A Dissertation

Submitted to the University at Albany, State University of New York

in Partial Fulfillment of

the Requirements for the Degree of

Doctor of Philosophy

College of Arts & Sciences

Department of Psychology

2011
ACKNOWLEDGEMENTS

Thank you to all of the advisors and mentors who have taught me and provided me with guidance along the way. In particular, to my advisor, Sharon; you’ve humored and inspired me through countless projects, posters, and papers. I am exceedingly thankful for everything.

This is dedicated to my wife, Jill, who during this whole ordeal always seemed to know when I needed a push, some space, or an embrace. I could not have finished this without your support. I love you am grateful for the family we’ve made together.
# TABLE OF CONTENTS

| Page |
|-----------------|-----------------|
| ACKNOWLEDGEMENTS | ii |
| LIST OF TABLES   | v  |
| LIST OF FIGURES  | vi |
| LIST OF ABBREVIATIONS | vii |
| ABSTRACT         | ix |

Chapter

I. Introduction ................................................................. 1
   Stress and the development of CVD..................................... 2
   Cardiovascular reactivity and blood pressure........................ 3
   Predictors of the development of hypertension........................ 4
   Non-pharmacological blood pressure interventions.................... 6
   Mindfulness......................................................................... 7
   Stress reactivity and mindfulness........................................ 10
   Mindfulness and blood pressure.......................................... 11
   Laboratory induction of cardiovascular reactivity................... 15
   Rationale for the proposed research.................................... 17
   The proposed study........................................................ 18
   Cardiovascular reactivity and recovery.................................. 19
   Hypoalgesia.................................................................... 19

II. Methods............................................................................. 19
   Participants....................................................................... 20
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Descriptive Variables by Mindfulness Analog vs. Control Conditions (Means, Standard Deviations &amp; Percentages)</td>
<td>62</td>
</tr>
<tr>
<td>2.</td>
<td>Baseline Measurement and Change in SBP, DBP, &amp; HR by Mindfulness-Analog vs. Control Conditions (Mean &amp; Standard Deviation)</td>
<td>63</td>
</tr>
<tr>
<td>3.</td>
<td>Recovery from CPT by Condition as Measured by SBP Across Three Time Periods</td>
<td>64</td>
</tr>
<tr>
<td>4.</td>
<td>Recovery from CPT by Condition as Measured by DBP Across Three Time Periods</td>
<td>65</td>
</tr>
<tr>
<td>5.</td>
<td>Recovery from CPT by Condition as Measured by HR Across Three Time Periods</td>
<td>66</td>
</tr>
<tr>
<td>6.</td>
<td>Recovery from MT by Condition as Measured by SBP Across Three Time Periods</td>
<td>67</td>
</tr>
<tr>
<td>7.</td>
<td>Recovery from MT by Condition as Measured by DBP Across Three Time Periods</td>
<td>68</td>
</tr>
<tr>
<td>8.</td>
<td>Recovery from MT by Condition as Measured by HR Across Three Time Periods</td>
<td>69</td>
</tr>
</tbody>
</table>
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Mean SBP responding through duration of experiment</td>
<td>70</td>
</tr>
<tr>
<td>2.</td>
<td>Mean DBP responding through duration of experiment</td>
<td>71</td>
</tr>
<tr>
<td>3.</td>
<td>Mean HR responding through duration of experiment</td>
<td>72</td>
</tr>
</tbody>
</table>
LIST OF ABBREVIATIONS

ACT: Acceptance and Commitment Therapy
ANCOVA: Analysis of Covariance
ANOVA: Analysis of Variance
BMI: Body Mass Index
BP: Blood Pressure
CAPER: Center for Addiction, Personality, and Emotion
CARDIA: Coronary Artery Risk Development in Young Adults
CPT: Cold Pressor Task
CVD: Cardiovascular Disease
CVR: Cardiovascular Reactivity
CHD: Coronary Heart Disease
DASH: Dietary Approaches to Stopping Hypertension
DBP: Diastolic Blood Pressure
DBT: Dialectical Behavior Therapy
HARMONY: Hypertension Analysis of Stress Reduction Using Mindfulness Meditation and Yoga
HPA: Hypothalamic-Pituitary-Adrenal axis
HR: Heart Rate
MA: Mindfulness Analog
MAT: Mental Arithmetic Task
MBCT: Mindfulness-Based Cognitive Therapy
MBSR: Mindfulness-Based Stress Reduction
MI: Myocardial Infarction
MT: Mirror Tracing task

SBP: Systolic Blood Pressure
Abstract

Ninety-seven undergraduate students with a family history of hypertension participated in a study that evaluated the effects of a brief mindfulness-induction on cardiovascular reactivity and recovery to two stressors. Participants were randomized to either a mindfulness-induction or control condition and were then exposed to the cold pressor task (CPT) followed by the mirror-tracing task (MT). Blood pressure and heart rate were measured at baseline, post-induction, as well as during and immediately following each stressor. There were no group differences in reactivity to either stressor. Participants in the mindfulness-analog condition experienced significantly greater latency to systolic blood pressure recovery following the CPT and a tendency towards greater latency to diastolic blood pressure recovery, although these findings were not replicated with the MT task. These results are contrary to what was hypothesized and to the anecdotal evidence available regarding effects of comprehensive mindfulness interventions on reactivity. The findings are discussed with respect to purported mechanisms of mindfulness and learning theory.
Introduction

Cardiovascular disease (CVD) is any condition that adversely affects the heart’s valves and muscles. The most common types of acute and chronic CVD are myocardial infarction, stroke, coronary heart disease (CHD), congenital cardiovascular defects, congestive heart failure, and hypertension (Roger et al., 2011). Hypertension is the most common CVD, even though the etiology is unknown in 95% of cases (Carretero & Oparil, 2000).

In individuals with hypertension the force of blood flowing through the blood vessels is above normal. Hypertension is defined as a systolic blood pressure (SBP) greater than or equal to 140 mmHg and diastolic blood pressure (DBP) greater than or equal to 90 mmHg, or being on an antihypertensive medication. Almost one out of every three adults in the United States, approximately 76 million, is hypertensive. Another third of adults are prehypertensive, with SBP between 120 mmHg and 139 mmHg and DBP between 80 mmHg and 89 mmHg (Roger et al., 2011). The category prehypertension was developed to classify individuals who do not qualify as having a medical disease, but are at increased risk of eventually developing hypertension (Chobanian et al., 2003). Hypertension can lead to CHD, stroke, myocardial infarction (MI), heart failure, or kidney failure. Even prehypertensive individuals with blood pressure (BP) values between 130-139/85-89 mmHg are at twice the risk of MI, stroke, or heart failure relative to normotensive individuals (Vasan, Larson, Leip, Evans, O’Donnell & Kannel, 2001). The risk for these types of CVD events appears to increase in a linear fashion with increasing blood pressure from prehypertensive levels and upwards.
Hypertension is the number one risk factor for stroke, but it is also a modifiable risk factor, and lifestyle modification factors can have a positive impact on BP (Roger et al., 2011). The National Institutes of Health (NIH, 2006) developed the Dietary Approaches to Stop Hypertension (DASH), which includes limiting sodium intake and adding fruits and vegetables. Other lifestyle factors that have been shown to have a positive impact include smoking cessation, weight loss, exercise, and stress management (Chobanian et al., 2003). Even small reductions in BP can make a big difference on health outcomes. A 2 mmHg reduction of DBP may result in as much as a 14% reduction in stroke and a 6% reduction in CHD (Cook, Cohen, Hebert, Taylor, & Hennekens, 1995). Similar results are estimated with a 5 mmHg reduction in SBP (Stamler, 1991).

Stress and the Development of CVD

Research on the deleterious impact of stress on cardiovascular health has implicated both chronic and acute stressors. In their review of the literature, Strike and Steptoe (2005) suggested that anywhere from 19% to 23% of individuals experienced some form of emotional stress directly preceding sudden cardiac death. The INTERHEART study found that some type of psychosocial stressor (e.g., perceived stress at home or work, major life events) accounts for 30% of the attributable risk of MI (Yusuf et al., 2004). In another study, experiencing some type of emotional upset was 2.7 times more likely to occur in patients relative to controls in the 24-hour period preceding an MI (Willich, Maclure, Mittleman, Arntz, & Muller, 1993). Furthermore, the risk of MI and stroke are highest within the first few hours of waking, which correlates with circadian rhythm crests of sympathetic activity and cortisol levels (Elliot, 2001).
The impact of psychosocial stress on CVD may in part be confounded by health-compromising behaviors such as increased substance abuse, poor diet, and poor medication management, as individuals who are higher in stress are more likely to engage in these types of behaviors (Das & O’Keefe, 2006). However, the impact of psychosocial stress on the development of CVD has also been demonstrated independent of these confounding factors, and a pathophysiology has been suggested (Rozanski, Blumenthal, Davidson, Saab, & Kubzansky, 2005). Within this pathophysiology, stressors activate the hypothalamic-pituitary-adrenal (HPA) axis, which constitutes the interactions between the hypothalamus and adrenal glands, which in turn activate the sympathetic nervous system. This can lead to a state of heightened cardiovascular reactivity (CVR) to acute stressors, which when interacting with chronic stressors may amplify deleterious physiological effects. Over time, this can lead to increased insulin resistance, hypertension, and autonomic nervous system dysfunction.

Large and recurrent physiological responses to acute stressors have been linked to hypertension and the development of CHD in several laboratory studies (Treiber, Kamarck, Schneiderman, Sheffield, Kapuku, & Taylor, 2003). Stress has also been linked to higher BP in correlational studies (e.g., Steptoe, 2000). Job, financial, and social/relational stress have all been shown to be associated with higher levels of SBP and DBP (Schnall, Landsbergis, & Baker, 1994).

Cardiovascular Reactivity and Blood Pressure

CVR has been conceptualized as a somewhat stable trait (Swain & Suls, 1996). This may be due to factors related to personality, such as a person high in sensation-seeking being drawn to vocations or situations that are more likely to cause reactivity
(Roberti, 2004). It may also be due to a biological proclivity towards greater CVR, as there is evidence of heritability in heightened responding to stressors (Turner & Hewitt, 1992). Likely, an interaction of both personality and biological factors contribute to CVR (Schwerdtfeger, Schmukle, & Egloff, 2005).

The CVR hypothesis of hypertension causally links the exaggerated cardiovascular response to a stressor to the development of hypertension (Pickering & Gerin, 1990). A recent meta-analysis (Chida & Steptoe, 2010) based on 31 cohorts supports this association, noting that stress reactivity in the laboratory is related to greater SBP and DBP in the future. Furthermore, the measurement of CVR in a laboratory setting seems to correlate with ambulatory levels of CVR (Turner, Ward, Gellman, Johnston, Light, & Van Doornen, 1994), although this may be contingent upon the degree of equivalence between the laboratory and natural environment (Turner et al., 1994).

**Predictors of the Development of Hypertension**

It has been proposed that the progression from CVR to hypertension may in part be moderated by a family history of hypertension (Light, 2001). It is well established that hypertension is heritable (Hunt, 2003). In addition, children of hypertensive parents appear to exhibit heightened SBP and DBP responding to stressors than children of normotensive parents (Frazer, Larkin, & Goodie, 2002; Kumar, & Singh, 2010) and may also have greater resting levels of SBP and heart rate (Frazer, Larkin, & Goodie, 2002).

The ability to recover from a stressor also appears to be related to the development of hypertension (Chida & Steptoe, 2010). Stewart and France (2001) demonstrated that the ability to recover more quickly from a stressor was related to lower
levels of SBP at follow-up. Quick recovery may also be associated with better overall cardiovascular health even when autonomic reactivity is high (Heponiemi et al., 2007).

Gender differences may also play a role in the pathway from CVR to hypertension. Differences between males and females appear to be prominent in both reporting of stressors and reactivity to stressors (Davis, Matthews, & Twamley, 1999). Women tend to report greater stress exposure (Davis et al., 1999), but experience lower baseline SBP as well as SBP reactivity (Stoney, 1992). However, numerous studies suggest that women may show greater HR reactivity compared to men (e.g. Whited & Larkin, 2009). In regards to recovery from stress, men appear to have a more delayed recovery to acute stressors, with higher SBP and DBP levels (Matthews et al., 2001).

Pain tolerance may be predictive of the development of hypertension above and beyond some demographic factors. Higher BP has been reliably shown to be correlated with a decreased sensitivity to painful stimuli, or hypoalgesia, in studies dating back almost 30 years (Zamir & Shuber, 1980). Relatedly, the correlation between increased sensitivity to painful stimuli, or hyperalgesia, and lower BP has also been demonstrated (Duschek, Schwarzkopf, & Schandry, 2008). It is hypothesized that the mechanism by which BP affects pain tolerance is mediated by baroreceptor responding. Higher BP results in enervation of baroreceptors resulting in decreased cerebral arousal and subsequent pain sensitivity (Pickering, 2003). This has been demonstrated in animal models by attenuating baroreceptor responding to increased BP, resulting in decreased responding to a painful stimulus (Pickering, 2003).

Hypoalgesia has been shown to precede increases in BP as well as the development of hypertension. In a group of adolescent males, pain tolerance to a pressure
gauge on the middle finger was predictive of both BP and heart rate (HR) variability eight years later (Campbell, Ditto, Seguin, Sinray, & Tremblay, 2003). In fact, in this particular study, pain tolerance was predictive of BP over and above BMI and family history of hypertension. France (1999) reviewed the literature on individuals with a family history of hypertension and found reliable tendencies towards hypoalgesia relative to those without a family history of hypertension. It is suggested that there is dysregulation in the roles of the hypothalamus that both regulates BP and modulates pain perception.

*Non-Pharmacological Blood Pressure Interventions*

With the demonstrated relationship between stress and hypertension, it is perhaps not surprising that behavioral interventions typically target the physical and cognitive components of stress. Behavioral techniques involve reducing physiological arousal (e.g., relaxation training, meditation) or teaching cognitive skills such as problem-solving, time-management, and thought-disputing. Linden and Moseley (2006) reviewed over 100 randomized controlled trials of behavioral treatments for hypertension. Treatments were often described as “stress management” and included relaxation, meditation, or biofeedback. Although studies differed in specific techniques, overall effect sizes ranged from medium to large and were comparable with results obtained using prescription antihypertensive medications.

The pathways by which traditional behavioral stress management techniques may reduce BP are manifold. They may include habituation to acute stressors or problem-solving or relaxation activities that are incompatible with stress-responding, thereby decreasing SNS responding to stressors. Avoiding the stressor strengthens the association
between avoidance and physiological arousal, thereby increasing the physiological response with each exposure. Conversely, confronting and accepting the stressor, whether it is in the form of a thought, feeling, or physical sensation, may decrease emotional reactivity to that stressor (Hayes, 1987). Therefore, physiological responding, including CVR, may be partially moderated by internal events (e.g., reactivity to thoughts, feelings, and sensations) (Kabat-Zinn, 1990).

**Mindfulness**

One technique with potential promise to address reactivity to stress is mindfulness. Derived from Buddhist traditions, the underlying philosophy of mindfulness is to overcome human fallibility (e.g., hatred, craving, ignorance) by centering and focusing attention in a particular way on thoughts, emotions, and bodily sensations (Kabat-Zinn, 2003). The key features of mindfulness appear to be awareness, acceptance, and labeling of present experience in a non-judgmental, non-reactive manner (Kabat-Zinn, 2003; Marlatt & Kristeller, 1999). No attempt is made to focus attention on anything in particular, but rather to be receptive to moment-to-moment experiencing. Conceptually, this may increase the individual’s flexibility of responding more generally, as well as in situations where heightened emotions could potentially be restricting.

Mindfulness may work to increase the individual’s comfort with and awareness of arousing internal experiences. This, in turn, may increase the individual’s ability to successfully become aware of and accept internal emotional experience. For example, mindfulness-based interventions have been effectively used to treat binge-eating disorder and may function to increase the individual’s awareness of satiation cues (Kristeller & Hallett, 1999), an awareness that is thought to be impoverished in binge-eating disorder.
There are a number of psychotherapies that incorporate mindfulness to varying extents. Mindfulness Based Cognitive Therapy (MBCT), Acceptance and Commitment Therapy (ACT), Dialectical Behavior Therapy (DBT), and Mindfulness Based Stress Reduction (MBSR), all teach mindfulness skills (Baer, 2003). MBSR, the earliest of these therapies, was first introduced by Jon Kabat-Zinn at the University of Massachusetts Medical School in 1979 (Kabat-Zinn, 1982). As described by Baer (2003), MBSR was originally developed for chronic pain and stress-related disorders within a behavioral medicine setting. The treatment is delivered as an 8-week course with participants meeting once weekly for 2-hour instruction and practice in mindfulness meditation skills. Participants are asked to practice the skills they learn each day for 45 minutes. Toward the end of this course an all day mindfulness meditation session is held. An example of the mindfulness meditation skills taught is focus on breathing while in a relaxed position with eyes closed. When emotions, thoughts, or physical sensations arise, participants are asked to observe them non-judgmentally, and then return their attention to the target of their meditation (in this example, breathing). With continued practice, participants learn to not become absorbed in their internal events and realize that these events are transitory.

Mindfulness interventions are being subjected to increasing empirical scrutiny and are being validated on various outcomes in a variety of populations. Baer (2003) reviewed 19 empirical studies of mindfulness-based interventions. According to that review, MBSR may meet criteria for a “probably efficacious” (Chambless & Hollon, 1998) treatment in the reduction of stress in student, community, and patient samples. MBCT may also meet this criterion for the reduction of depressive symptoms. When
studies of MBSR and MBCT are collapsed, the mean effect size is medium (Cohen’s $d = 0.59$). Empirical support is also being gathered for ACT and DBT. A meta-analysis (Öst, 2008) showed mean effect sizes of 0.68 and 0.58 for ACT and DBT, respectively. However, the relative contribution of mindfulness to these therapies has not been examined independently (Baer, 2003). A more recent meta-analysis of 39 mindfulness-based interventions that did not include ACT or DBT focused on studies that included some type of anxiety or mood outcome variable (Hofmann, Sawyer, Witt & Oh, 2010). The authors found moderate effect sizes (Hedge's $g = 0.63$ and 0.59 for improvement in anxiety and mood symptoms, respectively).

As mindfulness techniques have been applied in these therapies, a primary focus has been the importance of staying with present experience. The inability or unwillingness to do this has been termed experiential avoidance (Hayes, Wilson, Gifford, Follette, & Strosahl, 1996). Experiential avoidance occurs when the individual is unwilling to remain in contact with private experiences (thoughts, emotions, or physical sensations). Experiential avoidance is thought to be a harmful feature in a variety of psychopathologies, including obsessive-compulsive disorder, panic disorder, and substance use disorders (Hayes et al., 1996). From this perspective, the goal of therapies that incorporate mindfulness techniques is not to suppress the individual’s thoughts, emotions, or sensations. Rather, the goal is to notice these events in a non-judgmental and non-reactive manner. Interventions that include all of these mindfulness techniques in a comprehensive mindfulness protocol, such as MBSR, MBCT, DBT, and ACT, should not be equated with brief mindfulness-analog (MA) inductions. The purpose of these brief
inductions is to explore particular mechanistic aspects of mindfulness, which will be
discussed further below.

**Stress Reactivity and Mindfulness**

Non-reactivity to an acute stressor may be a primary pathway by which stress
reduction is achieved in mindfulness techniques. Mindfulness does appear to reduce
perceptions of stressors (e.g., Agee, Danoff-Burg, & Grant, 2009; Hafer, 1997) and
shows a tendency toward decreasing reactivity to an acute stressor (Kingston, Chadwick,
Meron, & Skinner, 2007; Skinner et al., 2008). While mindfulness techniques may
function by reducing discomfort of internal aversive states, relaxation is also potentially
promoted during meditation. A study by Marcus, Fine, Moeller, Khan, Pitt, and Liehr
(2003) showed that mindfulness has beneficial effects on stress that can be measured
physiologically. This study demonstrated that MBSR delivered to a sample of substance
abusers residing in a therapeutic community resulted in decreased cortisol levels in
response to stress. This study is indicative of the therapeutic benefit these techniques may
have.

Although mindfulness techniques have demonstrated positive and reliable effects
in a variety of medical and mental health symptom clusters, the mechanism of action is
still not yet entirely clear and may vary depending on the outcome being evaluated.
Proposed mechanisms include cognitive change, acceptance, self-regulation, exposure,
and relaxation (Baer, 2003). Since the mechanism of action is still unclear, it is not
surprising that there has been inconsistency and difficulty in the literature on how best to
measure mindfulness. Furthermore, there is no standardized optimal method for
delivering mindfulness techniques. The focus of mindfulness meditation can be on a
range of activities from walking to breathing, with duration ranging from a relatively brief 45-minute body-scan to an intensive 8-hour breathing session delivered over days or weeks. Finally, mindfulness techniques may be exerting their effects in a variety of different ways for different clients, and not in any one prevailing way. In spite of this uncertainty, mindfulness techniques have shown demonstrable effects on a variety of mental health and medical conditions (for reviews of this literature, see Baer, 2003; Brown, Ryan, & Creswell, 2007; Grossman, Niemann, Schmiedt, & Walach, 2004; Hofmann et al., 2010).

**Mindfulness and Blood Pressure**

There is persuasive anecdotal evidence in the literature for the positive effects of mindfulness meditation in aiding the treatment of hypertension. Marlatt (2006) described his own success in using mindfulness meditation to lower his BP. Kabat-Zinn (1990) described a case-study of a woman with diagnoses of hypertension as well as a variety of other medical conditions who experienced a dramatic decrease in BP (from 165/105 to 110/70) after having gone through his eight-week MBSR Program.

Only a handful of studies have specifically examined the application of mindfulness meditation techniques, whether delivered as a brief induction or a comprehensive protocol, on short-term BP or HR outcomes (Arch & Craske, 2006; Carlson, Speca, Faris, & Patel, 2007; Ditto, Matthews, & Twamley, 2006; Erisman & Roemer, 2010; Kingston et al., 2007; Sawada & Steptoe, 1988; Zeidan, Johnson, Gordon, & Goolkasian, 2010). Carlson et al. (2007) examined the effects of MBSR on a variety of health outcomes in a population of breast and prostate cancer patients. Although they did not include any type of control group, they found a significant effect of MBSR on BP,
resulting in approximately a 6mmHG decrease in SBP from baseline to follow-up. This reduction is fairly dramatic, given that this was a normotensive population.

Arch and Craske (2006) examined the effects of a brief focused breathing induction in response to the viewing of negative stimuli. College students were randomized to a focused breathing, worry, or unfocused attention induction. They were exposed to blocks of positive, negative, and neutral slides, counterbalanced, at three separate intervals. One block occurred prior to the induction, while the other two followed the induction. Participants who were assigned to the worry or unfocused attention groups scored higher on a measure of negative affect in response to the negative slides when compared to the focused attention group. The focused breathing group was also more willing to view negative slides. This study found no effect between the interaction of group assignment and slide type on HR. However, this study was limited in its sample size (60 participants randomized to 3 groups). HR was measured in only 48 participants across three groups, and post-hoc analyses of power were in the range of 55-60% across analyses.

Erisman and Roemer (2010) recently reported a laboratory study in which 30 participants were assigned to either a brief MA or control-education condition. They were then exposed to film clips that were either positively, negatively, or mixed affectively valenced. Although these authors found increases in positive affect in the mindfulness condition to the positively-valenced film clip, they found no differences between conditions on HR or skin conductance. This study was limited by a small sample size (n of 15 per cell), very brief MA induction (10 minutes), and the use of video clips that had not been previously standardized to elicit physiological responding.
Kingston et al. (2007) trained college students in mindfulness meditation techniques. The intervention was delivered in a series of six 1-hour classes over three weeks. The researchers noted significantly lower DBP in response to a stressor from pre-intervention to post-intervention in both the mindfulness and comparison groups, although there was no difference between groups. This study was innovative in examining the effects of mindfulness training on the physiological reaction to a stressor, the cold pressor task (CPT). However, the use of guided imagery as a comparative induction may not have been appropriate. Guided imagery may have key features in common with mindfulness meditation, such as the feeling of relaxation, which makes it difficult to disentangle their discrete effects.

Ditto et al. (2006) randomized healthy college students to one of three conditions: wait-list control, progressive muscle relaxation, or brief body-scan meditation, a technique used in MBSR. Inductions lasted for 20 minutes, during which participants listened to audio recordings in the progressive muscle relaxation and body-scan meditation conditions, or sat quietly in the wait-list condition. Participants were asked to practice these techniques for 1 month and then return to the laboratory. HR and BP were recorded pre and post-induction as well as at baseline and follow-up. No effects were found for group on either BP or HR. The only significant effect was for time (pre to post-induction) on HR, with all groups experiencing a decrease. This study was limited in its small sample size (32 participants randomized to 3 groups) and use of a body-scan meditation. As the authors suggest, the body-scan technique may differ from other mindfulness meditation techniques in its focus on specific, rather than naturally occurring phenomena.
Zeidan et al., (2010) compared a brief mindfulness meditation intervention delivered for twenty minutes a day over the course of three days to a sham meditation during which participants were instructed to “take deep breaths as we sit in meditation.” A third control group was merely instructed to sit in a chair for the same duration and frequency as the other two groups in order to control for the effects of time. Measurements of HR and BP were taken before and after each session. This study found that although all conditions experienced a reduction in HR from pre-post sessions when collapsed, the mindfulness group had the largest effect size ($\eta^2 = 0.52$ compared to $\eta^2 = 0.36$ for sham and $\eta^2 = 0.09$ for the control group). This study found no effect for condition on SBP or DBP. The researchers suggested that effects on BP may only be exposed in an experimental stress induction paradigm, which was not part of their study protocol.

The study that has perhaps most austerely attempted to specifically examine the effects of a brief meditation on BP and HR reactivity is one by Sawada and Steptoe (1988). In this study, 24 healthy female students were randomly assigned to either a brief mindfulness induction or a control-relaxation condition. In the mindfulness induction participants were instructed to increase awareness of their arms and be receptive and nonattached to their experiences. In the control-relaxation condition participants were told that relaxation had benefits on health, and they were instructed to relax in whatever way had been useful for them in the past. All participants were then exposed to both the CPT and a mental-arithmetic task (MAT) while blood pressure and heart rate were measured. The authors found that participants in the mindfulness condition experienced greater increases in SBP during both the CPT and MAT compared to the control-
relaxation condition. Similar trends were present for DBP with differences being more pronounced in response to the MAT.

Although the design of this study was generally good, it also had a couple of flaws. First, it was under-powered, as there were only twelve participants in each cell, making any results potentially spurious. Unfortunately, the authors failed to include effect sizes and, as they did not include variance data, this could not be calculated. Second, the control group was vague and non-standardized. Participants may have used any variety of strategies to cope with the stressors and with no manipulation check this introduces a high degree of heterogeneity to the condition, further confounding the results.

*Laboratory Induction of Cardiovascular Reactivity*

There are a number of laboratory stressors that have been used in CVR research. These include, but are not limited to, public speaking, mental arithmetic, the handgrip dynamometer, watching distressing films, and the CPT (Allen, 2001). While all of these tasks have been shown to elicit significant increases in HR and BP, the CPT also has a high success rate in predicting the development of hypertension in normotensive populations. Specifically, BP reactivity has been shown to be positively correlated with incidence rates of hypertension at follow-up in several studies as described below.

The CPT is an acute stress test that has been used to evaluate CVR (Velasco, Gomez, Blanco, & Rodriguez, 1997) by provoking generalized sympathetic activation, and evoking an increase of between 15 to 20 mmHg in SBP and 10 to 15 mmHg in DBP. Cold pressor responding involves the perception of pain (Peckerman, Hurwitz, Saab, Laabre, McCabe, & Schneiderman, 1994), making it useful for examining hypo- and
hyper-algesic responding. However, this responding needs to be examined in the context of gender, as men consistently have longer immersion times and lower ratings of pain in response to the CPT (Dixon, Thorn, & Ward, 2004).

In one longitudinal study (Kasagi, Akahoshi, & Shimaoka, 1995) of 824 normotensive Japanese males, SBP response to the CPT was found to be a predictor of hypertension at 24 year follow-up. Participants were classified as either hyper-reactors or normal-reactors to the CPT. Hyper-reactors exhibited SBP and DBP responses of greater than 15 mmHg. SBP hyper-reactors were 37% more likely to have developed hypertension at follow-up. DBP hyper-reactors were 34% more likely to have developed hypertension at follow-up when controlling for resting levels. Menkes et al. (1989) followed 910 male Caucasian medical students at 20 and 36 years. SBP reactivity to the CPT was predictive of the development of hypertension and was significant at both follow-up points, but HR and DBP were not, even when adjusting for pre-test resting rates.

Although research demonstrating a relationship between reactivity during CPT and development of hypertension is fairly robust, research relating reactivity and family history is less equivocal. For example, researchers have demonstrated the ability to predict family history of hypertension based on reactivity during CPT in African American adolescents (Covelli, 2006), whereas others have failed to replicate this (Lindqvist, Kahan, Melcher, & Hjemdahl, 1993). Other researchers have shown a negative relation between reactivity during CPT and family history of hypertension (Lambert & Schlaich, 2004), highlighting the complexity of this association as it may depend upon factors such as gender and genetic predisposition.
The mirror-tracing (MT) task has also been demonstrated to predict blood pressure as well as elicit moderate reactivity. For example, Matthews, Salomon, Brady, and Allen (2003) demonstrated that increases in resting blood pressure were predicted by reactivity to the MT task after a 3-year period in a group of prepubescent children and adolescents. Reactivity to the MT task in this study was between 8 and 10mmHG in SBP and DBP and 8 beats per minute in HR. Studies with non-clinical adult participants have variously achieved increases of HR beats per minute ranging from 1.81 (Ottaviana, Shapiro, Davydov, & Goldstein, 2008) to 6.9 (Steptoe & Marmot, 2006) and 8.04 (Harrel & Floyd, 2000). The MT appears to have a more stable and robust effect on BP. Steptoe, Gibson, Hamer, and Wardle (2007) achieved increases of 33.4 mmHg and 19.9 mmHg in SBP and DBP respectively. Steptoe and Marmot (2006) achieved increases of 22.5 mmHg and 13.6 mmHg, and Allen, Stoney, Owens, and Matthews (1993) reported increases of 12.54 mmHg and 11.92 mmHg on SBP and DBP, respectively.

Rationale for the proposed research

Kabat-Zinn’s MBSR program lasts eight weeks with daily practice and a retreat. Other programs that include mindfulness training as part of their package generally follow some derivation of that protocol. A major difficulty with examining efficacy of mindfulness in the treatment-package approach is the inability to extricate the specific effects of the mindfulness training from other aspects of the training. For example, a major feature of ACT is its focus on values (Wilson & Murrell, 2004). DBT emphasizes a variety of skills, including interpersonal skills such as assertiveness and problem-solving. Even MBSR, of which mindfulness techniques play a preeminent role, also incorporates group discussion of stress and coping. This makes mindfulness techniques difficult to
examine as there has been a dearth of dismantling studies that isolate the specific components of mindfulness training (Baer, 2003). A secondary problem with a number of studies using mindfulness techniques is threat to validity through volunteer selection bias. There may be something unique about participants who are willing to volunteer for a study that will last for weeks and through which daily practice is requested; these participants may already be more attentive and focused.

Arch and Craske (2006) used a brief “focused-breathing” induction as an analog of mindfulness to model an introduction to mindfulness for people without meditation experience. This kind of laboratory induction may be particularly good for examining the mechanisms of mindfulness as it allows for more rigorous control of variables including practice time and limiting the influence of potential interfering variables such as differences in individual practice. The proposed study was designed to examine CVR in response to a physiological and cognitive stressor following this kind of MA induction, relative to a control condition, in college students with a family history of hypertension.

The Proposed Study

This study proposed that an MA induction would reduce BP and HR reactivity and latency to recovery to a stressful task in college students with a family history of hypertension. Individuals with a family history of hypertension are at increased risk for developing hypertension and express greater reactivity in response to stressors (Frazer, Larkin, & Goodie, 2002; Hunt, 2003; Kumar, & Singh, 2010). As reactivity may precede the development of hypertension in those with a family history of hypertension (Light et al., 1999), ameliorating this reactivity may reduce the progression towards CVD states including hypertension.
Cardiovascular Reactivity and Recovery

This primary goal of this study was to examine the physiological effects of a brief MA induction to a stressor in college students who have a family history of hypertension. The research on mindfulness and blood pressure seems to suggest that traditional-length interventions (e.g., Carlson et al., 2007) have a greater effect on these markers than brief MA inductions. However, the research on brief MA inductions has been limited by small sample sizes (e.g., Arch & Craske, 2006; Ditto et al., 2006; Herisman & Roemer, 2010; Sawade & Steptoe, 1988) as well as potentially inappropriate comparison groups (Kingston et al., 2007) and inductions (Ditto et al., 2006). The present study proposed that a brief MA induction that addressed these limitations would result in decreased CVR and decreased latency to recovery from the CPT and MT task compared to a control group. Based on extant literature, it was also predicted that women would have lower baseline levels of SBP and lower levels of SBP reactivity, but greater HR reactivity compared to men (Matthews et al., 2001).

Hypoalgesia

Previous research has demonstrated a positive correlation between family history of hypertension and hypoalgesia (France, 1999). As this sample consisted solely of individuals with a family history of hypertension, we compared mean CPT immersion and pain ratings to normative samples from the literature. It was predicted that our sample would have longer CPT immersion times and lower pain rating scores. Furthermore, it was predicted that men would have longer CPT immersion times and lower pain ratings compared to women (Dixon, Thorn, & Ward, 2004).

Method
Participants

This study was approved by the University at Albany Institutional Review Board, and all participants provided informed consent. The sample consisted of 97 undergraduates (53.6% female) recruited from the research participant pool of the university. The experiment was advertised as a study in which the participant would be asked to complete questionnaires, sit still for 20 minutes, and be asked to place his or her hand in ice water while readings of HR and BP were collected. Potential research participants who expressed an interest in this study were briefly screened by answering a series of questions online relating to experience with meditation and family history of hypertension. Potential participants who didn't meet the criteria listed below were not eligible to participate or receive credit and were notified automatically upon completion of the screen. Participants who were eligible automatically received a pass-code with which they could sign up on the Experimentrak website. Eligible participants were required to: (a) be at least 18 years old; (b) be able to sit quietly for 20 minutes; (c) have minimal experience with meditation; (d) have no history of frost-bite or any other skin condition that may interfere with the CPT; and (e) have one or more first-degree relatives with hypertension. Seventy-one percent of participants were between 18 and 19 years old. Forty-one percent of individuals in the sample were members of an ethnic minority group (12.4% Spanish/Hispanic/Latino Hispanic; 11.3% Black/African-American; 9.3% Multi-racial; 6.2% Asian/Asian-American; 2.1% other; 0.0% missing/not reported [See Table 1 for breakdown of all descriptive variables by condition]).

Baer’s review (2003) demonstrated that studies examining mindfulness techniques typically have medium to large effect sizes when a full mindfulness-based
intervention protocol such as MBSR or MBCT is implemented. Although the present study only examined a brief mindfulness induction, there is not yet adequate information in the extant literature on effect sizes induced by these very brief interventions. According to Cohen (1988), sample sizes of at least 33 per group are necessary in order to determine if an effect is present with medium effect size inductions. Although this seems ample based on studies examining physiological responses using similar inductions (Arch & Craske, 2006; Kingston et al., 2007; Sawada & Steptoe, 1988) a power analysis was also conducted based on the work of Ditto et al. (2006) as this was the only study that provided adequate statistical information to conduct a power analysis. The results of this power analysis (see below) suggested that 48 participants per group would be necessary in order to determine if an effect is present. It was determined that a minimum of ninety-six undergraduate students with a positive family history of hypertension would be recruited and randomly assigned to either the MA or a control condition.

Procedure

Following the screening procedure described above, eligible participants were automatically able to sign up for 1.5 hour long time-slots via the Experimentrak website. Eligible participants were e-mailed on the day prior to their scheduled experiment and instructed that they should not smoke any cigarettes at least 30 minutes prior to this appointment, and not drink any caffeine at least 1 hour prior, in order to reduce exogenous effects on BP. Finally, any participants who were taking any adrenergic agonists (e.g., Pseudoephedrine and Afrin), other stimulants (e.g., Adderall, Dexedrine, and Ritalin), or illicit drugs (e.g., amphetamines, MDMA, cocaine, and PCP) were
requested to either schedule for a date when these agents would not be in their system or
told that they would not be able to participate in the research, as these can elevate BP
readings. When participants arrived for their appointment they were asked to provide
written informed consent and to complete questionnaires of demographic information and
more in-depth family history of CVD. Initial physiological readings of HR and BP were
collected after a five-minute resting period in order to obtain baseline resting levels. A
second reading was then taken after an additional five minutes and then a third reading
immediately proceeded the second (Reeves, 1995). The average of these readings was
then used as a baseline.

Participants were randomly assigned to one of two groups in which they received
either a experimental MA induction adapted from Kabat-Zinn (1990) or a control
condition in which they listened to a portion of an audio book (modeled from Ditto et al.,
2006). Each condition was conducted individually with a single participant by a trained
experimenter. Both the induction and the control were administered via prerecorded
audio to better ensure reliability and control. Participants were instructed prior to the
induction that they would need to utilize important instructions later in the experiment
and should therefore pay close attention. Both groups are described in greater details
below.

A behavioral manipulation check was administered and assessed by the
experimenter, whereby participants were instructed to raise their hands to the tone of a
bell at regularly scheduled intervals to indicate whether or not they were adhering to the
manipulation or paying attention to the audio book (instructions modeled from Frewen et
al., 2007). As Frewen et al. point out, ringing of bells during silent meditation sittings is a
common practice at mindfulness retreats in order to remind practitioners to return their attention to the meditation at hand.

Three consecutive physiological readings were collected immediately after the induction so that effects, if any, of the induction could be analyzed. After physiological data were collected, the CPT was administered (instructions adapted from Baeyer, Piira, Chambers, Trapanotto, & Zeltzer, 2005). The heart rate monitor was attached to the participant from this point onward so that readings of BP and HR could be taken as quickly and easily as possible both during and upon completion of the CPT and MT task.

In preparation for the CPT, participants were instructed that they should submerge their hand in the water to the wrist and that although they may experience pain, there would be no permanent nerve or skin damage that would occur as a result of this task. Participants in the MA condition received the additional instruction that it was essential that they employ the strategy they were taught during the induction during the course of the CPT. Participants in the control condition received no special instructions regarding what to do while their hand was submerged.

Participants were next instructed that although the experimenter would like for them to hold their hand in the water for as long as possible, they could make the decision to remove their hand at any point during the task (Charlton, 1995). They were also asked to indicate verbally to the experimenter when they first noticed the experience of pain during the CPT. Three readings of BP and HR were taken at one-minute intervals beginning thirty seconds into the task. After four minutes of immersion, the participant was asked to remove his or her hand from the water. They were then given a dry towel to place their hand on but instructed that they should not make any attempt to dry their
hand. Three recovery readings were taken at two-minute intervals after the task completion reading so that direction and slope could be assessed (Llabre, Spitzer, Siegel, Saab, & Schneiderman, 2004). During this time, the participant was asked to provide reports of overall and peak levels of pain during the task.

Upon completion of the three recovery readings, participants next engaged in the MT task. A computerized version downloaded from Center for Addictions, Personality, and Emotion (CAPER, 2007) was used (instructions modeled from Frazer, Larkin, & Goodie, 2002), in which participants were asked to trace the outline of a five-point star inversely on a computer screen (i.e., upward movement of the mouse resulted in downward movement of the cursor, etc.). Once again, participants in the MA condition were instructed to employ the strategy they were taught during the induction during the course of the MT task, while participants in the control condition received no such instructions.

Upon completion of the three recovery readings, the cuff was removed from the participant and he or she received the equivalent of one and a half hours of credit through the Psychology 101 Research Pool. Participants were debriefed upon completion as to the full nature of the experiment.

*Induction and Control*

Participants in the MA condition were exposed to a 20-minute audio recording that asked them to be aware of their breathing and, if they were to become distracted, to redirect their focus back to their breath. The term “mindfulness-analog” is used because a comprehensive mindfulness intervention, such as MBSR, is typically administered over weeks with participants practicing daily. This analog was adapted from the mindfulness
breathing exercise Kabat-Zinn (1990) used in his MBSR program. Arch and Craske (2006) used a similar “focused-breathing” induction to model the effects of inexperienced mediators’ introduction to mindfulness. This kind of brief, experimental induction may be appropriate for delineating the mechanisms of mindfulness because the laboratory setting may minimize some threats to internal validity, such as differences in individual practice, including frequency and duration of practice time.

The control condition was modeled after Ditto et al. (2006). As the MA condition involved listening to an audiotape of a person speaking in a soothing, pleasing voice, Ditto et al. argued that the control condition should involve similarly valenced stimuli. Therefore, participants in the present study listened to the initial 20 minutes of the audio book *Harry Potter and the Sorcerer’s Stone* (1999). This portion of the audio book features a narrator speaking in a pleasing baritone, and the content is not particularly sympathetically arousing.

**Equipment**

*Cold pressor task.* The CPT was selected as a laboratory stressor due to its having good reliability in inducing a strong sympathetic response (Graven-Nielsen, Sergerdahl, Svensson, & Arendt-Nielsen, 2001; Velasco et al., 1997). A basal skin temperature was achieved by having participants place their dominant hand in warm water (99-101 degrees Fahrenheit) for 2 minutes. The participant then transferred this hand to an adjacent tub of water that was maintained at between 33 and 35 degrees Fahrenheit. Water levels in both tubs were adequate to cover the hand, and participants were asked to keep their hands submerged up to their wrist.
Heart rate monitor. BP and HR were measured using a Critikon Dinamap, a reliable automatic reader used in medical settings. As there are a multitude of factors that can influence BP and HR, participants were given instructions prior to arriving at the laboratory to help achieve better control (Reeves, 1995). Even so, blood pressure measurement is highly variable over very short periods of time and can also be prone to error in measurement. Marshall (2004) recommends taking as many measurements as is feasible. For this reason, it was decided to take three measurements over a period of several minutes to achieve a reasonable baseline.

Audio induction. A prerecorded audio tape was used to implement the MA induction and the control. This was done in order to ensure greater reliability.

Measures

Screening. Participants who expressed interest in the study through the Psychology 101 Research Pool website were asked a brief series of questions online to determine eligibility. These questions mirrored the eligibility criteria outlined above.

Demographic information. Demographic information was collected via self-report measures when participants first arrived to the laboratory in order to describe the sample and analyze for any potential effects. Participants were asked to report their gender, race/ethnicity, age, level of education, religion, marital status, and height and weight.

Family history. Family history of BP, heart attack, and stroke were obtained via self-report measures when participants first arrived at the laboratory using the CARDIA (Coronary Artery Risk Development in Young Adults; Friedman et al., 1988) family history questionnaire. This is a semi-structured self-report inventory that asks 25 dichotomous (i.e., “yes or no”) questions pertaining to cardiovascular events and history
within first-degree members of the participant’s family. This measure has been widely used in the CARDIA study, which is an on-going multi-site longitudinal study examining risk factors for heart disease. If the participant reports that one or both parents had hypertension, that participant will be identified as having a positive family history.

_Pain readings._ Participants were asked to say out loud when they first began to experience pain during the CPT, and the number of seconds into the task was recorded. After this procedure, they were shown an 11-point scale and asked to verbally indicate overall and acute levels of pain from 0 (_no pain_) to 10 (_worst pain_) while the experimenter recorded their response. These types of scales are commonly used in clinical settings as well in studies that assess pain using the CPT (e.g., Sullivan, Tripp & Santor, 2000).

_Manipulation check._ At the conclusion of the experiment, participants in the MA condition were verbally asked to what extent they followed the taped instructions during the induction, during the CPT, and during the MT from 0 (_no adherence_) to 5 (_strict adherence_). The experimenter recorded their responses.

_Data Analysis_

_Power._ As explained above, a power analysis was conducted based on the induction reported by Ditto et al. (2006). These researchers achieved a beta of .628 on DBP for 30 participants acting as their own controls in a cross-intervention design. Beta was estimated based on a pooled mean of 1.8 (_S.D. = .65_), and 2.2 (_S.D. = .90_) for the mindfulness meditation group. To determine if an effect is present, with alpha set at .05, power at .80, and beta at .20, 48 participants per group are required. It was expected that the MA group would experience lower rates of physiological reactivity during the CPT.
compared to the control group. Adherence to the manipulation was assessed both during the induction, with a behavioral task, and in a questionnaire afterwards. Data from each condition were examined for variations in adherence, demographics, and other predictors to ensure group equivalency. Any such predictors that varied by condition were covaried in final analyses as were baseline measures of HR and BP (Van Breukelen, 2006).

*Measuring reactivity.* HR and BP were measured during six distinct time-periods: initial resting period (baseline), immediately following the induction, during the CPT (reactivity), recovery from the CPT, during the MT task (reactivity), and during recovery from the MT task. Each period consisted of three readings of HR and BP. For the baseline, post-induction, and reactivity periods these three readings were averaged for each of SBP, DBP, and HR (e.g., Liu et al., 2009). Reactivity scores to the CPT and MT task were calculated by averaging readings taken during the induction and the stressor and subtracting baseline levels of arousal, yielding a CVR change score (e.g., Hughes and Stoney, 2000; Malpass et al., 1997).

*Group differences in reactivity and recovery.* It was predicted that participants receiving the MA induction would have lower rates of physiological reactivity to the CPT and MT tasks compared to the control condition. To test for group differences, one-way analyses of variance (ANOVAs) examining condition (mindfulness vs. control) were performed with CVR change score as the dependent variable. This procedure was also performed with physiological readings taken after the induction and comparing them to baseline levels to determine what, if any, effect this had on BP and HR.

It was predicted that participants receiving the MA induction would have decreased latency to recovery to the CPT and MT tasks compared to the control
condition. Recovery was examined using repeated measures analyses of covariance (ANCOVAs) with baseline levels of HR or BP serving as the covariates. This was performed using a 2 (mindfulness vs. control) by 3 (time: 1 minute intervals post-CPT immersion/post-MT task) design with BP and HR as dependent variables.

It was predicted that women would have lower baseline levels of SBP, which was examined using an independent samples t-test. It was also predicted that women would have lower levels of CVR compared to men. To test for gender differences, one-way ANOVAs examining gender (male vs. female) were performed with the CVR change score as the dependent variable.

*Group differences in pain.* Comparisons of CPT immersion and pain ratings between the current sample and published data were conducted by examining mean values and standard deviations. This allows for an informal estimate of the difference in pain tolerance and perception in samples with and without a family history of hypertension.

**Results**

*Descriptive Statistics and Preliminary Analyses*

One-hundred participants were randomized to one of two conditions. Three were removed from analyses after examination of their data revealed that they did not have a family history of hypertension. After removal of these participants, there were 48 participants in the MA condition and 49 in the control condition.

Baseline levels of blood pressure were similar to what was found in previous studies examining children of hypertensive parents (e.g., Garg, Kumar & Singh, 2010; Lambert & Schlaich, 2004). The sample in the present study did exhibit reduced SBP
reactivity to the CPT compared to previous studies although DBP reactivity scores were similar. Reactivity to the MT was dissimilar to previous studies as it was marked by a lack of any increase in HR, SBP, or DBP. Potential reasons for this will be addressed in the discussion. Baseline levels, mean change scores and standard deviations for HR, SBP, and DBP by condition can be found in Table 2. Average scores on physiological indices by condition, collapsed on time periods, can be found in Figures 1-3.

CPT immersion times ranged from 14 seconds to the full 4 minutes with an average immersion time of 94.5 seconds ($SD = 64.18s$). These immersion times are longer than most studies using the CPT (e.g., Mitchell, MacDonald & Brodie, 2004), which is as expected, given the tendency towards hypoalgesia in this population. Studies examining CPT in participants with a family history of hypertension used varying procedures and did not report immersion times. The average reported pain rating was 6.23 on a 10-point scale ($SD = 1.75$), which is similar to previous studies using college student samples (e.g., Sullivan, Tripp, & Santor, 2000). There were no group differences in CPT immersion time or pain ratings.

Preliminary analyses were conducted to evaluate whether the MA and control groups varied on baseline demographic variables of gender, ethnicity, body mass-index (BMI), and age. Groups were also compared on baseline SBP, DBP, and HR as well as adherence to their induction. Chi-square tests were used on the categorical demographic variables of gender and minority status (racial/ethnicity was categorized into White/Caucasian or Minority). Univariate $t$ tests were conducted for age, DBP, SBP, HR, BMI, and adherence to the inductions. There were no significant group differences found for distribution of: gender, $\chi^2(1, 97) = 0.50, p = .48$; BMI, $t(1, 95) = 0.71, p = .48$; age,
Significant group differences were found for minority status, \( \chi^2 (1, 97) = 5.71, p = .02 \), indicating that there was an uneven distribution of race in the two groups with more minority participants having been randomly assigned to the control group. Significant group differences were also found for behavioral adherence to the induction, \( t(1, 95) = -2.40, p = .02 \), with participants in the control condition having been more likely to follow the instructions and be attending to the audio-book. Group differences were controlled for in subsequent analyses where appropriate.

Participants in the MA condition provided additional data on compliance with the mindfulness-induction as well as with their use of the induction during the two stressors on a 0-5 scale. Mean adherence to the induction was 3.56 (SD = 0.92) suggesting high-moderate levels of adherence to the instructions. Use of the induction during the two stressors was 2.72 (SD = 1.42) and 2.24 (SD = 1.31) for the CPT and MT respectively, indicating moderate use of the induction during these tasks.

Further preliminary analyses were done to test whether the inductions (i.e., mindfulness vs. control) resulted in any changes in SBP, DBP, or HR. One-way ANCOVAs examining induction (mindfulness vs. control) were performed with average post-induction score as the dependent variable. Covariates were minority-status and adherence to the induction as these variables differed by condition.

Examination of assumptions of normality of sampling distributions, linearity, homogeneity of variance, homogeneity of regression, and reliability of covariates suggested these were all adequate. There was no significant difference between the two conditions on measures of: SBP, \( F(1,92) = .9, p = .53 \), partial eta squared < .01; DBP,
Physiological changes to the inductions were assessed using linear regression with baseline physiological indices as the independent variable and the average post-induction score as the dependent variable. Across groups, inductions were significantly associated with decreased SBP, \( F(1,95) = 342.59, p < .001 \), DBP, \( F(1,95) = 247.14, p < .001 \), and HR, \( F(1,95) = 487.97, p < .001 \). Within the mindfulness condition, there were significant reductions in: SBP, \( F(1,46) = 242.90, p < .001 \), DBP, \( F(1,46) = 110.76, p < .001 \), and HR, \( F(1,47) = 175.46, p < .001 \). Likewise, within the control condition, there were also significant reductions in: SBP, \( F(1,47) = 120.42, p < .001 \), DBP, \( F(1,47) = 121.50, p < .001 \), and HR, \( F(1,47) = 361.31, p < .001 \).

Physiological Reactivity to CPT and MT

To test the hypothesis that participants in the mindfulness condition would experience reduced reactivity to the CPT and MT compared to those in the control condition, one-way ANCOVAs examining induction (mindfulness vs. control) were performed with a change score as the dependent variable. Covariates were minority status and adherence to the induction.

Examination of assumptions of normality of sampling distributions, linearity, homogeneity of variance, homogeneity of regression, and reliability of covariates suggested these were all adequate. There was no significant difference between the two conditions on reactivity to the CPT on measures of: SBP, \( F(1,92) = .57, p = .45 \), partial eta squared = .01; DBP, \( F(1,92) = .05, p = .83 \), partial eta squared < .01; or HR, \( F(1,92) = .05, p = .82 \), partial eta squared < .01. There was no significant difference between the
two conditions on reactivity to the MT on measures of: SBP, $F(1,93) = .11, p = .74$, partial eta squared < .01; DBP, $F(1,93) = .02, p = .89$, partial eta squared < .01; or HR, $F(1,93) = .41, p = .53$, partial eta squared < .01.

To examine whether the stressors induced heightened cardiovascular responding, linear regression with baseline physiological indices as the independent variable and the average reactivity score as the dependent variable. The CPT was significantly associated with increases in: SBP, $F(1,94) = 27.52, p < .001$, DBP, $F(1,92) = 14.67, p < .001$, and HR, $F(1,94) = 28.24, p < .001$. The MT was significantly associated with reductions in: SBP, $F(1,94) = 190.28, p < .001$ and HR, $F(1,95) = 202.88, p < .001$, but with increased DBP, $F(1,95) = 114.54, p < .001$.

*Recovery from the CPT*

To test the hypothesis that participants in the mindfulness condition would have reduced latency to recovery to the CPT compared to participants in the control condition, a 2 x 3 repeated measures analysis of covariance was performed on cardiovascular recovery to the CPT with 1-minute intervals of time up to 3 minutes as the independent variable. Covariates were minority status and adherence to the induction. CPT immersion time was added as a covariate as immersion time varied widely and can determine degree of reactivity. Baseline physiological indices (SBP, DBP, or HR) were also added to maximize power.

The main effect of SBP recovery significantly violated the sphericity assumption because the significance value was less than .05, $W = .763, \chi^2(2) = 24.40, p < .01$. Because sphericity was violated, a Huynh-Feldt correction was used (Girden, 1992) to examine the main effect on SBP recovery. There was no significant main effect on SBP.
recovery $F(1.73) = 0.79, p = 0.44$. The pairwise comparisons for the three levels of recovery with Bonferroni adjustments indicated that there was a significant change from the first to the second reading but no change from the second to the third reading. Homogeneity of variance was assessed using Levene’s test and indicated that all variables were homogenous (all $p$’s > .05). There was a significant main effect of condition $F(1,91) = 4.13, p = 0.043$, with a partial eta-squared of .04, indicating that condition had an impact on SBP recovery from CPT (Table 3).

The main effect of DBP recovery did not significantly violate the sphericity assumption because the significance value was greater than .05, $W = .991, \chi^2(2,95) = 0.84, p = .66$. There was no significant main effect on DBP recovery $F(2,95) = 1.18, p = 0.31$. Pairwise comparison tests indicated that there was a significant change from the first to the second reading but no change from the second to the third reading. Homogeneity of variance was assessed using Levene’s test and indicated that all variables were homogenous (all $p$’s > .05). There was no significant main effect of condition $F(1,91) = 2.00, p = 0.16$, with a partial eta-squared of .02, indicating that condition had no impact on DBP recovery from the CPT (Table 4).

The main effect of HR recovery did not significantly violate the sphericity assumption because the significance value was greater than .05, $W = .980, \chi^2 (2,95) = 1.56, p = .46$. There was no significant main effect on HR recovery $F(2,95) = 1.03, p = 0.36$. Pairwise comparisons for the three levels of recovery indicated that there were no significant changes among any of the readings. Homogeneity of variance was assessed using Levene’s test and indicated that all variables were homogenous (all $p$’s > .05). There was no significant main effect of condition $F(1,91) = 0.47, p = 0.49$, with a partial
eta-squared of .005, indicating that condition had no impact on HR recovery from CPT (Table 5).

**Recovery from the MT**

To test the hypothesis that participants in the mindfulness condition would have reduced latency to recovery to the MT compared to participants in the control condition, a 2 x 3 repeated measures analysis of covariance was performed on cardiovascular recovery to the MT task with 1-minute intervals of time up to 3 minutes as the independent variable. Covariates were minority status and adherence to the induction.

The main effect of SBP recovery did not significantly violate the sphericity assumption because the significance value was greater than .05, $W = .999$, $\chi^2(2) = 0.053$, $p = .974$. There was no significant main effect on SBP recovery $F(2,95) = 2.012$, $p = 0.137$. The pairwise comparisons for the three levels of recovery are shown below with Bonferroni adjustments. These indicate that there were no significant changes among any of the three readings. Homogeneity of variance was assessed using Levene’s test and indicated that all variables were homogenous (all $p$’s > .05). There was no significant main effect of condition $F(1,92) = 0.671$, $p = 0.415$, with a partial eta-squared of .007, indicating that condition had no impact on SBP recovery from the MT (Table 6).

The main effect of DBP recovery did not significantly violate the sphericity assumption because the significance value was greater than .05, $W = .944$, $\chi^2(2) = 5.21$, $p = .074$. There was no significant main effect on DBP recovery $F(2,95) = 0.757$, $p = 0.470$. The pairwise comparisons for the three levels of recovery are shown below with Bonferroni adjustments. These indicate that there were no significant changes among any of the three readings. Homogeneity of variance was assessed using Levene’s test and
indicated that all variables were homogenous (all p’s > .05). There was no significant main effect of condition F(1,92) = 0.006, p = 0.937, with a partial eta-squared of .000, indicating that condition had no impact on DBP recovery from the MT (Table 7).

The main effect of HR recovery did not significantly violate the sphericity assumption because the significance value was greater than .05, $W = .944$, $\chi^2(2) = 5.209$, $p = .074$. There was no significant main effect on HR recovery F(2,95) = 0.757, $p = 0.470$. The pairwise comparisons for the three levels of recovery are shown below with Bonferroni adjustments. These indicate that there were no significant changes among any of the three readings. Homogeneity of variance was assessed using Levene’s test and indicated that all variables were homogenous (all p’s > .05). There was no significant main effect of condition F(1,92) = 0.006, $p = 0.937$, with a partial eta-squared of .000, indicating that condition had no impact on HR recovery from the MT (Table 8).

**Impact of Gender on Outcomes**

To test the hypothesis that there would be baseline differences on physiological indices between genders, univariate $t$-tests were conducted with gender as the independent variable and alternately baseline SBP, DBP, and HR as dependent variables. There was a significant difference between genders on SBP with men having higher baseline levels, $t(1,96) = 4.06$, $p < .001$ (123.3 [sd = 14.8] for males, 110.7 [sd = 15.6] for females) There were no significant differences with DBP, $t(1,96) = 0.50$, $p = .62$ or HR, $t(1,96) = -0.18$, $p = .85$.

To test the hypothesis that men would have increased reactivity to the CPT and MT, between-subjects ANOVAs were run with a CVR change score as the dependent variable for both the MT and CPT on reactivity outcomes. All outcomes were non-
significant for both the CPT (SBP, $F[1,94] = 1.85, p = 0.18$; DBP, $F[1,94] = 1.96, p = 0.17$; $F[1,94] = 2.82, p = 0.10$) and the MT (SBP, $F[1,95] = 0.30, p = 0.58$; DBP, $F[1,95] = 0.61, p = 0.44$; HR, $F[1,95] = 1.05, p = 0.31$). Next, between-subjects repeated-measures ANOVAs were run with gender as the between factor for recovery scores. All outcomes were non-significant for both the CPT (SBP, $F[1,94] = 1.85, p = 0.18$; DBP, $F[1,94] = 1.96, p = 0.17$; $F[1,94] = 2.82, p = 0.10$) and the MT (SBP, $F[1,95] = 0.30, p = 0.58$; DBP, $F[1,95] = 0.61, p = 0.44$; HR, $F[1,95] = 1.05, p = 0.31$).

Gender was also analyzed as a potential moderator by condition on main outcomes. Both gender and condition were centered by subtracting their means and then multiplied to compute an interaction term. The centered gender and condition predictors were entered in the first step of a two-step regression equation and their interaction in the second step. Recovery change scores were computed by subtracting the last of the three readings from the first for SBP, DBP, and HR. Reactivity and Recovery change scores for both the CPT and the MT were entered as dependent variables. The interaction of gender and condition was not significant for any of the potential physiological outcomes (all $p$'s > .05).

Gender differences in pain responding and CPT immersion time were analyzed with univariate $t$ tests. There were no significant gender differences found for time to first pain response, average pain rating, or highest pain rating. A significant gender difference was found for length of CPT immersion time, with males keeping their hands submerged in the water longer than females (112s vs. 74s), $t(1, 95) = 3.07, p = .003$.

Discussion
This study evaluated the effect of a brief mindfulness induction compared to a control condition on short-term physiological outcomes when participants were exposed to a physical and a cognitive stressor. A small handful of studies have looked at the effects of mindfulness inductions on physiological outcomes (e.g., Ditto et al., 2006; Kingston et al., 2007), but no previous studies have examined the effects on cardiovascular reactivity and recovery to a stressor after a single-session mindfulness induction. Furthermore, no previous studies have looked at these effects in participants with a family history of hypertension, a population which is predisposed to experiencing increased cardiovascular reactivity and is at greater risk of developing hypertension.

The discussion of this study will begin by presenting outcomes related to the reactivity and recovery hypotheses, along with a discussion of why the limited findings are contrary to what was expected. Next, secondary hypotheses concerning algesia and gender will be discussed. Finally, clinical implications, limitations of the present study, and suggestions for future research are presented.

Reactivity and Recovery to Stressors

This study proposed that exposure to a MA induction would result in reduced reactivity and quicker recovery to a stressful task. These hypotheses were not supported, and a portion of the recovery findings were in the opposite direction of what was expected. In particular, when exposed to the CPT, participants in the mindfulness condition had slower and reduced rates of SBP recovery than participants in the control condition. DBP recovery was trending in this same direction as well. Since the effect size was small and there is no theoretical reason to think that there would be a differential impact on diastolic vs. systolic responding, it is reasonable to conclude that DBP
recovery was affected similarly to SBP recovery. These findings are seemingly in contrast to the burgeoning literature suggesting that mindfulness interventions that are longer in duration reduce the physiological response to stress (e.g., Kingston et al., 2007).

However, this study did not evaluate a true mindfulness intervention. It evaluated a brief analog of mindfulness that gave participants only a limited dose of the mindfulness experience. Furthermore, participants in the present study were meditation-naïve. These points are salient because initial exposure to discriminative stimuli that are aversive in nature should theoretically result in a large physiological response which should then decrease with repeated exposure to the stimuli or exposure of adequately lengthy duration (i.e., in those experienced with meditation). For example, single-session exposure therapies treating specific phobias that are of sufficiently long duration have been shown to dramatically reduce the physiological arousal associated with the feared stimulus (see Zlomke & Davis, 2008 for a review of this literature). Over time enhanced attention and awareness to discriminative stimuli leads to habituation of physiological responding to these stimuli. This paradigm has been demonstrated in studies incorporating meditation going back more than 30 years (e.g., Goleman & Schwartz, 1976). However, the answer to the question of adequate dosage in mindfulness meditations is still uncertain (Roemer & Orsillo, 2003). As habituation works over time, this is in an important empirical question for the mindfulness literature and may explain why the expected results were the inverse of what was expected.

The self-consciousness literature suggests that increased awareness of private consciousness events increases reactance (Carver & Scheier, 1981). These researchers postulate that increased attention to private experiences raises awareness of threats to
freedom that lead to emotional reactions. This may also explain the latency to recovery in
the group of participants who were primed to be more aware of internal processes while
being subjected to the threat of the CPT.

Across conditions, the CPT elicited heightened DBP, SBP, and HR reactivity,
whereas the MT task elicited heightened DBP but reduced SBP and HR responding
compared to baseline levels. During recovery from a stressor the vagus nerve is activated
in an attempt to reduce sympathetic responding and maintain homeostasis. As the MT
task occurred immediately following the CPT there may have been a carryover effect
whereby vagal activity was still suppressing SBP and HR responding, an effect that has
previously been demonstrated by Mezzacappa et al., 2001. As BP and HR responding can
be variable, there may have been a stronger vagal effect on SBP and HR compared to
DBP.

The present study failed to demonstrate any significant effects on cardiovascular
reactivity by condition, which may in part have been an artifact of the population we
were examining. People with a family history of hypertension have higher baseline levels
of blood pressure and heart rate and appear to exhibit greater cardiovascular reactivity.
The heightened cardiovascular reactivity across participants may have captured most of
the variance for this effect. It is not clear why recovery scores were able to differentiate
between the two conditions yet reactivity scores were not. It is possible that participants
found it difficult to practice mindful breathing during the reactivity period when there
was a considerable amount of competition for their cognitive resources, but effects of the
induction were revealed during the recovery period. This is consistent with the cognitive
load literature, which suggests that physical and cognitive tasks share competition for
bodily resources. Therefore, increasing blood pressure and heart rate would make it more difficult for participants to engage in practicing the mindful-breathing induction (e.g., Fredericks, Choi, Hart, Butt, & Mital, 2005).

Algesia and Gender

There is wide variability in the methodology of the CPT. Studies may expose a foot, forehead, hand, or arm to cold water for varying lengths of time at varying levels of temperature in baths that may or may not be circulating. This study used procedures similar to Dixon et al. (2004), in which participants were allowed up to 4 minutes of submersion of their dominant hand in a circulating ice bath maintained at between 33 and 35 degrees Fahrenheit. Several studies have measured BP and HR at basal levels and in response to cold pressor reactivity in participants with a family history of hypertension. There tends to be a great deal of divergence in these findings, which may be an artifact of both small sample sizes (e.g., Garg, Kumar & Sing, 2010; Lambert & Schlaich, 2004) and variations in cold pressor procedures. Therefore, it’s difficult to compare the present study with other studies, although baseline levels of BP and HR were roughly equivalent.

The only significant finding relating to gender and CPT in the present study was the difference in immersion time between males and females. Males had longer duration of immersion, which has also been demonstrated in previous studies (e.g., Back, Brady, Jackson, Salstrom & Zinzow, 2005; Dixon, Thorn & Ward, 2004). Although immersion time can be thought of as an analog to pain, gender differences in self-reported pain ratings were not present. The present study is not the first that was unable to replicate gender differences in pain in response to the CPT (e.g., Jones & Zachariae, 2004), and pain differences may be dependent upon other cognitive or contextual variables that were
not measured. However, it should also be noted that hypoalgesia is common in this sample and may be genetically linked to some of the same mechanisms that predispose for hypertension such as baroreceptor responding. Therefore, pain responding may have been attenuated across groups, making it more difficult to detect any gender differences. Finally, there were no differences in immersion or pain ratings by condition. As there were no group differences in reactivity, this was not surprising.

Clinical Implications

This study evaluated a sample of participants with a family history of hypertension, a population that is predisposed towards the development of hypertension. It has been proposed that this development may in part be mediated by greater cardiovascular reactivity and latency to recovery from stress. Therefore, interventions that may reduce this reactivity and latency to recovery may ameliorate the progression towards hypertension. There is a burgeoning literature demonstrating the effect of traditional-length mindfulness interventions on reducing blood pressure in normotensive samples. There is also anecdotal evidence of the effectiveness of mindfulness meditation on hypertension, but efficacy has yet to be examined and the mechanism is unclear. For example, it is uncertain whether practicing mindfulness meditation may lead to a cognitive reframing of stress, habituate physiological responding to stressors, or some combination of both.

The present study demonstrated that participants with a family history of hypertension showed lower rates of SBP recovery to a physiological stressor following a brief mindfulness meditation. Although it is possible that this particular population may be anomalously effected by mindfulness inductions, this is unlikely as there is no
theoretical or extant plausible reason. More likely, there is a dose-response relationship present in mindfulness-type interventions whereby exposure to novel internal stimuli (i.e., the physiological stress response) may heighten cardiovascular responding upon initial presentations. With more frequent and longer duration of exposures, learning theory predicts that habituation and therefore reduced cardiovascular responding would occur as has been demonstrated in previous studies (e.g., Kingston et al., 2007).

Patients who are considering mindfulness-type interventions to reduce hypertension should first be made aware that there is still only limited evidence of its effectiveness and that no large-scale randomized clinical trials have yet to be published (although at least one is in the works, the HARMONY Study [Hypertension Analysis of Stress Reduction Using Mindfulness Meditation and Yoga; Sunnybrook Health Sciences Centre & University Health Network, Toronto, 2011]). Second, for novice practitioners of mindfulness meditation, this study suggests that initial practice may actually reduce or inhibit their blood pressure recovery from a stressor. This should not necessarily deter patients with hypertension from continuing to engage in mindfulness interventions. Perhaps, as is suggested above, there is a habituation effect that occurs, whereby increased frequency of practice will lessen physiological reactivity. Longitudinal studies such as the HARMONY study will hopefully result in some tangible empirical evidence that can provide clinical guidance.

Limitations

The hand CPT was used as a physiological stressor as it has demonstrated a large and reliable effect on sympathetic nervous system indices. This effect, and the associated nociceptive pain, requires instructing participants that they can halt the task at any time.
This complicates data analysis as it subsequently results in a varying number of physiological readings depending upon the participants’ immersion time. The choice of a physiological stressor that allows for an equal number of reactivity readings for each participant would have allowed for measurement in slope as well as changes in directionality over the course of the stressor as opposed to just having a single averaged reactivity reading.

The MT task did not elicit a predictable stress response as has previously been demonstrated in the literature. Approximately four minutes passed between the end of the CPT and the beginning of the MT. This may not have been sufficient time for sympathetic responding to attain equilibrium.

Participants in the MA condition were significantly less likely to adhere to the audiotape than participants in the control condition. There could be a couple of explanations for this: (1) The control audiotape featured a professionally trained actor speaking in a very entertaining voice, whereas the MA condition featured this author speaking in a calm, even voice. (2) The control audio was delivered in a constant stream, making it easy to attend to and more difficult to become distracted by internal stimuli. In contrast, the MA condition included long pauses between instructions, designed to allow the participants to engage in the mindfulness exercise, which might have made it more difficult to stay focused.

Gender was examined as a potential moderator, although no interaction was observed with condition and reactivity or recovery outcomes. However, there may be other moderating variables present that were not accounted for. For example, the distress tolerance literature suggests that individuals who are low in distress tolerance are more
likely to become absorbed by distressing emotions and experiences (Simons & Gaher, 2005). Distress tolerance may have been disproportionately variable in condition assignment and could be taken into account in future studies.

Future Directions

Participants in the mindfulness condition were less likely to adhere to the induction than those in the control condition. Although this was controlled for in analyses, it likely led to a reduction in power and therefore the ability to detect group differences. The mindfulness instructions were limited in order to give participants time in between directions to practice. However, in novice mindfulness practitioners, this may lead to greater distraction and therefore less adherence. A study with increased frequency of instructions may better control for this problem; however, finding a balance between listening to instructions and allowing time for practice is important and is not a question that has yet to be addressed empirically.

The early work on distraction and attention in coping with distress can also inform this literature (for an early meta-analysis see Suls & Fletcher, 1985). For example, McCaul and Haugtvedt (1982) conducted an experiment in which participants used distraction or attentiveness to cope with cold pressor distress. They found that distraction was the superior coping method in the initial period of the CPT, but attentiveness was the superior coping method for managing distress in the latter stages. Perhaps the mindfulness induction was exerting a similar effect in the present study. Accordingly, future studies may employ a cold pressor paradigm that is more tolerable (i.e., lower temperature) in order to be able to discern effects that unfold over longer periods of time.
and whether a mindful-awareness strategy begins to exert superiority with longer duration of immersion.

It is worth noting that the control condition received no instructions on how to cope with the CPT. Consequently, their coping method was self-chosen. Some participants may have attempted to distract themselves, whereas others may have tried approach-oriented coping strategies, and others may not have engaged in any purposeful coping efforts. It should therefore be noted that although participants who engaged in a brief MA induction had a greater latency to SBP recovery, it cannot be said with certainty compared with what. Future studies could may provide participants with prompts about how to cope or could assess coping responses afterwards to reduce this potential heterogeneity.

This MA induction was designed to evaluate only one component of mindfulness, awareness. But mindfulness is thought to be a multi-faceted construct (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006). Other facets, such as cultivating a non-judgmental attitude, may be an additional necessary component in reducing reactivity. Future studies could examine the added benefit that the addition of such components induces.

The question of minimum or adequate amount of dosage (i.e., length and number of sessions) to reveal treatment effects is one with great potential clinical utility. What is the minimum amount of treatment necessary to acquire benefits, and is there a point of diminishing returns? Future studies might contrast various frequency and duration of doses to further answer these questions.
References


Sunnybrook Health Sciences Centre & University Health Network, Tortonto.

HARMONY Study (Hypertension Analysis of Stress Reduction Using Mindfulness Meditation and Yoga). In: ClinicalTrials.gov [Internet]. Bethesda.


Table 1

Descriptive Variables by Condition (Means, Standard Deviations, and Percentages)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mindfulness Analog (n = 48)</th>
<th>Control Group (n = 49)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-19</td>
<td>77.1%</td>
<td>65.3%</td>
</tr>
<tr>
<td>20-21</td>
<td>18.8%</td>
<td>20.4%</td>
</tr>
<tr>
<td>22-24</td>
<td>0.0%</td>
<td>10.2%</td>
</tr>
<tr>
<td>25 and above</td>
<td>4.2%</td>
<td>4.1%</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>50.0%</td>
<td>57.1%</td>
</tr>
<tr>
<td>Male</td>
<td>50.0%</td>
<td>42.9%</td>
</tr>
<tr>
<td><strong>Ethnicity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asian/Asian American</td>
<td>2.1%</td>
<td>10.2%</td>
</tr>
<tr>
<td>Black/African/African-American</td>
<td>8.3%</td>
<td>14.3%</td>
</tr>
<tr>
<td>Spanish/Hispanic/Latino</td>
<td>6.3%</td>
<td>18.4%</td>
</tr>
<tr>
<td>White/Caucasian</td>
<td>70.8%</td>
<td>46.9%</td>
</tr>
<tr>
<td>Multi-racial</td>
<td>12.5%</td>
<td>6.1%</td>
</tr>
<tr>
<td>Other</td>
<td>0.0%</td>
<td>4.1%</td>
</tr>
<tr>
<td>Missing/None Reported</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td><strong>Religion</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protestant</td>
<td>12.5%</td>
<td>10.2%</td>
</tr>
<tr>
<td>Catholic</td>
<td>35.4%</td>
<td>42.9%</td>
</tr>
<tr>
<td>Jewish</td>
<td>10.4%</td>
<td>8.2%</td>
</tr>
<tr>
<td>Buddhist</td>
<td>0.0%</td>
<td>2.0%</td>
</tr>
<tr>
<td>Hindu</td>
<td>2.1%</td>
<td>2.0%</td>
</tr>
<tr>
<td>None</td>
<td>16.7%</td>
<td>18.4%</td>
</tr>
<tr>
<td>Other</td>
<td>22.9%</td>
<td>16.3%</td>
</tr>
<tr>
<td><strong>Marriage</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>2.1%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Never Married</td>
<td>97.9%</td>
<td>98.0%</td>
</tr>
<tr>
<td>Widowed</td>
<td>0.0%</td>
<td>2.0%</td>
</tr>
<tr>
<td><strong>Body Mass Index</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td>24.39 (4.16)</td>
<td>23.82 (3.81)</td>
</tr>
</tbody>
</table>
Table 2

Baseline Measurement and Change in SBP, DBP, & HR by Mindfulness-Analog vs. Control Conditions (Means & Standard Deviations)

<table>
<thead>
<tr>
<th>Measure</th>
<th>Mindfulness Analog</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline SBP</td>
<td>118.65 ±16.73</td>
<td>116.27 ±16.00</td>
</tr>
<tr>
<td>Baseline DBP</td>
<td>61.78 ±7.21</td>
<td>59.06 ±6.53</td>
</tr>
<tr>
<td>Baseline HR</td>
<td>75.28 ±10.89</td>
<td>75.16 ±10.72</td>
</tr>
<tr>
<td>Change in SBP(^1)</td>
<td>-4.87 ± 6.68</td>
<td>-4.46 ± 8.50</td>
</tr>
<tr>
<td>Change in DBP(^1)</td>
<td>-2.03 ± 3.96</td>
<td>-2.18 ± 3.66</td>
</tr>
<tr>
<td>Change in HR(^1)</td>
<td>-0.83 ± 5.09</td>
<td>-0.15 ± 3.7</td>
</tr>
<tr>
<td>Change in SBP(^2)</td>
<td>8.43 ± 29.57</td>
<td>10.27 ± 18.15</td>
</tr>
<tr>
<td>Change in DBP(^2)</td>
<td>14.72 ± 18.76</td>
<td>13.94 ± 13.24</td>
</tr>
<tr>
<td>Change in HR(^2)</td>
<td>1.36 ± 17.48</td>
<td>1.75 ± 12.86</td>
</tr>
<tr>
<td>Change in SBP(^3)</td>
<td>1.98 ± 9.74</td>
<td>-1.60 ± 11.78</td>
</tr>
<tr>
<td>Change in DBP(^3)</td>
<td>4.77 ± 7.09</td>
<td>2.82 ± 6.49</td>
</tr>
<tr>
<td>Change in HR(^3)</td>
<td>-4.55 ± 5.87</td>
<td>-3.31 ± 5.20</td>
</tr>
<tr>
<td>Change in SBP(^4)</td>
<td>-2.53 ± 9.31</td>
<td>-2.80 ± 10.44</td>
</tr>
<tr>
<td>Change in DBP(^4)</td>
<td>3.57 ± 6.37</td>
<td>3.17 ± 6.27</td>
</tr>
<tr>
<td>Change in HR(^4)</td>
<td>-3.88 ± 6.41</td>
<td>-2.65 ± 5.81</td>
</tr>
<tr>
<td>Change in SBP(^5)</td>
<td>-3.92 ± 8.35</td>
<td>-4.71 ± 8.86</td>
</tr>
<tr>
<td>Change in DBP(^5)</td>
<td>1.07 ± 4.53</td>
<td>1.24 ± 5.07</td>
</tr>
<tr>
<td>Change in HR(^5)</td>
<td>-2.57 ± 6.52</td>
<td>-2.79 ± 4.03</td>
</tr>
</tbody>
</table>

Note. \(^1\)Post-Induction Period; \(^2\)CPT Reactivity Period; \(^3\)CPT Recovery Period; \(^4\)MT Reactivity Period; \(^5\)MT Recovery Period
Table 3

Recovery from CPT by Condition as Measured by SBP Across Three Time Periods

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Mindfulness-Analog</th>
<th>Control Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>M</td>
</tr>
<tr>
<td>1-Minute Post CPT</td>
<td>48</td>
<td>124.79</td>
</tr>
<tr>
<td>2-Minutes Post CPT</td>
<td>48</td>
<td>118.98</td>
</tr>
<tr>
<td>3-Minutes Post CPT</td>
<td>48</td>
<td>118.10</td>
</tr>
</tbody>
</table>
Table 4

Recovery from CPT by Condition as Measured by DBP Across Three Time Periods

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Mindfulness-Analog</th>
<th>Control Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>M</td>
</tr>
<tr>
<td>1-Minute Post CPT</td>
<td>48</td>
<td>68.08</td>
</tr>
<tr>
<td>2-Minutes Post CPT</td>
<td>48</td>
<td>65.85</td>
</tr>
<tr>
<td>3-Minutes Post CPT</td>
<td>48</td>
<td>65.71</td>
</tr>
</tbody>
</table>
Table 5
Recovery from CPT by Condition as Measured by HR Across Three Time Periods

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Mindfulness-Analog</th>
<th>Control Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>M</td>
</tr>
<tr>
<td>1-Minute Post CPT</td>
<td>48</td>
<td>69.83</td>
</tr>
<tr>
<td>2-Minutes Post CPT</td>
<td>48</td>
<td>71.94</td>
</tr>
<tr>
<td>3-Minutes Post CPT</td>
<td>48</td>
<td>70.44</td>
</tr>
</tbody>
</table>
Table 6
Recovery from MT by Condition as Measured by SBP Across Three Time Periods

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Mindfulness-Analog</th>
<th>Control Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>M</td>
</tr>
<tr>
<td>1-Minute Post MT</td>
<td>48</td>
<td>114.54</td>
</tr>
<tr>
<td>2-Minutes Post MT</td>
<td>48</td>
<td>115.23</td>
</tr>
<tr>
<td>3-Minutes Post MT</td>
<td>48</td>
<td>114.40</td>
</tr>
</tbody>
</table>
Table 7
Recovery from MT by Condition as Measured by DBP Across Three Time Periods

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Mindfulness-Analog</th>
<th>Control Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>M</td>
</tr>
<tr>
<td>1-Minute Post MT</td>
<td>48</td>
<td>62.21</td>
</tr>
<tr>
<td>2-Minutes Post MT</td>
<td>48</td>
<td>63.69</td>
</tr>
<tr>
<td>3-Minutes Post MT</td>
<td>48</td>
<td>62.65</td>
</tr>
</tbody>
</table>
Table 8

Recovery from MT by Condition as Measured by HR Across Three Time Periods

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Mindfulness-Analog</th>
<th></th>
<th></th>
<th>Control Condition</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>M</td>
<td>SD</td>
<td>n</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>1-Minute Post MT</td>
<td>48</td>
<td>72.50</td>
<td>10.31</td>
<td>49</td>
<td>71.80</td>
<td>10.90</td>
</tr>
<tr>
<td>2-Minutes Post MT</td>
<td>48</td>
<td>73.33</td>
<td>9.42</td>
<td>49</td>
<td>72.14</td>
<td>10.09</td>
</tr>
<tr>
<td>3-Minutes Post MT</td>
<td>48</td>
<td>72.31</td>
<td>10.45</td>
<td>49</td>
<td>73.16</td>
<td>10.48</td>
</tr>
</tbody>
</table>
Figure 1. Mean SBP Responding though duration of Experiment (B1 = Baseline; PI1 = Post-Induction; CPT1 = Cold-Pressor Reactivity; CPT2 = Cold-Pressor Recovery; MT1 = Mirror-Tracing Reactivity; MT2 = Mirror-Tracing Recovery).
Figure 2. Mean DBP Responding though duration of Experiment (B1 = Baseline; PI1 = Post-Induction; CPT1 = Cold-Pressor Reactivity; CPT2 = Cold-Pressor Recovery; MT1 = Mirror-Tracing Reactivity; MT2 = Mirror-Tracing Recovery).
Figure 3. Mean HR Responding though duration of Experiment (B1 = Baseline; PI1 = Post-Induction; CPT1 = Cold-Pressor Reactivity; CPT2 = Cold-Pressor Recovery; MT1 = Mirror-Tracing Reactivity; MT2 = Mirror-Tracing Recovery).