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Mindfulness Meditation: Effects of a Brief Intervention on Cardiovascular Reactivity during Acute Stress

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ABSTRACT

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Mindfulness has historically been cultivated via formal meditation practice and the majority of meditation research examines individuals with extensive training or participants in mindfulness based stress reduction programs that require considerable expense, a trained facilitator, and take approximately 8 weeks to complete. However, current literature does not speak directly to those who do not have the time or ability for such commitments. Formal mindfulness meditation practice and interventions reduce stress in various populations; however, the outcomes of a one-time intervention are relatively unknown. This study aims to examine whether a one-time (20-min) mindfulness meditation intervention would improve cardiovascular variables during acute stressors in a meditation naïve sample when compared to a control group. Fifty-eight (58) normotensive undergraduate students (27 males, 31 females) with no prior meditation experience were randomly placed into either a treatment group that participated in one-time 15-minute audio training session on mindfulness meditation or a control group which listened to an audio health article. Following the training, participants participated in a psychosocial stressor modeled after the Trier Social Stress Test. Heart rate and blood pressure were assessed before and after the intervention and during the stress task. Results showed the mindfulness meditation condition group was effective in decreasing blood pressure response during the study, when compared to the control group. These results indicate that brief meditation training has beneficial effects on cardiovascular variables. These findings suggest that the benefits of a brief one-time mindfulness meditation intervention can be recognized immediately after a brief training treatment.

Keywords: mindfulness meditation, stress reduction, cardiovascular reactivity, blood pressure, stress

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Cardiovascular disease is the leading cause of death in the United States (Flaa, Eide, Kjeldsen, & Rostrup, 2008) and accounts for more deaths than cancer, chronic lower respiratory diseases, accidents and diabetes mellitus combined (Rosamond et al., 2007). According to the American Heart Association (2010), stress-related illnesses costs exceed $200 billion annually and nearly 16 million American adults have coronary heart disease. Past research has indicated that stress-induced cardiovascular reactivity is associated with early pathogenesis of cardiovascular disease (Roemmich, et al., 2011), atherosclerosis and cardiovascular events (Trieber, et al., 2008; Jennings, et al., 2004). The need for people to learn how to manage the stress in their lives is evident, as are the potential health and economic benefits. Efforts to develop and evaluate techniques for preventing and/or managing stress have grown over the past decade (Mosely & Linden, 2006).

Recently, there has been a growth of clinical treatment and wellness programs based on stress reduction programs (Kabat-Zinn, 1990; Ma & Teasdale, 2004; Segal, Williams, & Teasdale, 2002; Salmon, Lush, Jablonski, & Sephton, 2009). In particular, interest in mindfulness has rapidly grown in both the medical and scientific community in recent years (Keng, Smoski, & Robins, 2011; Brown, Ryan, & Creswell, 2007). Beneficial outcomes of traditional mindfulness meditation programs have been extensively studied over the past decade and found to develop effective mood regulation, decrease reactivity, and improved well being (i.e. Anderson, Lau, Segal & Bishop, 2007; Farb et al, 2010; Cahn & Polich, 2009; Nyklicek & Kuijpers, 2008); however, the effects of brief mindfulness meditation interventions are relatively unknown. There are only a few studies that have directly examined brief mindfulness meditation training and reported positive health outcomes (Lane, Seskevich, & Peiper, 2007; Zeidan, Gordon, Merchant & Goolkasian, 2010; Tang et al. 2007). This study addresses the effects of a one-time mindfulness meditation intervention and the effects of cardiovascular reactivity during an acute stressor.

Stress and the Stress Response

The cognitive stress theory states that physiological and psychological responses to stress emerge when an individual's perception of environmental demands are appraised as potentially harmful (Grant, et al., 2003) and exceed that individual's resources that allow for adapting to the situation (Cohen, Janicki-Deverts, & Miller, 2007). Stressful events that challenge or threaten a persons' well-being produce a shift in metabolic resources to ensure survival and involve the sympathetic adrenal medullary system (SAM) and the hypothalamic-pituitary-adrenal (HPA) axis (Boyce & Ellis, 2005).

Physiological stress weakens optimal body function and disrupts allostatic balance (Watkins & Maier, 2005); eventually leading to increased risk of cardiovascular disease and mortality (Kiecolt-Glaser, McGuire, Robles & Glaser, 2002). Acute stress testing that involves cardiovascular measurements and biological responses to laboratory induced stress is a central approach to investigating the core mechanisms behind this "stress-cardiovascular disruption" relationship (Dimsdale, 2008). Prospective studies to date have devised a variety of laboratory-based stress tasks under controlled conditions that include cognitive and/or physical challenge (e.g. the cold pressor test, the Stroop test, public speaking and others); however, such protocols have produced varying results in psychological and physiological outcomes (Carrol, Ring, Hunt, Ford & Macintyre, 2003; Kingston, Chadwick, Meron, & Skinner, 2007; Hassellund, Flaa, Sandvik, Kjeldsen, & Rostrup, in press).

A recent meta-analysis showed that acute stress can induce a reliable stress response by exposing individuals to elements of socio-evaluative threat and uncontrollable situations (Dickerson and Kemeny, 2004). More specifically, the Trier Social Stress Test (TSST; Kirschbaum, Pirke & Hellhammer, 1993) has been introduced as a widely used protocol for the induction of moderate psychosocial stress in a laboratory setting. Briefly, in the original TSST protocol, participants are asked to deliver a 10-minute public speech and to perform a subsequent 5-minute mental arithmetic task verbally in front of an evaluating audience. The audience includes two unfamiliar evaluators that do not respond emotionally during the test, and maintain a neutral facial expression. These two tasks, as well as anticipation during the preparation of the speech, consistently evoke subjective stress and produce a 2-3 fold increase in the activation of the HPA axis and the SAM system (Schommer, Hellhammer & Kirschbaum, 2003; Kudielka, Schommer & Hellhammer, 2004; Kudielka, et al., 2006; Zgraggen et al., 2005; Nater et al., 2006; Kelly, Tyrka, Anderson, Price & Carpenter, 2008).

Stress Reactivity and Cardiovascular Reactivity

These changes in the SAM and HPA have clearly been linked to the individual stress response and the development of stress-related disorders (Chrousos, & Gold, 2007; Steptoe, 1991; McEwen, 1998) such as hypertension (Esler et al. 2008) and adverse cardiac symptoms (Brotman, Golden & Wittstein, 2007; Hamer & Stamatakis, 2008; Rosengren et al., 2004). When confronted with a stressor, not all individuals will proceed to develop stress-related disorders. The psychobiological stress reactivity hypothesis states that the individual differences in the relationship between stress and disease can be explained by individual differences in response to stress (Boyce & Ellis, 2005; Cohen & Manuck, 1995; Lovallo & Gerin, 2003). It is suggested that stress responses within individuals are relatively stable over response systems, stressors and time (Hawkley et al., 2001; Schlotz et al., 2008) but at the same time are variable, depending on current and previous exposure to chronic stress (McEwen, 1998).

Recent studies have established reliable differences in individual reactivity that predicts the development of hypertension and coronary heart disease over time (Hilmert, Ode, Zielke, & Robinson, 2010). In a current meta-analysis on cardiovascular reactivity and its impact on clinical outcomes, Chida and Steptoe (2010) found a 23% increased risk of hypertension in individuals with higher reactivity. Early research by Hines and Brown (1936) originally suggested that an exaggerated cardiovascular response to a stress task (i.e. cold pressor test) revealed an increased risk for developing hypertension later in life. This finding led to the development of the cardiovascular reactivity hypothesis, which states that individuals who show exaggerated change in cardiovascular measures (e.g, heart rate or blood pressure) during a stressful situation are at higher risk of developing cardiovascular disease that those who show lesser reactivity. Furthermore, research has shown that after controlling for traditional risk factors, cardiovascular reactivity is associated with carotid intima-media thickness (Kamarck et al., 2004; Troxel, Matthews, Bromberger & Sutton-Tyrrell, 2003), cardio-vasculature damage (Gianaros et al., 2002), the development of hypertension (Treiber, et al., 2003; Carroll et al., 2001), coronary heart disease (Moseley & Linden, 2006) and sudden cardiac death (McDade, Hawkley, & Cacioppo, 2006).

While studies usually measure the magnitude of cardiovascular response during stress exposure, the return of blood pressure to pre-stress levels is critical and may have a role in the progression of hypertension. Past research suggests that delayed cardiovascular recovery following a stressful event may be directly related to negative disruptions in psychological and biological systems (Carroll et al., 2001), that then may contribute to adverse changes in blood pressure over time (Brosschot, Gerin, & Thayer, 2006; Steptoe & Marmot, 2005). Stressful events can be damaging and often lead to negative affect, including anxiety or depression, which can prolong the physiological response. Negative moods and emotions related to stress may also persist beyond when the stressor is actually present (Everson, et al. 2001). Incomplete cardiovascular recovery after stress exposure may be related to rumination, which has been defined as repetitive thoughts, intrusive, and negative cognitions about past distress (Nolen-Hoeksema & Jackson, 2001). Studies have provided convincing evidence that thinking about past stressful events (i.e. rumination) or worried thoughts play an important role in the process of incomplete cardiovascular recovery (Brosschot, et al., 2006; Radstaak, Geurts, Brosschot, Cillessen & Kompier, 2011; Glynn, Christenfeld & Gerin, 2007).

Stress Reduction and Treatment of Cardiovascular Risk Factors

Over the past several years, stress reduction interventions are increasingly used among researchers and clinicians in attempt to address a person's mental and physical health (Astin, Shapiro, Eisenberg, & Forys, 2003). The earliest intervention strategies for stress reduction originated from the work of cardiologist Herbert Benson (1975). His research was based on a hypothesis that the relaxation response elicits various physiological changes such as decreased respiratory rate, heart rate and blood pressure. Further evidence suggests that behavioral treatment (e.g., relaxation, meditation, biofeedback, etc) can decrease systolic blood pressure and heart rate (Rainforth, et al., 2007) by reducing the effects of the stress response and returning the body to homeostasis (Mosely & Linden, 2006). Specifically, a recent assessment of meditation practices found that interventions such as mindfulness meditation are associated with lower blood pressure and may be effective in reducing hypertension (Ospina, et al., 2008). Thus, such behavioral stress-reduction interventions may be useful in improving the various detrimental effects of stress on the cardiovascular system.

Mindfulness Meditation

Many philosophical, spiritual, and psychological traditions emphasize the importance of the quality of consciousness for the maintenance and enhancement of personal well-being (Wilber, 2000). One attribute of consciousness that has been discussed in relation to well-being is *mindfulness*. Mindfulness has been defined as "the awareness that emerges through paying attention on purpose, in the present-moment, and nonjudgementally to the unfolding of experiences moment by moment" and can be used formally or informally as one goes throughout his or her day. (Kabat-Zinn, 2003; p. 145). Generally speaking, two thoughts have developed regarding the conceptualization of mindfulness. First, some researchers propose that mindfulness is an innate trait related to attention and awareness, and something that is present in all individuals to varying degrees (Segal, et al., 2002). On the other hand are individuals who conceptualize mindfulness as a state and as something that is useful as a skill or technique (Hayes, Strosahl, & Wilson, 1999).

Mindfulness meditation aims to allow individuals to fully attend to stressful situations while focusing on the flow of each breath which increases self-awareness, self-realization, increased integration of subjective experience and acceptance and tolerance of affective experience (Wallace, 2006). Kabat-Zinn (1994) described the mindfulness component of breathing as being "the current connecting body and mind, connecting our body with the outer world's body" (p. 24), which creates a foundation for individuals to be in the present moment, and therefore, unites the body and mind, which serves to ground individuals to the present moment (Weiss, 2004). It is believed that when we are in the present moment, we are in a state of "being", versus a "doing" state (Weiss, 2004, p.4). Worrying about the future and rumination about the past are generally associated with increased psychological stress, anxiety and depression and considered the “doing” functions of the brain. While more positive emotional outcomes (i.e. self-compassion) are associated with the “being” functions of the brain (Nyklicek & Kuijpers, 2008). Mindfulness allows the participant to observe the continual change of internal and external stimuli (Brown & Ryan, 2003; Kabat-Zinn, 2003) and teaches one how to cultivate attention that is nonreactive, sustained and concentrated, so we can see clearly what is arising (Shapiro, Carlson, Astin, & Freedman, 2006).

Mindfulness as an Effective Psychological Treatment

Research suggests that mindfulness meditation creates short and long-term changes in both physically and mentally ill and healthy subjects (Cahn & Polich, 2006; Bishop, 2002; Grossman, Niemann, Schmidt, & Walach, 2004). For example, mindfulness practice has been used to treat depression, stress, chronic pain (Kabat-Zinn, 1990; Grossman, Tiefenthaler-Gilmer, Raysz & Kesper, 2007; Koszycki, Benger, Shlik, & Bradwejn, 2007; Morone, Greco, & Weiner, 2008), and to enhance coping strategies and self-compassion (Shapiro, Bootzin, Figueredo, Lopez, & Schwartz, 2003).

Mindfulness meditation is a frequently used approach for dealing with stress (Bishop, 2002; Allen et al., 2006). Specifically, Mindfulness-Based Stress Reduction (MBSR; Kabat-Zinn, 1990) is the most commonly cited model of mindfulness intervention (Grossman, et al., 2004). This intervention was introduced as a means of dealing with the stress of chronic pain and to reduce the risk of heart disease. MBSR practice focuses on intentionally focused awareness to develop self-awareness and self-knowledge. Through facilitating a greater self-awareness and self-control, MBSR participants can address stress-related physical and emotional symptoms (Grossman, et al., 2004; Zeidan Johnson, Diamond, David, & Goolkasian, 2011).

Several studies have examined the effects of meditation on the stress response and cardiovascular output. In an early examination of the effects of meditation on cardiovascular reactivity, Goleman and Schwartz (1976) found an initial increase in heart rate reactivity but a faster recovery to baseline in the meditation group compared to a control. A review by Curtis & O' Keefe (2002) found that any factor that reduces sympathetic nervous system (SNS) tone and improves SNS reactivity to stressors tends to improve outcomes for myocardial infarction, cardiovascular heart disease, and congestive heart failure. For example, there is evidence that stress reduction through mindfulness meditation mediates physiological changes, including decreased sympathetic nervous system arousal (Walton, Schneider, & Nidich, 2004), decrease blood pressure and cardiovascular reactivity, and improve cardiovascular recovery (Barnes, et al., 2005; Black, Milam, & Sussman, 2009). These findings suggested that mindfulness meditation techniques enhance coping strategies and assist the body in returning to a homeostatic state.

Conclusion

The benefits of mindfulness meditation may be associated with stress reduction, (Rubia, 2009; Grossman, et al., 2004), cardiovascular variables (Zeidan et al., 2010; Ditto, Eclache & Goldman, 2006), enhanced cognitive control, (Lutz, Greischar, Rawlings, Richard, & Davidson, 2004) and/or emotional regulation (Lutz, Brefczynski-Lewis, Johnstone, & Davidson, 2008). The majority of meditation research examines individuals with extensive training or participants in MBSR programs (Grossman et al., 2004) that require considerable expense, a trained facilitator, and take approximately eight weeks to complete. Formal mindfulness meditation practice and interventions reduce stress in various populations; however, the outcomes of a one-time intervention are relatively unknown. There are only a few studies that have examined brief meditation interventions and reported positive results on a variety of outcomes. In one study, Lane and colleagues (2007) used a mantra-based meditation in four 1-hour sessions, and found reductions on negative mood and stress. Tang and colleagues (2007) found that five training sessions that focused on body-mind training was effective in improving cognitive functioning, and in decreasing negative mood and stress-related cortisol levels. To date, no studies assess the benefits of a one-time meditation intervention on cardiovascular reactivity. If a brief one-time intervention could promote well-being and better cardiovascular health, then a wider audience could experience the benefits of mindfulness meditation. This study aims to examine the potential effects of a one-time mindfulness meditation intervention on cardiovascular function during acute stressors in a meditation naïve sample.

Hypothesis:

Hypothesis 1: It is hypothesized that higher levels of mindfulness will be related to lower levels of cardiovascular reactivity and improved affect compared to individuals with lower levels of mindfulness.

Hypothesis 2: It is hypothesized that a brief, one-time, mindfulness meditation intervention will improve cardiovascular response. More precisely, it is hypothesized that individuals in the mindfulness group will show decreased systolic and diastolic blood pressure during stress tasks when compared with individuals in the control group.

Hypothesis 3: It is hypothesized that healthy college students that receive the brief mindfulness training will report improved positive affect and decreased negative affect compared to the control condition.

Methods

Participants

Fifty-eight normotensive men and women, between the ages of 18-26 years old, were recruited for this study. Exclusion criteria included a history of chronic health problems (e.g., heart disease, high blood pressure, respiratory disease, etc.), current smoked tobacco or smokeless tobacco use at least once daily, current medication use that affect heart rate or blood pressure, or prior experience with meditation (i.e. mindfulness, transcendental, etc). Because the following behaviors may affect the results of this study, participants were asked to refrain from consuming caffeine within 24 hours of the study, exercising on the day of study, and eating food within 2 hours of the study. Students enrolled in undergraduate psychology courses at Brigham Young University were recruited through SONA research system, and offered course extra credit for participation in the study. Consent forms were administered by the researchers to each participant on an individual basis prior to any data collection or starting the intervention. To ensure anonymity and enhance accurate responding, participants' consent forms were physically separated from the questionnaires at the point of data collection and randomly assigned an ID number.

Procedure

The study was described to participants as a free stress management class in which stress reduction methods like relaxation and meditation would be taught. The study used a two-group comparison design and participants were randomly assigned to the treatment (mindfulness meditation intervention) or a control condition. Participants receiving the treatment underwent one training session of mindfulness meditation, lasting approximately 15 minutes. Each intervention was run in the same classroom by the same researcher.

Participants took an on-line questionnaire (See Appendix A) approximately one week prior to study participation. After arrival at the laboratory, participants were greeted by the experimenter and given a brief summary of the study. They were informed that their participation in this study was voluntary and they could withdraw at any time. Participants, who agreed to take part in this study, were asked to provide informed consent. Following initial informed consent, a blood pressure cuff was placed on the upper portion on the participants non-dominate arm to ensure it would not interfere with their ability to complete tasks or fill out questionnaires. Blood pressure and heart rate measurements began at minute zero and continue at established times during the procedure (See Fig. 1). Participants in the treatment condition took part in the mindfulness meditation intervention as described below. Participants in the control condition were asked to sit quietly and listen to an audio recording about mindfulness and ethics for approximately 15 minutes before starting the stress task.

Mindfulness meditation protocol. The intervention was described as a stress reduction technique and consisted of one 15 minute session. The Mindfulness Meditation (MM) intervention used during this study was modeled after the Mindfulness-Based Stress Reduction (MBSR) program (Kabat-Zinn, 1982). Participants in the treatment group listened to portions of an audio clip from the series used by participants in the MBSR clinic at the Center for Mindfulness, University of Massachusetts. Participants explored guided meditation that teach breath-by-breath mindfulness techniques that include practices such as focused attention on each part of the body, focused breathing, and becoming observant to the sensations of sound, thoughts and emotions (Kabat-Zinn, 2006). Listeners were asked to attend to various parts of their body and their breathing, gently observing these areas and allowing other thoughts to recede. If a random thought arose, participants were asked to passively notice the thought and simply let it go, bringing attention back to the sensation of breathing.

Immediately following the intervention or control period, psychosocial stressors were induced using the Trier Social Stress Test (TSST) (Kirschbaum et al., 1993). The TSST is one of the most frequently used psychological procedures in stress research and was created to stimulate moderate psychosocial stress in a laboratory setting (von Dawans, Kirschbaum & Heinrichs, 2011). To optimize the level of stress, two performance tasks combining elements of socio-evaluative threat and uncontrollability were administered to elicit consistent psychobiological stress response (Dickerson and Kemeny, 2004). Cardiovascular measurements were taken every three minutes throughout the duration of both tasks.

Trier Social Stress Test protocol. The TSST (Kirschbaum et al., 1993) consists of three phases: (i) an introduction, preparation, and anticipation phase of five min, (ii) a public speaking task of 5 minutes, and (iii) a mental arithmetic task of five minutes. During the introduction stage, participants received instruction for the subsequent tasks. One evaluator (who was trained to withhold verbal and nonverbal feedback) entered the room and sat at a table wearing white laboratory coats and holding a clipboard. The evaluator was introduced to the participant and told that he/she was trained to evaluate body language and non-verbal behavior. Participants were instructed to prepare for a mock interview. They were given paper and pencils for outlining their talk, but they were not allowed to use the written ideas during their speech. After five minutes the evaluator re-entered the room and instructed the participant to begin their interview. It is important to note that the evaluator asked no questions during the interview. If the participant finished in less than two minutes, the evaluators responded in a standardized way saying: “You still have time, please continue.” If the participant finished a second time before the five minutes were over, the evaluator sat quietly for 20 seconds before moving on. Once the participant had given his/her speech they were instructed to verbally subtract 13 serially from a four digit number (e.g. 3,578) as quickly and accurately as possible. If participants answer incorrectly, the investigators promptly instructed them to "Stop. Please start over from the beginning." In order to obtain a percentage of correct subtractions the number of successful subtractions was divided by the number of attempted subtractions and multiplied by 100.

After completing the TSST, participants sat quietly for a ten minute recovery period. Cardiovascular measurements were taken every three minutes during recovery. Upon completion of the recovery period, the experimenter removed the blood pressure cuff and participants were asked to complete the post-assessment self-report questionnaire. Participants were then debriefed at the conclusion of the study and asked if they had any questions.

Control group

The purpose of the control group was used to compare the mindfulness meditation group to a non-manipulated group that met for the same time period. Control group participants were also told that they are registering for a free stress reduction program. Participants in the control group went through the same procedure as the treatment group, however, instead of receiving the mindfulness meditation intervention participants listened to two audio clips from the MBSR series by Kabat-Zinn (2006). The audio clips included topics of mindfulness and ethics in research.

Measures

Upon signing up to participate in the study, participants were asked to complete a pre-study self-report questionnaire approximately one-week prior to the day of the study that included demographic information, well-being and health related questions, personality, and mood constructs (see Appendix A). Post-experiment surveys were administered immediately following the study and included measurements of affect, and perceived stress of the study.

Mindfulness. The Philadelphia Mindfulness Scale (PHLMS) is a measure of mindfulness that comprises of twenty items and employs a five-point Likert-type scale. The PHLMS indirectly measures mindfulness skills through two sub scales of acceptance and present moment awareness. Respondents are instructed to rate their agreement with each statement, selecting answers that range from *never* to *very often* (e.g. I am aware of thoughts I'm having when my mood changes; I am aware of the emotions I am experiencing; There are things I try not to think about*)*. Initial research on this measure published by Cardaciotto, Herbert, Forman, Moitra, & Farrow, (2008) demonstrated good internal consistency and test-retest reliability with high reliability (Cronbach's alpha = .87 for the Acceptance sub-scale; Cronbach's alpha = .85 for the Awareness sub-scale) when administered across a variety of college undergraduate and general community samples.

Positive and Negative Affect Schedule. The Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988) is a 20-item self-report instrument asking the participant to rate how strongly they currently feel using a 5 point Likert-type scale that ranges from (1) very slightly to (5) extremely. The PANAS measures positive affect (e.g. interested, enthusiastic) and negative affect (e.g. upset, ashamed). The PANAS has strong reported validity and reliability (Cronbach's alpha= 0.87)

Cardiovascular measures. Systolic blood pressure, diastolic blood pressure, mean arterial blood pressure and heart rate measurements were collected using an automatic blood pressure monitor (GE ProCare 100). A blood pressure cuff that contains an electronic pulse sensor to detect blood flow was placed around the participant's non-dominant arm to reduce interference with movement during the task. Cardiovascular variables (SBP, DBP, MAP, HR) was assessed during the pre-intervention, intervention, TSST tasks, and recovery period. During these times, cardiovascular variables were measured three times at two minute intervals in order to obtain an average reading. Measures of systolic blood pressure and diastolic blood pressure and heart rate were displayed digitally and manually recorded by the experimenter.

Analysis

The statistical package SPSS 20 was used to conduct all statistical analyses. Individual differences in measures of cardiovascular reactivity variables (SBP, DBP, MAP, HR) were analyzed across baseline, audio, speech task, math task, and recovery periods. Separate linear regression analyses were used to examine our first hypothesis regarding the association between levels of mindfulness, cardiovascular reactivity variables (SBP, DBP, MAP and HR), and affect. To examine the effects of mindfulness meditation (MM) intervention participants versus control group, analyses of repeated measures covariance (ANCOVA) was conducted; 2 groups (treatment, control) x 6 tasks (baseline, treatment, preparation, speech task, math task, and recovery). We also examined the effects of age, gender, and body mass index (BMI) on each cardiovascular measure using linear regression. Variables showing significant effects (age, gender, BMI) were included in the models as covariates. A significance level of 0.05 was used for all statistical tests.

Results

During the study, cardiovascular data was taken every three minutes and averaged across 6 tasks (i.e. 3 cardiovascular readings at two minute intervals were averaged for baseline). Demographic information and baseline scores for all measured variables are presented Table 1 for the treatment and control groups. Preliminary analyses were performed using linear regression to examine known factors that independently influence cardiovascular measures.

Gender was statistically significant in predicting decreased levels of systolic BP, $\beta = .20$, $t(59) = 2.28$, $p < .001$, and diastolic BP in females, $\beta = .27$, $t(59) = 2.10$, $p = .05$. Higher levels of BMI was statistically significant in predicting increased levels of SBP $\beta = .23$, $t(59) = 2.38$, $p = .02$, and DBP $\beta = .19$, $t(59) = 2.16$, $p = .02$. Gender and BMI were therefore included as covariates in the analyses for the appropriate cardiovascular variables. It is also important to note that significant group differences were not evident on any baseline cardiovascular (SBP, DBP, MAP, HR) or PANAS measures. Baseline equivalences of each group were tested using independent samples t-tests. Results (see Table 1) revealed no significant differences among treatment and control groups on baseline cardiovascular measures, $p > .05$. Similarly, results indicated no significant differences among groups for the subscales or overall scores on the Positive Affect Negative Affect scale $p > .05$ (see Table 1). It is important to note that participants had no prior reported meditative experience.

It was hypothesized that individuals who scored high in mindfulness would show lower cardiovascular reactivity and improved affect when compared with individuals who scored low in mindfulness. To better assess individual differences in high/low trait mindfulness, total Philadelphia Mindfulness Scale scores were dichotomized and coded into high (total PHLMS score ≥ 60) and low (total PHLMS score ≤ 59) groups. We employed a 2 (high mindfulness, low mindfulness) x 6 (baseline, treatment, preparation, speech task, math task, and recovery) repeated measures ANOVA to analyze differences in high/low Philadelphia Mindfulness Scale scores and cardiovascular measures. Results showed there was a significant main effect for time associated with scores and cardiovascular reactivity across tasks, HR: $F(5, 280) = 25.70$, $p < .01$; SBP: $F(5, 280) = 32.14$, $p = .02$, respectively, further examination of means indicated that individuals who scored higher in mindfulness had decreased heart rate and systolic blood pressure across tasks. Also, we used 2 (high mindfulness, low mindfulness) x 2 (pre/post PANAS scores) repeated measures ANOVA to analyze differences in levels of mindfulness and affect. Individuals who scored higher in trait mindfulness showed a significant decline in total negative affect scores, $F(1, 56) = 31.59$, $p < .01$ and displayed a significant increase of positive affect scores, $F(1, 56) = 7.31$, $p = .001$. These findings are consistent with previous research (Grossman et al., 2004; Zeidan et al., 2010), showing that individuals who have higher levels of trait mindfulness exhibit lower cardiovascular reactivity and improved mood.

In our primary analysis, a 2 (treatment, control) x 6 (baseline, treatment, preparation, speech task, math task, and recovery repeated-measures ANOVA was used to test the hypothesis that participants in the mindfulness meditation condition would demonstrate lower levels of cardiovascular response than those in the control condition. Those data are summarized in Figure 2 (systolic BP), Figure 3 (diastolic BP), Figure 4 (mean arterial pressure) and Figure 5 (HR). There was a significant main effect of time for cardiovascular responses across tasks; SBP: $F(5, 280) = 71.89$, $p < .01$; DBP: $F(5, 280) = 24.93$, $p < .01$; HR: $F(5, 280) = 38.01$, $p = .001$; MAP: $F(5, 280) = 73.64$, $p = .001$. Furthermore, results also indicated that there was a statistically significant time x group interaction for SBP, $F(5, 280) = 11.\ 81$, $p < .01$. Further examination of simple contrast comparison against baseline revealed that individuals who practiced brief mindfulness meditation exhibited significantly lower systolic BP in baseline-recovery differences than participants in the control group across tasks. However, there were no significant group x task difference on all other cardiovascular measures, $p > .05$.

We examined the hypothesized differences of treatment and control groups on pre/post positive and negative affect scores. PANAS scores were taken approximately one week before and immediately after the recovery period to measure changes in affect for the mindfulness meditation and control groups (Table 2). PANAS scores were analyzed using a 2 x 2 repeated-measures ANOVA (Group [treatment, control] × Time [pre, post]) for the Positive Affect (PA) subscale, Negative Affect (NA) subscale, and Total PANAS (PA + NA) scores. Total PANAS scores were examined for overall experience of feeling and emotion. Results indicated pre and post NA scores significantly decreased across tasks, $F(2,54) = 11.79$, $p = .001$, showing that the mindfulness meditation group had decreased post negative affect scores. There were no significant differences found for the positive affect scores or total PANAS scores, $p > .05$.

Discussion

The purpose of this study was to examine the effectiveness of brief one-session mindfulness meditation training on mood and cardiovascular reactivity and cardiovascular recovery from acute stress compared to a control group. To our knowledge no previous study has examined whether brief one-time mindfulness meditation training can decrease cardiovascular reactivity and negative affect in a mindfulness meditation naïve population. Individuals in both groups did not differ on any baseline physiological or affect measures, suggesting that participants began the study at equal levels in terms of measured variables and any changes in cardiovascular and affect measures could be attributed to the tasks. The results of this study indicate that meditation naïve individuals who participate in 15 minute mindfulness meditation training benefited in lower negative affect and decreasing systolic blood pressure and heart rate reactivity, at least in the short term. Our findings show that cardiovascular reactivity and negative affect improve under treatment of mindfulness which are consistent with previous results in long-term practitioners (Ditto et al., 2007; Grossman, et al., 2004) and suggest that the benefits of meditation may begin to be realized after a brief training.

Mindfulness Meditation & Cardiovascular Reactivity

It was hypothesized that individuals high in mindfulness would show less cardiovascular reactivity. In general, results indicated that individuals with higher scores of mindfulness had lower SBP reactivity compared to those low in mindfulness. These finds suggest that during a social stressor, individuals higher in MM may experience decreased cardiovascular reactivity and may be able to quickly recover following a stressor. Heightened levels of mindfulness may allow individuals to respond to situations with less stress and be more aware and accepting of their current environments (Brown and Ryan, 2003). These results are in line with Creswell and colleagues (2007) findings that higher levels of mindfulness were associated with increased responses in the prefrontal cortex and decreased amygdala responses, which has been shown to decrease blood pressure reactivity (Gianaros et al., 2008). Based on these findings, one might speculate that mindfulness could be linked with less blood pressure reactivity (Kingston et al. 2007; Ditto et al. 2007; Grossman et al., 2004).

We conducted analyses to investigate the effect of a MM intervention on cardiovascular parameters. Participants receiving brief mindfulness meditation training showed a decrease in HR and SBP reactivity across all tasks compared to those in control group. Past research has found an overall improvement with cardiovascular variables in individuals with long-term mindfulness practice (Grossman et al., 2004). The results of this study indicate that brief mindfulness meditation may improve cardiovascular reactivity and recovery time. Consistent with previous research (Zeidan, 2011), this study supports findings that meditation plays a distinct role in reactions to laboratory stressors in that those trained in meditation tend to recover faster from stress. Meditation practice has been considered an effective method of easing stress, which in turn, can reduce blood pressure levels (Grossman et al., 2004). Davidson et al. (2003) showed that mindfulness meditation training was linked to greater left-sided anterior brain activation, which has been associated with changes to individuals' response to negative and/or stressful events.

Mindfulness involves maintaining attention on the present-moment, in a way that encourages non-reaction to sensory events, and reduces anticipation of the future and reflection of the past (Ditto et al., 2006; Wallace, 2006). It is possible that brief mindfulness meditation training may improve the ability to control attention, allowing the individual to react less to different environmental stimuli and quickly recover after the acute stressor by continuing to focus on the present-moment in a non-judgmental manner and prevent rumination about the past event. Moreover, this finding could be attributed to awareness of breath and slower and deeper breathing control that is often found in MBSR treatment (Kabat-Zinn, 2003). Similarly, past research (Joseph et al., 2005; Grossman, Grossman, Schein, Zimlichman & Gavish, 2001) found that controlled breathing significantly decreased systolic as well as diastolic pressures in participants.

Mindfulness Meditation and Affect

Effects of mindfulness meditation on affect showed participants exhibiting a significant decrease in negative affect. One may gather that mindfulness meditation may reduce intensity of feelings and individuals are more likely to draw on positive emotions rather than negative emotions. Previous research has found mindfulness meditation training to be effective in attenuating negative affect (Cahn & Polich, 2006), but not after a brief intervention. This finding is consistent with recent studies that examined the mediating roles of mindfulness upon responding to laboratory stressors. Arch & Craske (2006) found that mindfulness instruction resulted in lower overall negative affect and improve overall mood in participants when placed in a stressful situation. These differences on the PANAS scores may be associated with the capability to objectively evaluate negative feelings in a non-judgmental manner. It is possible that lower levels of negative affect, and in turn higher levels of positive affect, may buffer against cardiovascular reactivity by reducing the intensity of stressful experiences and associated physiological response and shorten the duration of recovery. Prior research (Tugade & Fredrickson, 2004) showed that experiencing positive emotion facilitated faster cardiovascular recovery. Overall, the results of our study suggest that brief mindfulness meditation training can be useful at supporting changes in acute affect states.

Limitations

There are a number of limitations worth mentioning. Because this study was conducted in a laboratory setting on college-age students, it could be argued that the artificial nature of the laboratory affected cardiovascular functioning differently than what would be observed in a more natural setting. Moreover, participants were predominantly Caucasian, and it is unclear to what extent these findings generalize to those in different age groups, races and/or ethnicities, and other clinical groups. Another limitation of this study was the failure to properly detect or measure changes in mindfulness from pretreatment to posttreatment. Although there were group differences in cardiovascular variables, there were no indications they resulted directly from an increase in trait mindfulness. Also, knowing that relaxation has been shown to reduce distress, mood and cardiovascular reactivity in students as well as other populations (Jain et al., 2007 and Luebbert, Dahme, & Hasenbring 2001), it would be important to compare brief mindfulness meditation with relaxation in future studies.

Conclusions

Many of the traditional MBSR program have taught meditation and offered a wide range of emotional and physical benefits through regular practice and intensive training (Grossman et al., 2004). However, the cost and length of training may reduce its wide acceptance and appeal to the average person. It is possible that brief mindfulness meditation trainings could be made more appealing and available at low cost to individuals facing acute daily stressors.

It is important to consider implications of these findings for clinical practice. Research studies on mindfulness meditation have provided an increase in evidence about the short- and long term changes that occur in mindfulness practice (Cahn & Polich, 2006) and about outcomes in physically, mentally ill and also healthy subjects related to such practices (Bishop, 2002; Grossman et al. 2004; Coelho et al. 2007). The development of mindfulness could be clinically useful in psychiatric and physical disorders and may lead to improved outcomes. It is possible that patients who experience a mindful state can gain awareness to certain aspects of their experience and identify ways of warding off distress that interferes with clinical treatment.

The results of this study demonstrated that brief mindfulness meditation training was effective in lowering SBP and HR, and reducing negative affect in a college sample of young adults. These findings suggest that benefits of mindfulness meditation techniques can be directly realized immediately after brief training (Zeidan et al., 2011). Findings regarding cardiovascular reactivity may be important to consider when working with individuals who knowingly go into acute stressors. For example, college students during finals week or prior to a job interview may benefit from brief mindfulness training. These individuals would be able to listen to a 15-minute audio of mindfulness meditation and potential approach such situations focusing on the present-moment in a nonjudgmental approach.

Future research may find encouraging results in larger and diverse populations through the implementation of less demanding meditation training programs. Clinical research is necessary to explore the effects of brief mindfulness training on health. With additional research in mindfulness meditation, interventions may continue to evolve into mainstream practice within clinical settings.

References

Allen, N. B., Blashki, G., Chambers, R., Ciechomeski, L., Gullone, E., Hassad, C., . . . Medows, G. (2006). Mindfulness-based psychotherapies: A review of conceptual foundations, empirical evidence and practical considerations. *Australian and New Zealand Journal of Psychiatry, 40,* 285-294.

American Heart Association. (2010). *Heart and stroke statistical update*. Dallas, TX: American Heart Association.

Anderson, N. D., Lau, M. A., Segal, Z. V., & Bishop, S. R. (2007). Mindfulness-based stress reduction and attentional control. *Clinical Psychology and Psychotherapy*, *14*, 449-463.

Arch, J. J. & Craske, M. G. (2006). Mechanisms of mindfulness: Emotion regulation following a focused breathing induction. *Behavior Research and Therapy, 44,* 1849-1858.

Astin, J. A., Shapiro, S. L., Eisenberg, D. M., & Forys, K. L. (2003). Mind-body medicine: State of the science, implications for practice. *Journal of the American Board of Family Medicine, 16,* 131-147.

Barnes, V. A., Schneider, R. H., Alexander, C. N., Rainforth, M., Staggers, F., & Salerno, J. (2005). Impact of transcendental meditation on mortality in older African Americans with hypertension – eight-year follow-up. *Journal of Social Behavior and Personality, 17,* 201-216.

Benson, H. (1975). *The relaxation response.* New York, NY: Harpertorch.

Black, D. S., Milam, J., & Sussman, S. (2009). Sitting-meditation interventions among youth: A review of treatment efficacy. *Pediatrics, 124,* 532-541.

Bishop, S. R. (2002). What do we really know about mindfulness-based stress reduction? *Psychosomatic Medicine, 6,* 71-84.

Brosschot, J.F., Gerin, W. & Thayer, J.F. (2006). The preservative cognition hypothesis: A review of worry, prolonged stress-related physiological activation, and health. *Journal of Psychosomatic Medicine, 60, 113-124.*

Brotman, D. J., Golden, S. H., & Wittstein I. S. (2007). The cardiovascular toll of stress. *Lancet*, *370*, 1089–1100.

Brown. K. W., & Ryan, R. M. (2003). The benefits of being present: Mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology, 84*, 822-848.

Brown, K. W, Ryan, R. D., & Creswell, J. D. (2007). Mindfulness: Theoretical foundations and evidence for its salutary effects. *Psychological Inquiry, 18*, 211-237.

Boyce, T. W., & Ellis, B. J. (2005). Biological sensitivity to context: An evolutionary developmental theory of the origins and functions of stress reactivity. *Development and Psychopathology, 17*, 271–301.

Cahn, B.R., & Polich, J. (2006). Meditation states and traits: EEG, ERP, and neuroimaging studies. *Psychology Bulletin, 132,* 180.

Cardaciotto, L., Herbert, J. D., Forman, E. M., Moitra, E., & Farrow, V. (2008). The assessment of present-moment awareness and acceptance: The Philadelphia Mindfulness Scale. *Assessment, 15*, 204-223.

Carroll, D., Ring, C., Hunt, K., Ford, G., & Macintyre, S. (2003). Blood pressure reactions to stress and the prediction of future blood pressure: Effects of sex, age, and socioeconomic position. *Psychosomatic Medicine, 65,* 58-64.

Carroll, D., Smith, G. D., Shipley, M. J., Steptoe, A., Brunner, E. J., & Marmot, M. G. (2001). Blood pressure reactions to acute psychological stress and future blood pressure status: A

10-year follow-up of men in the Whitehall II study. *Psychosomatic Medicine, 63*, 737-743.

Chida, Y., & Steptoe, A. (2010). Greater cardiovascular responses to laboratory mental stress are associated with poor subsequent cardiovascular risk status: A meta-analysis of prospective evidence. *Hypertension, 55,* 1026-1032.

Coelho H. F., Canter P. H., & Ernst E. (2007). Mindfulness-based cognitive therapy: Evaluating current evidence and informing future research. *Journal of Consulting and Clinical Psychology, 75*, 1000–1005.

Chrousos, G. P. & Gold, P. W. (2007). The concepts of stress and stress system disorders: Overview of physical and behavioral homeostasis *Psychoneuroendocrinology, 32*,991-999.

Cohen, S., Janicki-Deverts, D., & Miller, G. E. (2007). Psychological stress and disease. *Journal of the American Medical Association, 298,* 1685-168.

Cohen, S., & Manuck, S. B. (1995). Stress, reactivity and disease. *Psychosomatic Medicine, 57*, 423-426.

Creswell, J. D., Way, B. M., Eisenberger, N. I., & Lieberman, M. D. (2007). Neural correlates of dispositional mindfulness during affect labeling. *Psychosomatic Medicine, 69*, 560-565.

Curtis, B. M., & O'Keefe, J. H. (2002). Autonomic tone as a cardiovascular risk factor: The dangers of chronic fight or flight. *Mayo Clinic Proceedings, 77*, 45–54.

Davidson, R. J., Kabat-Zinn, J., Schumacher, J., Rosenkranz, M., Muller, D., Santorelli, S. F., . . . Sheridan, J. F. (2003). Alterations in brain and immune functioning produced by mindfulness meditation. *Psychosomatic Medicine, 65,* 564–570

Dickerson, S. S., & Kemeny, M. E. (2004). Acute stressors and cortisol responses: A theoretical integration and synthesis of laboratory research. *Psychological Bulletin 130,* 355-391.

Dimsdale, J. E. (2008). Psychological stress and cardiovascular disease. *Journal of American College of Cardiology, 51*, 1237-1246.

Ditto, B., Eclache, M., & Goldman, N. (2006). Short-term autonomic and cardiovascular effects of mindfulness body scan meditation. *Annuls of Behavioral Medicine, 32*, 227-234.

Esler, M., Eikelis, N., Schlaich, M., Lambert, G., Alvarenga, M., Dawood, T., . . . Lambert, E. (2008). Chronic mental stress is a cause of essential hypertension: Presence of biological markers of stress. *Clinical Experimental Pharmacological Physiology, 35*, 498-502.

Everson, S. A., Lynch, J. W., Kaplan, G. A., Lakka, T. A., Sivenious, J., & Salonen, J. T. (2001). Stress-induced blood pressure reactivity and incident stroke in middle-aged men. *Stroke*, *32*, 1263-1270.

Farb, N. A., Anderson, A. K., Mayberg, H., Bean, J., McKeon, D. & Segal, Z. V. (2010). Minding one's emotions: Mindfulness training alters the neural expression of sadness. *Emotion, 10,* 25–33.

Flaa, A., Eide, I. K., Kjeldsen, S. E., & Rostrup, M. (2008). Sympathoadrenal stress reactivity is a predictor of future blood pressure: An 18-year follow-up study. *Hypertension, 52,* 336 341.

Gianaros, P. J., Bleil, M. E., Muldoon, M. F., Jennings, J. R., Sutton-Tyrrell, K., McCaffery, J. M., & Manuck, S. B. (2002). Is cardiovascular reactivity associated with atherosclerosis among hypertensives? *Hypertension, 40,* 742-747.

Gianaros, P. J., Sheu, L. K., Matthews, K. A., Jennings, J. R., Manuck, S. B., & Hariri, A. R. (2008). Individual differences in stressor-evoked blood pressure reactivity vary with activation, volume, and functional connectivity of the amygdala. *Journal of Neuroscience, 28,* 990-999.

Glynn, L. M., Christenfeld, N., & Gerin, W. (2007). Recreating cardiovascular responses with rumination: The effects of a delay between harassment and its recall. *International Journal of Psychophysiology, 66,* 135-140.

Grant, K. E., Compas, B. E., Stuhlmacher, A. F., Thurm, A. E., McMahon, S. D. & Halpert, J. A. (2003). Stressors and child and adolescent psychopathology: Moving from markers to mechanisms of risk. *Psychological Bulletin, 129,* 447–466.

Goleman, D. J., & Schwartz, G. E. (1976). Meditation as an intervention in stress reactivity. *Journal of Consulting and Clinical Psychology, 44,* 456-466.

Grossman, E., Grossman, A., Schein, M. H., Zimlichman, R. & Gavish, B. (2001). Breathing control lowers blood pressure. *Journal of Human Hypertension, 15*, 263-369.

Grossman, P., Niemann, L., Schmidt, S., & Walach, H. (2004). Mindfulness based stress reduction and health benefits: A meta-analysis. *Journal ofPsychosomatic Research, 57*, 35-43.

Grossman, P., Tiefenthaler-Gilmer, U., Raysz, A., & Kesper, U. (2007). Mindfulness training as an intervention for fibromyalgia: Evidence of postintervention and 3 year follow-up benefits in well-being. *Psychotherapy and Psychosomatics 76*, 226-233.

Hamer, M., & Stamatakis, E. (2008). The accumulative effects of modifiable risk factors on inflammation and haemostasis. *Brain, Behavior and Immunity*, *22*, 1041–1043.

Hassellund, S. S., Flaa, A., Sandvik, L., Kjeldsen, S. E., & Rostrup, M. (in press). Effects of anthocyanins on blood pressure and stress reactivity: A double-blind randomized placebo controlled crossover study. *Journal of Human Hypertension.*

Hawkley, L. C., Burleson, M. H., Poehlmann, K. M., Berntson, G. G., Malarkey, W. B., & Cacioppo, J.T., (2001). Cardiovascular and endocrine reactivity in older females: Intertask reliability. *Psychophysiology, 38*, 863–872.

Hayes, S. C., Strosahl, K., & Wilson, K. G. (1999). *Acceptance and commitment therapy.* New York: Guilford.

Hilmert, C. J., Ode, S., Zielke, D. J., & Robinson, M. D. (2010). Blood pressure reactivity predicts somatic reactivity to stress in daily life. *Journal of Behavioral Medicine, 33,* 282-292.

Hines, E. A, & Brown, G. F. (1936). The Cold pressure test for measuring the reactibility of the blood pressure: Data concerning 571 normal and hypertensive subjects. *American Heart Journal, 11*, 1-9.

Jain, S., Shapiro, S. L., Swanick, S., Roesch, S. C., Mills, P. J., Bell I., & Schwartz, G. (2007). A randomized controlled trial of mindfulness meditation versus relaxation training: Effects on distress, positive states of mind, rumination, and distraction. *Annals of Behavioral Medicine, 33*, 11-21.

Jennings, J. R., Kamarck, T. W., Everson-Rose, S. A., Kaplan, G. A., Manuck, S. B., & Salonen, J. T. (2004). Exaggerated blood pressure responses during mental stress are prospectively related to enhanced carotid atherosclerosis in middle-aged Finnish men. *Circulation, 110,* 2198–2203.

Joseph, C. N., Porta, C., Casucci, G., Casiraghi, N., Maffeis, M., & Rossi, M. (2005). Slow breathing improves arterial baroreflex sensitivity and decreased blood pressure in essential hypertension. *Hypertension, 46,* 714-718.

Kabat-Zinn, J. (1982). An outpatient program in behavioral medicine for chronic pain patients based on the practice of mindfulness meditation: Theoretical considerations and preliminary results, *General Hospital of Psychiatry, 4,* 33 -47.

Kabat-Zinn, J. (1990). *Full catastrophe living*. New York, NY: Delta Books.

Kabat-Zinn, J. (1994). *Wherever you go, there you are: Mindfulness meditation in everyday life.* New York, NY: Hyperion.

Kabat-Zinn, J. (2003). Mindfulness-based interventions in context: Past, present, and future. *Clinical Psychology: Science and Practice, 10*, 144- 156.

Kabat-Zinn, J. (2006). Mindfulness of breathing. On *Mindfulness for beginners* [CD]. Denver, CO: Sounds True.

Kamarck, T. W., Muldoon, M. F., Shiffman, S., Sutton-Tyrrell, K., Gwaltney, C., & Janicki D. L. (2004). Experiences of demand and control in daily life as correlates of subclinical carotid atherosclerosis in a healthy older sample. *Health Psychology, 23*, 24–32.

Kelly, M. M., Tyrka, A. R., Anderson, G. M., Price, L. H. & Carpenter, L. L. (2008). Sex differences in emotional and physiological responses to the Trier Social Stress Test. *Journal of Behavioral Therapy of Experimental Psychiatry, 39*, 87–98.

Keng, S., Smoski, M. J. & Robins, C. J. (2011). Effects of mindfulness on psychological health: A review of empirical studies. *Clinical Psychology Review, 31*, 1041-1056.

Kiecolt-Glaser, J. K., McGuire, L., Robles, B. S. & Glaser, R. (2002). Psychoneuroimmunology and psychosomatic medicine: Back to the future. *Psychosomatic Medicine, 64*, 15–28.

Kingston, J., Chadwick, P., Meron, D., & Skinner, T. C. (2007). A pilot randomized control trial investigating the effect of mindfulness practice on pain tolerance, psychological well-being, and physiological activity. *Journal of Psychosomatic Research*, *62*, 297–300.

Kirschbaum, C., Pirke, K., & Hellhammer, D. (1993). The Trier Social Stress Test: A tool for investigating psychobiological stress response in a laboratory setting. *Neuropsychobiology, 28,* 76-81.

Koszycki, D., Benger, M., Shlik, J, & Bradwejn, J. (2007). Randomized trial of a meditation based stress reduction program and cognitive behavior therapy in generalized social anxiety disorder. *Behaviour Research and Therapy, 45*, 2518-2526.

Kudielka, B. M., Schommer, N. C., Hellhammer, D. H. & Kirschbaum, C. (2004). Acute HPA axis responses, heart rate, and mood changes to psychosocial stress (TSST) in humans at different times of day. *Psychoneuroendocrinolohy, 29*, 983–992.

Kudielka, B. M., von Kanel, R., Preckel, D., Zgraggen, L., Michler, K. & Fischer, J. E. (2006). Exhaustion is associated with reduced habituation of free cortisol responses to repeated acute psychosocial stress. *Biological Psychology, 72*, 147–153.

Lane, J., Seskevich, J., & Peiper, C. (2007). Brief meditation training can improve perceived stress and negative mood. *Alternative Therapies in Health and Medicine, 13*, 38–44.

Lovallo, W. R., & Gerin, W. (2003). Psychophysiological reactivity: Mechanisms and pathways to cardiovascular disease. *Psychosomatic Medicine, 65*, 36–45.

Luebbert, K., Dahme, B., & Hasenbring, M. (2001). The effectiveness of relaxation training in reducing treatment-related symptoms and improving emotional adjustment in acute non surgical cancer treatment: A meta-analytical review. *Psycho-Oncology, 10,* 490-502.

Lutz, A., Brefczynski-Lewis, J., Johnstone, T., & Davidson, R. J. (2008). Regulation of the neural circuitry of emotion by compassion meditation: Effects of meditative expertise. *PLoS ONE, 3:e1897.*

Lutz, A., Greischar, L. L., Rawlings, N. B., Richard, M., & Davidson, R. J. (2004). Long-term meditators self-induce high amplitude gamma synchrony during mental practice. *Proceedings of the National Academy of Sciences, 101*, 16369–16373.

Ma, S. H., & Teasdale, J. D. (2004). Mindfulness-based cognitive therapy for depression: Replication and exploration of differential relapse prevention effects. *Journal of Counseling and Clinical Psychology, 72,* 31-40.

McDade, T. W., Hawkley, L. C. & Cacioppo, J. T. (2006). Psychological and behavioral predictors of inflammation in middle-aged and older adults: The Chicago health, again, and social relations study. *Psychosomatic Medicine, 68*, 376-381.

McEwen, B. S. (1998). Stress, adaptation, and disease. Allostasis and allostatic load. *Annals of the New York Academy of Sciences, 840*, 33–44

Morone, N. E., Greco, C. M., & Weiner, D. K. (2008). Mindfulness meditation for the treatment of chronic low back pain in older adults: A randomized controlled pilot study. *Pain, 134*, 310–319

Moseley J. V., & Linden W. (2006). Predicting blood pressure and heart rate change with cardiovascular reactivity and recovery: Results from 3 year and 10-year follow up. *Psychosomatic Medicine, 68:* 833-843.

Nater, U. M., La Marca, R., Florin, L., Moses, A., Langhans, W., Koller, M. M. & Ehlert, U. (2006). Stress-induced changes in human salivary alpha-amylase activity-associations with adrenergic activity. *Psychoneuroendocrinology, 31,* 49–58.

Nolen-Hoeksema, S., & Jackson, B. (2001). Meditators of the gender differences in rumination. *Psychology of Women Quarterly, 25,* 37-47.

Nyklícek, I., & Kuijpers, K. F. (2008). Effects of mindfulness-based stress reduction intervention on psychological well-being and quality of life: Is increased mindfulness indeed the mechanism? *Annals of Behavioral Medicine, 35,* 331-340.

Ospina, M. B., Bond, K., Karkhaneh, M., Buscemi, N., Dryden, D. M., Barnes, V., . . . Shannahoof_Khalsa, D. (2008). Clinical trials of meditation practices in health care: Characteristics and quality. *Journal of Alternative and Complementary Medicine, 14,* 1199–1213.

Radstaak, M., Geurts, S., Brosschot, J. F., Cillessen, A. and Kompier, M. (2011). The role of affect and rumination in cardiovascular recovery from stress. *InternationalJournal of Psychophysiology, 81*, 237-244.

Rainforth, M. V., Schneider, R. H., Nidich, S. I., King, C. G., Salerno, J. W., & Anderson, J. W. (2007). Stress reduction programs in patients with elevated blood pressure: A systematic review and meta-analysis. *Current Hypertension Reports, 9,* 520-528.

Roemmich, J. N., Feda, D. M., Seelbinder, A. M., Lambiase, M. J., Kala, G. K. & Dorn, J. (2011). Stress-induced cardiovascular reactivity and atherogensis in adolescents. *Atherosclerosis, 215,* 465-470.

Rosamond, W., Flegal, K., Friday, G., Furie, K., Go, A., Greenlund, K., . . . Hong, Y. (2007). Heart disease and stroke statistics - 2007 update: A report from the American Heart Association Statistics Committee and Stroke Statistics Subcommittee. *Circulation, 115,* 169-171.

Rosengren, S., Hawken, S., Ounpuu, K., Sliwa, M., Zubaid, W. A., Almahmeed, K. N., . . . Yusuf, S. (2004). Association of psychosocial risk factors with risk of acute myocardial infarction in 11119 cases and 13648 controls from 52 countries (the INTERHEART study): Case-control study. *Lancet*, *364*, 953–962.

Rubia, K. (2009). The neurobiology of meditation and its clinical effectiveness in psychiatric disorders. *Biological Psychology, 82,* 1–11.

Salmon, P., Lush, E., Jablonski, M., & Sephton, S. E. (2009). Yoga and mindfulness: Clinical aspects of an ancient mind/body practice. *Cognitive and Behavioral Practice, 16,* 59–72.

Schlotz, W., Kumsta, R., Layes, I., Entringer, S., Jones, A., & Wust, S. (2008). Covariance between psychological and endocrine responses to pharmacological challenge and psychosocial stress: A question of timing. *Psychosomatic Medicine, 70,* 787–796.

Schommer, N.C., Hellhammer, D.H., Kirschbaum, C., (2003). Dissociation between reactivity of the HPA-axis system and the sympathetic adrenal medullary system to repeated psychosocial stress. *Psychosomatic Medicine, 65,* 450–460.

Segal, Z. V., Williams, J. M. G., & Teasdale, J. D. (2002). *Mindfulness-based cognitive therapy for depression: A new approach to preventing relapse.* New York, NY: Guilford.

Shapiro, S. L., Bootzin, R. R., Figueredo, A. J., Lopez, A. M., & Schwartz, G. E. (2003). The efficacy of mindfulness-based stress reduction in the treatment of sleep disturbance in women with breast cancer: An exploratory study. *Journal of Psychosomatic Research, 54,* 85-91.

Shapiro, S. L., Carlson, L. E., Astin, J., & Freedman, B. (2006). Mechanisms of mindfulness. *Journal of Clinical Psychology, 62,* 373–386.

Steptoe, A. (1991). The links between stress and illness. *Journal of Psychosomatic Research, 35*, 633-644.

Steptoe, A. & Marmot, M. (2005). *Socioeconomic position and coronary heart disease: A psychobiological perspective.* L.J. Waite (Ed.) Aging, health and public policy. New York, NY: Population Council.

Tang, Y.Y., Ma, Y., Wang, J., Fan, Y., Feng, S., Lu, Q., . . . Posner, M. I. (2007). Short term meditation training improves attention and self-regulation. *Proceedings of the National Academy of Sciences, 104,* 17152–17156.

Treiber, F. A., Kamarck, T., Schneiderman, N., Sheffield, D., Kapuku, G., & Taylor, T. (2003). Cardiovascular reactivity and development of preclinical and clinical disease states. *Psychosomatic Medicine, 65*, 46– 62.

Troxel, W. M., Matthews, K. A., Bromberger, J. T., & Sutton-Tyrrell, K. (2003). Chronic stress burden, discrimination, and subclinical carotid artery disease in African American and Caucasian women. *Health Psychology, 22,* 300–309.

Tugade, M. M., & Fredrickson, B. L. (2004). Resilient individuals use positive emotions to bounce back from negative emotional experiences. *Journal of Personality and Social Psychology, 86*, 320-333.

von Dawans, B., Kirschbaum, C., & Heinrichs, M. (2011). The Trier Social Stress Test for groups (TSST-G): A new research tool for controlled simultaneous social stress exposure in a group format. *Psychoneuroendocrinology. 36, 514-522.*

Wallace, A. (2006). *The attention revolution: Unlocking the power of the focused mind.* Boston, MA: Wisdom Publications.

Walton, K. G., Schneider, R. H., & Nidich, S. (2004) Review of controlled research on the transcendental meditation program and cardiovascular disease. *Cardiology Review, 12,* 262-266.

Watkins, L. R., & Maier, S. F. (2005). Immune regulation of central nervous system functions: from sickness responses to pathological pain. *Journal of Internal Medicine, 257*, 139–155.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS Scales. *Journal of Personality and Social Psychology, 54*, 1063-107.

Weiss, A. (2004). *Beginning mindfulness: Learning the way of awareness*. Novato, CA: New World Library.

Wilber, K. (2000). *Integral psychology: Consciousness, spirit, psychology, therapy.* Boston, MA: Shambhala.

Zeidan, F., Gordon, N. S., Merchant, J., & Goolkasian, P. (2010). The effects of brief mindfulness meditation on experimentally induced pain. *Journal of Pain, 11,* 199 209.

Zeidan, F., Johnson, S. K., Diamond, B. J., David, Z. & Goolkasian, P. (2011). Mindfulness meditation improves cognition: Evidence of brief mental training. *Consciousness and Cognition, 19,* 597-605.

Zgraggen, L., Fischer, J. E., Michler, K., Preckel, D. Kudielka, B. M. & von Kanel, R. 2005. Relationship between hemoconcentration and blood coagulation responses to acute mental stress. *Thrombosis Research, 115,* 175–183.

Table 1

Group comparison of means (and standard deviations) on baseline scores for each measured variables

	Treatment group	Control group	p
Age	22 (2.96)	21 (3.14)	.13
Ethnicity (% White)	98%	98%	.47
Gender (% Female)	54%	52%	.21
Baseline SBP	113.65 (10.0)	115.05 (10.8)	.61
Baseline DBP	66.93 (8.1)	65.91 (5.5)	.58
Baseline MAP	82.63 (8.1)	82.61 (7.6)	.99
Baseline HR	71.9 (14.1)	75.4 (14.7)	.36
Baseline PA subscale	36.07 (6.8)	34.54 (6.8)	.38
Baseline NA subscale	21.40 (6.5)	20.39 (5.5)	.52

Note. *Systolic blood pressure (SBP); Diastolic blood pressure (DBP); Mean arterial pressure (MAP); Heart rate (HR); Positive Affect (PA); Negative Affect (NA).*

Table 2

Means (and standard deviations) of affect scores at baseline and follow-up for Treatment and Control groups

	Treatment		Control		F	p
	Pre	Post	Pre	Post		
PA	36.0 (6.8)	35.1 (6.6)	34.5 (6.8)	34.0 (5.9)	1.05	.31
NA	21.4 (6.5)	18.8 (5.4)	20.3 (5.5)	19.8 (6.2)	11.79	.01

Note. Positive affect (PA), Negative affect (NA).

Figure 1. Study design: Sequence of events and timeline.

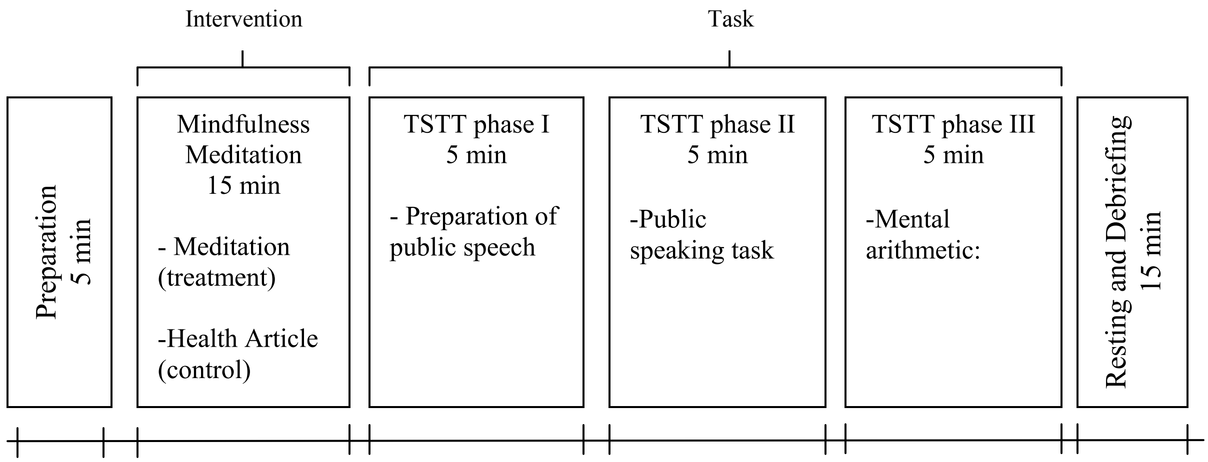


Figure 2. Mean scores on systolic blood pressure for the mindfulness intervention (n = 30) and control (n = 28) groups on 6 tasks measurements

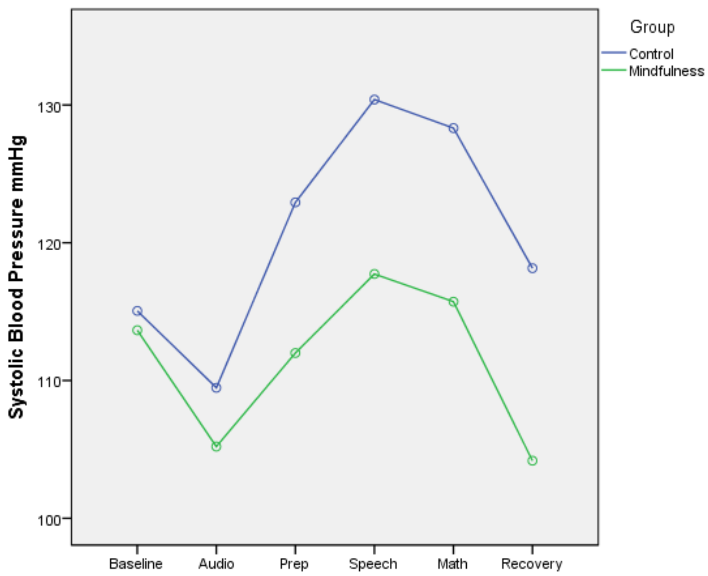


Figure 3. Mean scores on diastolic blood pressure for the mindfulness intervention (n = 30) and control (n = 28) groups on 6 tasks measurements

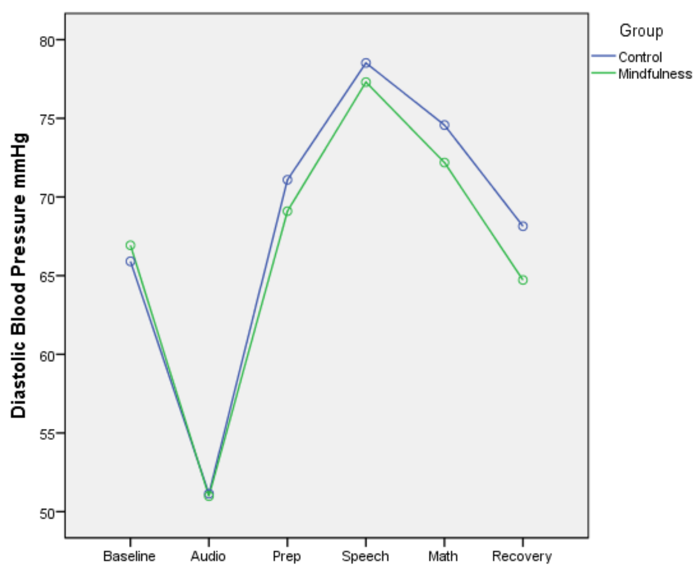


Figure 4. Mean scores on mean arterial pressure for the mindfulness intervention (n = 30) and control (n = 28) groups on 6 tasks measurements

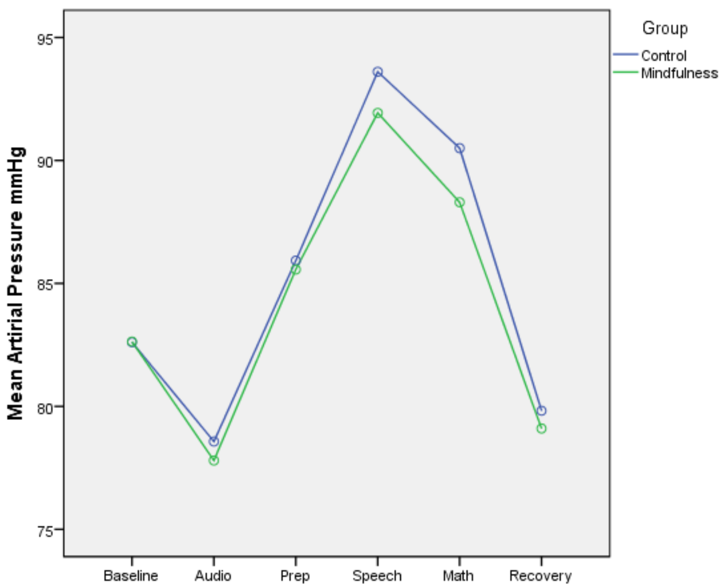
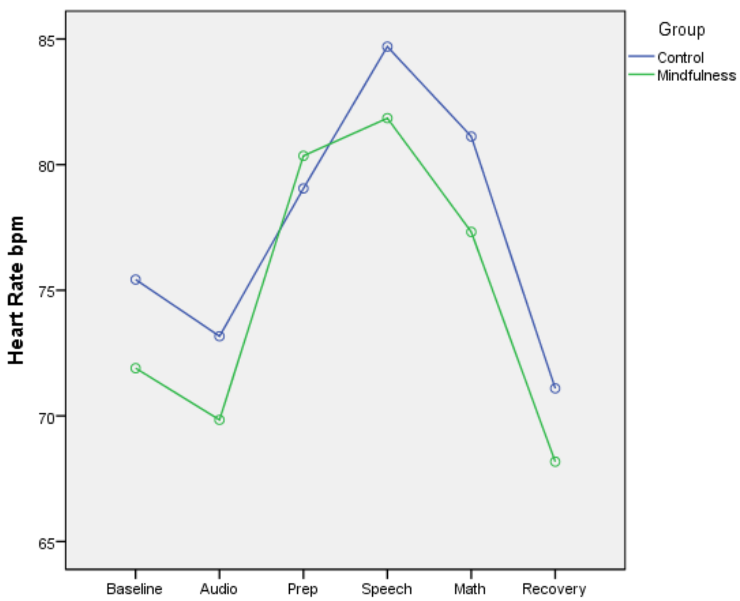


Figure 5. Mean scores on heart rate (beats per minute) for the mindfulness intervention (n = 30) and control (n = 28) groups on 6 tasks measurements



Appendix A

DEMOGRAPHICS (DEMO)

Instructions: Please provide some basic background information about yourself:

1. When were you born? __________________________, 19_________
   (Month) (Year)

2. What is your current marital status? (check one)

   ☐ Married[1] ☐ Divorced[2] ☐ Widowed[3]
   ☐ Separated[4] ☐ Never Married[5]

3. What is your sex? ☐ Male[1] ☐ Female[2]

4. Are you: ☐ Caucasian[1] ☐ African-American[4]
   ☐ Hispanic[2] ☐ Native-American[5]
   ☐ Asian[3] ☐ Other[6] ____

5. Are you: ☐ LDS (Mormon)[1] ☐ Jewish[4]
   ☐ Catholic[2] ☐ No religion[5]
   ☐ Protestant[3] ☐ Other[6] ____

6. Are you: ☐ Freshman[1] ☐ Junior[4]
   ☐ Sophmore[2] ☐ Senior[5]

7. What is your current grade point average?
   ☐ 4.0-3.6[1] ☐ 2.5-2.0[4]
   ☐ 3.5-3.2[2] ☐ 2.0 or lower[5]
   ☐ 3.1-2.6[3]

8. Are you currently:
   ☐ Employed full-time[1] ☐ Employed part-time[2] ☐ Unemployed[3]

9. How many hours on average do you work per week?
   ☐ 1-10 hours[1] ☐ 21-30 hours[3]
   ☐ 11-20 hours[2] ☐ 31-40 hours[4]
   ☐ More than 40 hours[5]

Health Questionnaire

Instructions: For each statement please indicate your response by marking one of the options. Your honesty is very important. Please note that all information given is strictly confidential.

10. How often do you consume caffeine?

☐ Infrequently (less than once a month)[1] ☐ More than 3 times a week[4]
☐ Occasionally (at least once a month)[2] ☐ Daily[5]
☐ Weekly (at least one a week)[3] ☐ More than once a day[6]

11. Have you used any stimulants, including caffeine within the past 24 hours?

☐ Yes[1] ☐ No[2]

12. Have you exercised today?

☐ Yes[1] ☐ No[2]

13. How often do you participate in some form of aerobic exercise?

☐ Infrequently (less than once a month)[1] ☐ Weekly (at least once a week)[4]
☐ Occasionally (at least once a month)[2] ☐ Daily (at least 5 days a week)[5]

14. How long do you typically exercise on each occasion?

☐ 5-10 minutes[1] ☐ 30-60 minutes[4]
☐ 10-15 minutes[2] ☐ more than 60 minutes[5]
☐ 15-30 minutes[3]

15. Have you eaten in the last 2 hours?

☐ Yes[1] ☐ No[2]

16. Are you currently seeing a physician for any current illness?

☐ Yes[1] ☐ No[2]

If yes, please explain.

17. Are you currently taking any prescription medications?

☐ Yes[1] ☐ No[2]

If yes, please indicate.

18. Please describe any cardiovascular related illness that you may have, including high blood pressure: ____

19. Please list any other medical or psychiatric problems that you have:____

20. Please list any major surgeries and medical or psychiatric illnesses you have had *in the past.*

____

Philadelphia Mindfulness Scale (PHLMS)

Instructions: For each of the statements located below, please indicate your response by marking one of the scale categories to the right of each statement. Use the scale shown below:

Never	Rarely	Sometimes	Often	Very Often
①	②	③	④	⑤

1. I am aware of what thoughts are passing through my mind.*	①	②	③	④	⑤
2. I try to distract myself when I feel unpleasant emotions. †	①	②	③	④	⑤
3. When talking with other people, I am aware of their facial and body expressions.*	①	②	③	④	⑤
4. There are aspects of myself I don't want to think about. †	①	②	③	④	⑤
5. When I shower, I am aware of how the water is running over my body.*	①	②	③	④	⑤
6. I try to stay busy to keep thoughts or feelings from coming to mind. †	①	②	③	④	⑤
7. When I am startled, I notice what is going on inside my body.*	①	②	③	④	⑤
8. I wish I could control my emotions more easily. †	①	②	③	④	⑤
9. When I walk outside, I am aware of smells or how the air feels against my face.*	①	②	③	④	⑤
10. I tell myself that I shouldn't have certain thoughts. †	①	②	③	④	⑤
11. When someone asks how I am feeling, I can identify my emotions easily.*	①	②	③	④	⑤
12. There are things I try not to think about. †	①	②	③	④	⑤
13. I am aware of thoughts I'm having when my mood changes.*	①	②	③	④	⑤
14. I tell myself that I shouldn't feel sad. †	①	②	③	④	⑤
15. I notice changes inside my body, like my heart beating faster or my muscles getting tense.*	①	②	③	④	⑤
16. If there is something I don't want to think about, I'll try many things to get it out of my mind. †	①	②	③	④	⑤
17. Whenever my emotions change, I am conscious of them immediately.*	①	②	③	④	⑤
18. I try to put my problems out of my mind. †	①	②	③	④	⑤
19. When talking with other people, I am aware of the emotions I am experiencing.*	①	②	③	④	⑤
20. When I have a bad memory, I try to distract myself to make it go away. †	①	②	③	④	⑤

Positive and Negative Affect Schedule (PANAS)

Instructions: For each of the words located below, please indicate your response by marking one of the scale categories to the right of each statement. Indicate to what extent you have felt this way during the past few weeks. Use the scale shown below:

Very Slightly or Not at all	A Little	Moderately	Quite a bit	Extremely
①	②	③	④	⑤

1. Interested	①	②	③	④	⑤
2. Distressed	①	②	③	④	⑤
3. Excited	①	②	③	④	⑤
4. Upset	①	②	③	④	⑤
5. Strong	①	②	③	④	⑤
6. Guilty	①	②	③	④	⑤
7. Scared	①	②	③	④	⑤
8. Hostile	①	②	③	④	⑤
9. Enthusiastic	①	②	③	④	⑤
10. Proud	①	②	③	④	⑤
11. Irritable	①	②	③	④	⑤
12. Alert	①	②	③	④	⑤
13. Ashamed	①	②	③	④	⑤
14. Inspired	①	②	③	④	⑤
15. Nervous	①	②	③	④	⑤
16. Determined	①	②	③	④	⑤
17. Attentive	①	②	③	④	⑤
18. Jittery	①	②	③	④	⑤
19. Active	①	②	③	④	⑤
20. Afraid	①	②	③	④	⑤