THE EFFECTS OF BRIEF MINDFULNESS MEDITATION TRAINING ON MOOD, COGNTIVE, AND CARDIOVASCULAR VARIABLES

by

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ABSTRACT

FADEL ZEIDAN. The effects of brief mindfulness meditation training on mood, cognitive, and cardiovascular variables (Under the direction of Dr. Susan K. Johnson)

This study examined whether a brief mindfulness meditation intervention, a style of meditative practice marked by focusing on the sensations of the breath without judgment, would affect mood, cognition, and cardiovascular measures. Participants with no prior meditation experience participated in four sessions that involved training in either meditation training (N = 24) or listening to a book recording (N = 23). Both conditions were found to be similarly effective at improving mood. Meditation was more effective at reducing fatigue, reducing anxiety, improving visuo-spatial processing, and working memory performance, in comparison to the book listening group. The meditation group also reduced systolic blood pressure following meditation training, whereas the book listening group did not. These results indicate that brief meditation has beneficial effects on some measures of mood, cognition, and blood pressure. Brief mindfulness meditation training effectively enhanced participants' ability to sustain attention, evidenced by improvements on cognitive measures. Our findings suggest that the benefits of meditation can be realized after a brief training regimen.

DEDICATION

To Dr. and Mrs. Zeidan for their lifetime of

unconditional support and love.

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CHAPTER 1: INTRODUCTION

Many studies have reported positive effects on mood (Grossman, Neimann, Schmidt, & Walach, 2004), cognition (Cahn & Polich, 2006), and overall health (Carlson et al., 2007) following extensive mindfulness meditation training. This study examined the effects of brief mindfulness meditation training on mood, cognitive, and cardiovascular measures, compared to a group that is performing a pleasurable activity (listening to a popular book).

Cognition and Mood

The attenuating effect of depression and fatigue on cognition has been investigated in recent research (Chepenik, Farah, & Cornew, 2007; Diamond, Johnson, Kaufman, & Graves, 2008). Negative mood and fatigue have been found to impair cognition in patients (Wearden & Appleby, 1996), as well as in experimental settings (Ciesla & Roberts, 2007). Researchers have found that negative mood disrupts top-down cognitive control processes, as well as, reflexive, bottom up processes (Vuilleumier, 2005). How mood disrupts cognitive processes has been of great interest in cognitive science. Phan and colleagues (2002) found activation in overlapping neural networks of cortical and subcortical regions associated with cognition and mood, suggesting that the two constructs work in parallel. Moreover, negative mood, specifically depression, has been found to alter executive functioning; impairing speed and accuracy of cognitive processes (Cabeza & Nyberg, 2000).

Depressed mood disrupts activity in the prefrontal cortex (PFC) (Davidson et al., 2003). Activation of the PFC has been related to a set of higher order cognitive abilities and positive temperament, referred to as executive functions and positive dispositional affect, respectively (Davidson et al., 2003). Depressed patients demonstrate abnormal activations (e.g. lack of activity) in the PFC (Cohen et al., 1997). Specifically, areas such as the Anterior Cingulate Cortex (ACC) and the Dorso-lateral PFC (DLPFC) are significantly less active in patients that report depression when compared to non-depressed individuals. Interestingly, experimental paradigms that induce sad mood find similar de-activations in the prefrontal cortical areas.

Depressed mood may impair working memory (Forgas, 2000). Behavioral studies have found that those who report higher levels of negative mood demonstrate a decreased capacity to hold a stimulus representation in mind, even over a brief interval of time (Chepenik, Farah, Cornew, 2007). A robust measure of working memory performance is the two-back task. The two-back task requires participants to continually encode new items into working memory by comparing a newly presented item with the one presented two items earlier. N-back task performance has been found to decline with negative mood. For instance, depressed patients performed worse on the verbal n-back task when compared to healthy controls (Harvey et al., 2005).

Another factor that has been found to adversely affect cognition is fatigue (Wearden & Appleby, 1996). Depressed mood and fatigue are strongly related and attenuate the processing of information and cognitive control processes (Diamond et al., 2008). Examining Multiple Sclerosis (MS) patients' performance on cognitive tasks has greatly contributed to understanding the relationship between fatigue, depression, and information processing. In a study that controlled for accuracy on a working memory task, depression and fatigue were found to account for a significant amount of variance in information processing speed in MS patients (Diamond et al., 2008).

Researchers have found that MS causes cerebral atrophy, which is correlated with mood and cognitive dysfunction (Benedict, Carone, & Bakashi, 2004). However, Diamond and colleagues (2008) suggested that cerebral atrophy would promote mood disturbances, such as depression, which would, consequently affect cognitive processes. Recent evidence for this theory has been supported in the current literature (Bush, Luu, & Posner, 2000; Chepenik, Cornew, & Farah, 2007).

Many studies of information processing have employed MS patients as participants, as they have significant problems with fatigue and mood as well as discrete cognitive deficits. Cognitive processing speed can be measured in a variety of ways. A robust approach of examining processing speed is by employing complex visual tracking tasks. Digit symbol coding is comprised of a series of numbers that are paired with hieroglyphic-like symbols. Subjects are asked to match numbers with their respective symbols, with an emphasis on doing so with high speed and accuracy. A similar measure of working memory is the Wechsler Memory Scale-III which assesses if participants can accurately match abstract designs and shapes when asked to recall after a brief interval period. In a study using these measures, self-reported fatigue mediates the relationship between information processing in MS patients (Anderasen, Spliid, Andersen, & Jakobsen, 2009). In other words, non-fatigued MS patients did not demonstrate a decline in cognitive performance, as measured by the Wechsler’s Memory Scale-III, when compared to fatigued MS patients. Additionally, patients that reported higher levels of fatigue processed information slower and less accurately, as measured by digit symbol coding. Johnson and colleagues (1998) postulated that distraction may play a key role in cognitive dysfunction within an MS sample. MS patients may have an inability to ignore distracters, which may contribute to their detriments in cognitive and working memory assessments. Distraction reduces the ability to allocate novel information into working memory (Raz & Buhle, 2006).

The ability to maintain information in the face of distracters promotes deficits in top-down control processes; specifically executive functioning (Cohen, 1997; Raz & Buhle, 2006). Researchers believe that fatigue affects executive cognitive functioning, which in turn may adversely affect mood (Anderasen, Spliid, Andersen, & Jakobsen, 2009). Researchers have postulated that extensive meditation training can promote cognitive functioning in a manner that reduces attention taxing detriments such as fatigue and distraction (Jha, Krompinger, & Baime, 2007). Extensive meditation practice and training has been found to improve mood, reduce fatigue, as well as promote cognitive control and flexibility (Kabat-Zinn et al., 1982; 1985; Austin, 1998). However, the majority of Western society does not have the time or money to participate in the long-term meditation interventions (Davidson et al., 2003; Jain et al., 2007).

The proposed dissertation project examined whether brief mindfulness meditation training can promote positive mood, reduce fatigue, increase mindfulness skills, as well as improve cognitive performance, when compared to an active control group. Meditation is based on training the mind to non-judgmentally focus on the present, and to reappraise sensory events (e.g. distraction) as fleeting (Wallace, 2006). The ability to be mindful may reduce distraction, improve cognition, and possibly reduce feelings of fatigue by sustaining levels of attention and vigilance (Zeidan, Johnson, & Goolkasian, 2009).

We were also interested in whether brief meditation training would improve cardiovascular outcomes (blood pressure, heart rate). Previous research has found mindfulness meditation training to be effective in promoting working memory, cardiovascular health, as well as attenuating negative mood (Cahn & Polich, 2006). The main purpose of examining a brief meditation intervention is to evaluate if a short interval of practicing meditation has measurable effects on cognition and health. Importantly, the translation of meditation to clinical practices would be more attractive, if meditation's palliative effects can be realized after a short period of time.

Overview of Meditation

Meditation has been found effective in treating a wide spectrum of mental and physical outcomes. The benefit of meditation on overall health (Grossman, Neimann, Schmidt, & Walach, 2004) is associated with an overall enhancement of executive attention functioning (Cahn & Polich, 2006) and emotional regulation (Creswell, Baldwin, Way, Eisenberger, & Lieberman, 2007). However, there are many different forms of meditation practice that employ varying attention promoting techniques. Transcendental meditation is simply focused on relaxation while implementing music, mantras, and incense (Cahn & Polich, 2006). Compassion meditation is associated with cultivating feelings of compassion to self and others (Wallace, 2006). Mindfulness meditation is premised on focusing on the dynamic sensations of an object (e.g. breath; sensations of the body; Wallace, 2006). Mindfulness meditation practitioners are taught to non-judgmentally appraise arising thoughts, and to simply return the focus of the breath without affective reaction. Moreover, it is postulated that the practice of mindfulness meditation promotes the ability to be aware of the present moment, in a manner that encourages non-reaction to sensory events, and reduces anticipation of the future and reflection of the past (Wallace, 2006).

Mindfulness meditation‘s roots are based in Buddhism, which posits that all suffering originates in the mind (Austin, 1998). Moreover, the mental construct of *attachment* is thought to be the driving force of suffering. In other words, any form of attachment to objects, people, or ideals is a cause for suffering. The ability of individuals who practice mindfulness meditation to not-react, and regulate affective appraisals associated with sensory events is associated with overall well-being, quality of life, vitality, and coping skills (Ekman, Davidson, Ricard, & Wallace, 2006). To this extent, mental training has been found to promote positive changes in the brain and in overall health (Austin, 1998; Damasio, 1994).

Mindfulness meditation’s benefits are directly associated with promoting higher executive functioning, and top down control processes, also referred to as cognitive control attentional processes. Mindfulness meditation has been found to enhance attentional processing, as measured by attentional blink (Lutz, Greischar, Rawlinings, Ricard, & Davidson, 2004), the Stroop task (Cahn & Polich, 2006), and the Attention Network Test (Tang et al., 2007; Jha, Krompinger, & Baime, 2007). Areas of the brain associated with executive functioning and affective regulation promote a top-down influence on the autonomic nervous systems, which leads to lower stress reactivity and overall well-being (Lazar, Bush, Gollub, Fricchione, Khalsa, & Benson, 2000).

The majority of mindfulness meditation research examines the effects of long-term meditators (adepts). Adept meditators are typically contemplative Buddhist monks who have dedicated their lives to meditation practices or those with over 5,000 hours of meditation experience (Grossman, Neimann, Schmidt, & Walach, 2004; Austin, 1998). However, there is increasing interest in the effects of mindfulness meditation in individuals with far less training. For example, one common training regimen, mindfulness-based stress reduction (MBSR), is a structured 8-10 week group program (Kabat-Zinn et al.., 1992; Grossman, Neimann, Schmidt, & Walach, 2004). Moreover, researchers are beginning to demonstrate examples where novice meditators show some of the same changes in cognitive processes that have been demonstrated in adepts (Zeidan & Johnson, 2003; Jain et al., 2007; Zeidan & Faust, 2008; Zeidan, Johnson, & Goolkasian, 2009; Zeidan, Gordon, Merchant, & Goolkasian, *In Press*).Moreover, novice meditators have been found to reliably differ on mood, attention, and pain outcomes when compared to controls.

Meditation and Health

MBSR has been found to have positive implications on a variety of health outcomes. Tacon and colleagues (2003) found that MBSR was effective in reducing anxiety and promoting positive emotions in hypertensive women. MBSR was found to be effective in reducing depression and anxiety in patients with a lifetime of mood disorders, when compared to a wait-listed control group (Carlson, Speca, Patel, & Goodey, 2003). Moreover, the researchers attributed these changes to meditation's modification of cognitive processes; specifically decreases in rumination and discursive thoughts, which can lead to cardiovascular reactivity. Jon-Kabat Zinn and colleagues

(1992) found that MBSR was effective in reducing anxiety and depression symptoms in general anxiety and depression patients.

MBSR programs have also been found to promote physical health outcomes (Grossman, Neimann, Schmidt, & Walach, 2004). For instance, MBSR was effective in clearing skin lesions in severe psoriasis patients (Kabat-Zinn et al., 1998). Adept meditators exhibited enhanced immune functioning, evidenced by an increase in anti-body titers; when compared to a control group (Davidson et al., 2003). Carlson and colleagues (2003) found that a MBSR program was associated with enhanced quality of life and sleep quality, as well as a decrease in stress symptoms within cancer patients. MBSR also promoted increases in T-cell and overall cytokine production in cancer patients. These findings suggest that the ability to regulate emotions by way of enhanced executive function can promote lasting changes in immune functioning and overall health (Wallace, 2006; Grossman, Neimann, Schmidt, & Walach, 2004; Carlson et al., 2003).

Meditation and Cardiovascular Health

Hypertension (high blood pressure) is a reversible risk that leads to heart disease, currently the leading cause of death in the United States (Carlson et al., 2007). Meditation practice has been considered an effective method of alleviating stress, which in turn, reduces blood pressure levels (Grossman, Neimann, Schmidt, & Walach, 2004). However, the effects of meditation on cardiovascular variables have been largely explored in the transcendental meditation tradition (Peng et al., 2004; Chiesa, 2009). Long-term transcendental meditation practice has been generally found to decrease systolic and diastolic blood pressure, as well as increase heart rate variability (Peng et al., 2004). Transcendental meditation has been found to reduce blood pressure after an hour of practice to extensive retreat-like practice (Cahn & Polich, 2006). Transcendental meditation is associated with mantra chanting, incense burning, as well as guided instruction by a "guru" (Wallace, 2006); therefore it may not be translatable to the general population. Mindfulness meditation has also been found effective in improving cardiovascular health; however, the few studies that have examined mindfulness meditation, have examined the effects of the MBSR regimen.

Carlson and colleagues (2007) examined the effects of a MBSR program on breast and prostate cancer patients on blood pressure (BP). Blood pressure was measured before and after the 8 week MBSR intervention. There was a significant decrease in systolic BP after meditation training. Heart rate also decreased after the intervention, when compared to baseline. There was no change in diastolic BP. In a two experiment study, Ditto and colleagues (2007) compared short-term autonomic and cardiovascular effects of four weeks of mindfulness meditation and progressive relaxation training to a wait-listed group. In second study, to control for inter-group cardiovascular variability, the researchers employed a within groups analysis. Participants practiced mindfulness meditation or listened to an audiotape of a popular novel (Harry Potter) in a counterbalanced manner. The researchers examined heart rate, heart rate variability, and blood pressure. Heart rate variability has been associated with higher quality of life and well being (Ditto et al., 2007). High heart rate variability is associated with better cardiovascular health (Grossman et al., 2004). In study 1, the researchers found no change in heart rate or blood pressure across groups; after one month of meditation training. However, there was a significant increase in heart rate variability during meditation when compared to relaxation and control groups. This finding may speak to the impact of meditation on the parasympathetic nervous system above and beyond the effects of relaxation (Ditto et al., 2007). In study 2, the researchers found no significant decrease in systolic BP after a month of training, when compared to baseline, although systolic BP went down before and after each meditation training session. Again, the meditation group improved their heart rate variability from baseline to post intervention. There were no differences in heart rate, and diastolic BP only decreased for the females.

The effect of meditation on cardiovascular outcomes is inconclusive (Peng et al., 2004). Our protocol will examined if four days of mindfulness meditation training can decrease BP and heart rate. There is one known study that has examined the effects of brief mindfulness meditation training on cardiovascular measures (Zeidan, Johnson, & Goolkasian, 2009). Three days of mindfulness meditation training was effective at reducing systolic BP across sessions when compared to a sham meditation and control group, although diastolic BP and heart rate did not change. There is, however, more conclusive evidence of the effects of mindfulness meditation on attentional processing.

Meditation and Attention

Research has consistently found that meditation is effective in enhancing executive function and attentional processing (Cahn & Polich, 2006). Lutz and colleagues (2004) found that long-term meditators exhibited robust gamma-band oscillations and “long-distance” synchrony during meditation practice. These results suggest that gamma-band synchrony could reflect an enhancement in the “quality” of moment to moment awareness. These results propose that neural changes can be exhibited through mental training; illustrating the “plastic” nature of the brain (Lutz, Greischar, Rawlings, Ricard, & Davidson, 2004). The researchers suggest that gamma band synchrony exhibited in their adept meditation cohort is indicative of higher level consciousness and emotional regulation. Slagter and colleagues (2007) found that a three month intensive meditation intervention was effective in enhancing cognitive flexibility, evidenced by changes in the attentional blink paradigm. Attentional blink is associated with a time lapse of information processing in the time required to consciously identify and consolidate a visual stimulus into short-term memory. The ability to consciously perceive the second stimulus can be temporally delayed by as much as a half a second (e.g. attentional blink) after the presentation of the first stimulus. This deficit in conscious perception has been associated with competition between two targets for limited attentional resources (Slagter et al., 2007). When compared to pre-training results, the researchers found that three months of intensive meditation training resulted in a reduced attentional blink and attentional resource allocation, evidenced by an increase in target one, evoked brain potentials (Slagter et al., 2007). The researchers postulated that meditation practice increases the control over the distribution of limited brain resources which enhances the processing of novel sensory events (Cahn & Polich, 2006; Slagter et al., 2007). Moreover, long term practice of meditation has been consistently found to activate the same brain areas associated with executive cognitive control and functioning.

Holzel and colleagues (2007) found that when compared to an arithmetic distraction condition (non-meditators), adept meditators demonstrated greater activations in the Anterior Cingulate Cortices (ACC) and the Dorso-Lateral Prefrontal Cortices (DLPFC) during meditation practice. The ACC has been closely related to conflict monitoring, cognitive control, and cognitive monitoring (Aftanas & Golocheikine, 2001). The DLPFC has been associated with the attention required to execute and plan willful acts and tasks. In conjunction with the DLPFC, the ACC is involved in focusing attention, as well as the monitoring of moment to moment sensory events (Newberg & Iverson, 2003). Researchers believe that activation in these higher order areas may be associated with the meditators' ability to continually focus on the flow of the breath, while ignoring "irrelevant" sensory information. Creswell and colleagues (2007) found that sustained activation in the DLPFC and the ACC was associated with meditative experience. During meditation, both novice and adept meditators exhibited activation of the ACC and DLPFC; however, those with more meditation experience exhibited more sustained activation in higher order neural areas (Lutz, Greischar, Rawlinings, Ricard, & Davidson, 2004). Newberg and colleagues (2001) found increased cerebral blood flow (CBF) in the fronto-parietal cortices and the ACC during an examination of Tibetan monks who were meditating for one hour. Activation in the fronto-parietal circuit provides robust evidence for meditation's enhancement of attention functioning and consciousness (Farb et al., 2007). The promotion of attentional skills allows experienced meditators to perceive sensory events in a manner that does not cause emotional reaction (Nielsen & Kazniak, 2006), which is correlated with better health outcomes (Grossman, Neimann, Schmidt, & Walach, 2004). Chan and Woollacott (2007) found that meditation experience was associated with reduced interference on the Stroop task effect. The Stroop task is a cognitive assessment that measures cognitive control and executive attention. Subjects were instructed to respond to the color of printed words, but told to ignore reading the word. The Stroop interference effect is the time latency of responding to colors of words that do not correspond to the word of a color, for example, the word red in the color blue. This condition is compared to responses identifying colors of the words that properly correspond with that particular word, for example, the word red in the color red. The researchers suggested that long-term meditation practice increases the efficiency of the executive attention network. However, research on the effects of brief meditation training on cognitive tests has been limited.

Tang and colleagues (2007) examined whether five days of integrative body-mind training (IBMT) would improve attention, as measured by the Attention Network Test (ANT) and the Profile of Mood States (POMS). The ANT is cognitive assessment that measures orienting, alerting, and executive control components of attention (Tang et al., 2007). The task consists of a combination of a cued reaction time task and a flanker tasks, and is reliable at dissecting various aspects of attention, as opposed to measuring general disturbances in attention processing. The researchers found that brief IBMT was effective at improving all aspects of the ANT, as well as improving scores on the vigor portion of the POMS. IBMT is associated with many practices, including visual imagery, music therapy, and mindfulness; so it does not provide an independent measure of mindfulness meditation on cognition and mood. Wenk-Sormaz (2005) examined the effects of twenty minutes of Zen (mindfulness) meditation training, when compared to twenty minutes of relaxation and non-active control groups on the Stroop task. The researcher found twenty minutes of meditation training was effective at reducing errors and response times on the Stroop task when compared to the other groups. The studies cited above indicate that meditation is associated with improvements in cognitive processing. Current research is examining how cognitive processes such as awareness and attention are related to the regulation of emotions.

Meditation and the Regulation of Emotion

It has been established that meditation regulates affective processes (Cahn & Polich, 2006; Newberg & Iverson, 2003). Creswell and colleagues (2007) found that dispositional mindfulness was associated with greater widespread Prefrontal Cortex (PFC) and attenuated amygdala (fear; negative affect) activation during a negative affect labeling paradigm. Pre-frontal activation in conjunction with amygdala de-activation is associated with the neural circuitry of emotional regulation (Newberg & Iverson, 2003). Creswell and colleagues (2007) also found that those who exhibited higher mindfulness skills, as measured by mindfulness assessments, demonstrated higher activity in the PFC regions and lower activation in the amygdala. Those that scored lower in “mindfulness” did not exhibit this relationship (Creswell, Way, Eisenberger, & Lieberman, 2007). Interestingly, the researchers found a positive relationship between activation in the medial PFC (mPFC) and mindfulness. The mPFC is associated with self-monitoring of affective states, and other self-relevant tasks (Creswell, et al., 2007). The researchers proposed that meditators are trained to appraise sensory and affective “thoughts” as “objects” of attention; therefore detachment from these thoughts is promoted, which leads to a reduction of cognitive appraisals. Meditation’s neural activation (increased mPFC and decreased amygdala activation) have also been found to be associated with reduced cortisol levels (Carlson et al., 2007), improved cardiovascular outcomes, and overall positive health outcomes (Davidson et al., 2003).

Damasio’s somatic marker hypothesis proposes that emotions affect decision making by both consciously perceiving context relevant cues (e.g. smiling; crying) and by unconscious pre-attentive cues (memory; conditioning) (Damasio, 1994). To this extent, the ability to regulate affective processes would be particularly important for decisions that have uncertain outcomes (Damasio, 1994). Researchers postulated that meditation promotes enhancement of emotional awareness that is related to the ability to access, identify, regulate, and act on emotional information (Austin, 1998). Nielsen and Kaszniak (2006) compared experienced meditators to non-meditators on measures of emotional awareness as measured by skin conductance response, and facial electromyography (EMG) when presented with masked and unmasked emotional pictures, in order to test for Damasio's somatic marker hypothesis. For half of the trials, participants were first presented with an unmasked picture of an emotional face (happy; disgust) and then presented with a "neutral" picture of a face (masked) 100msecs after the presentation of the first face. The other half of the trials were presented with a neutral face (masked) first and then presented the picture of an emotional face (unmasked) 100 msecs after the first. The two groups responded similarly to the masked condition. However, the meditators demonstrated greater emotional regulation than controls when presented with the unmasked condition. Additionally, meditators who exhibited higher emotional clarity were, when presented with emotion inducing pictures, found to exhibit lower physiological arousal (skin conductance; EMG) and improved valence discrimination in the masked condition. Nielsen and Kaszniak (2006) suggested that their findings provide evidence for the somatic marker hypothesis and meditation's ability to regulate affect, even in the presence of ambiguous information.

Brief Meditation Training

Research has been sparse in examining the efficacy of brief meditation intervention on naïve participants. Nonetheless, the few studies that have examined brief mindfulness training report positive results for executive cognitive functioning, mood variables, and several other health outcomes (Lane, Seskevivh, Peiper, 2007; Kingston, Chadwick, Meron, Skinner, 2007; Tang et al., 2007). Lane and colleagues (2007) utilized a mantra based meditation in 4, one hour small group meetings, and found significant reductions from baseline on Profile of Mood States (POMS) measures, Perceived Stress Scale, State/Trait Anxiety Inventory, and Brief Symptom Inventory. Kingston et al. (2007) did not find any effect of 6 one-hour mindfulness sessions on mood (using Positive Affective Negative Affective Schedule), but did find an effect on diastolic blood pressure and improved pain tolerance (employing a cold pressor test) compared to 2 one-hour guided imagery sessions. Tang and colleagues (2007) found that five 20 minute training sessions with an integrative body-mind training (IBMT) intervention was effective in improving cognitive functioning, as well as significantly decreasing depression, tension, fatigue, confusion, and increasing vigor as measured by the POMS, and decreasing stress-related cortisol levels. Research in our laboratories at UNCC have examined the efficacy of brief meditation training on a variety of outcomes described below.

In 2003, we examined the efficacy of a twenty minute meditation training session on various mood ratings (Zeidan & Johnson, 2003). The study implemented mindfulness meditation techniques on 48 naïve participants compared with a 28-participant control group. Participants completed measures of anxiety, depression, and anger before and after meditation. There were significant decreases on anxiety levels when compared with the control group. The meditation group reported significantly less anxiety as measured by the State Anxiety Inventory (SAI) after 1 twenty minute meditation training session.

However, there were no significant decreases on depression and anger levels (Zeidan & Johnson, 2003).

In another study (Zeidan & Faust, 2008), we examined the effect of a twenty minute meditation training session on the paper/pencil version of the Stroop task. We found a significant reduction in errors on the Stroop task for the meditation group when compared to a control group; however there were no differences between groups on reaction times. In part two of this experiment, we implemented a longer training session (3 days) and found that meditators again made fewer errors, and demonstrated a trend of reacting more quickly, when compared to controls. These data suggest that brief mindfulness meditation training is effective at reducing habitual responding, and improving cognitive, top-down control cognitive processes (Wenk-Sormaz, 2005).

As the perception of pain involves affective, sensory, and cognitive components, we examined the efficacy of a brief meditation intervention on experimental pain perception. Researchers have postulated that meditation’s analgesic effect may be associated with increased attentional functioning (mindfulness), distraction, and/or a relaxation response (Grant & Rainville, 2009). We examined the effectiveness of a three day (20 minutes/day) mindfulness meditation intervention on experimental pain perception (Zeidan, Gordon, Merchant, Goolkasian, 2007). We compared the meditators to a math distraction and relaxation condition, as well as a non-manipulated control group. Our training protocol is the briefest known meditation training that has been found to be effective in reducing pain reports. We found that the meditation group was effective in reducing low and high ratings of electrically stimulated pain ratings. Additionally, the math distraction condition was effective in reducing high, but not low pain ratings. The relaxation condition was not effective in reducing pain perception. Moreover, the meditation group was more effective in reducing pain perception when compared to the math distraction condition. Meditation also reduced ratings of state anxiety, as measured by the SAI. The meditation group significantly increased in mindfulness skills as measured by the Freiburg Mindfulness Inventory (FMI), and reductions in pain ratings were found to be related to increases in mindfulness skills. These data suggest that meditation's palliative effect on high and low pain intensities, may be due to the ability to modulate the sensory experience more broadly. These data highlight differences between cognitive distraction and mindfulness. One difference is that meditation may regulate the affective appraisal systems while distraction may not (Zeidan, et al., *In Press*; Grant & Rainville, 2009). The ineffectiveness of math distraction to reduce low pain ratings may be, in part, due to differences in the distribution of attentional resources to the two levels of stimulation. For example, high pain stimulation likely requires more attentional resources and therefore lends itself to cognitive modulation more readily than the low pain stimulation. Moreover, these findings demonstrated the effects of a very brief meditation intervention, and may prove fruitful to clinical populations in behaviorally treating various health outcomes.

Previous research suggests that the benefits of mindfulness meditation may be associated with a relaxation response, facilitator attention, or with demand characteristics in which participants may feel more inclined to report positive changes, because of meditation's "reputation" for enhancing positive mood and health. In a recent study, we examined the efficacy of a three day (20 minutes/day) mindfulness meditation intervention on mood and cardiovascular variables (Zeidan, Johnson, & Goolkasian, 2009). To examine the efficacy of a brief meditation intervention, we compared the meditation group to a group that believed that they were practicing meditation (e.g. sham mindfulness meditation group), while not employing the cognitive focus associated with mindfulness meditation. By including a relaxation intervention that resembles meditation (e.g. closing the eyes; taking deep breaths) and labeling such training a mindfulness meditation intervention, we attempted to separate the effects of relaxation, belief and expectations, from the cognitive state of concentrative meditation. Although a number of studies have employed relaxation controls, there are no published studies that have compared meditation interventions to a sham meditation condition.

We found that a very brief meditation intervention was effective in reducing overall traits for negative mood including depression, tension, fatigue, confusion, and anxiety when compared to the sham meditation and control groups. Sham meditation was effective in significantly reducing state anxiety and tension. The meditation group was effective at reducing heart rate across sessions and promoting positive mood (e.g. improving depression, anxiety, tension, confusion, and fatigue) when compared to the sham and control groups. Comparisons with a sham meditation group are an effective way of controlling for the demand characteristics associated with meditation practice in experimental trials. Finally, this study demonstrated that brief mindful training is associated with positive mood changes above and beyond the demand characteristics of a sham meditation condition.

The Dissertation Project

The dissertation project examined whether four days (20 minutes/day) of mindfulness meditation training can reliably increase mindfulness skills, positive mood, cognitive control, and improve cardiovascular variables, when compared to a control group that listens to a recorded book over the same period of time. We hypothesized that when compared to the control group, the meditation group will exhibit increased positive mood, and perform better on cognitive tasks. The cognitive domains assessed in this protocol are complex visual tracking using the Symbol Digit Modalities Test (SDMT) (Smith, 1968; Lengenfelder, Bryant, Diamond, Kalmar, Moore, & DeLuca, 2006), working memory (visual working memory adjustable 2-back task) (Diamond, 2009), retrieval from long term memory (Controlled Oral Word Association Test (Benton, 1969) and complex attention (Forward and Backward Digit Span) (Jensen & Figueroa, 1975). We also hypothesized that the meditation group would exhibit decreases in heart rate and blood pressure (BP), and the Hobbit listening group would not.

A novel aspect of this project is the use of the visual working memory adjustable 2-back task, a newly developed way of assessing complex information processing. The task is a computer adaptive task designed to match participants on accuracy, thus reducing the speed-accuracy confound common to *n*-back and other speed of processing tasks (Diamond, 2009). During the two back task, the participant views a computer screen and is asked to press a key that designates whether a stimulus that is currently on the screen is the "SAME or DIFFERENT" from the stimulus that was seen *two*-trials back (i.e., 2 back). The task makes ongoing adjustments so that each subject reaches the selected accuracy level (75% for our participants). In this manner, all participants will reach an equivalent level of accuracy, but the speed at which they perform the task will vary (Diamond, 2009).

The study examined whether brief meditation has effects on cognitive tasks that measure executive functioning (working memory), complex attention, and processing speed. Prior meditation research has found that mindfulness can modify subsystems of attention (Jha, Krompinger, & Jaime, 2008), regulate emotional processes (Creswell et al., 2007), and improve some health outcomes (Grossman, Neimann, Schmidt, & Walach, 2004). However, previous studies have used participants who were either adept meditators or those who had completed MBSR training. This study is the first study to comprehensively investigate cognitive control, mood and cardiovascular measures after only four (20 minutes/day) day mindfulness meditation intervention.

CHAPTER 2: METHODS AND MATERIALS

Participants

Fifty-three University of North Carolina at Charlotte (UNCC) students were enrolled for the experiment through the General Psychology sign-up webpage (SONA systems). Twenty-seven subjects were assigned to the meditation group. Three of these participants did not return after session 1. Twenty-six subjects were randomly assigned to the control group and, of those, three subjects did not return to following sessions. Data from the six students who did not complete all four sessions were not included. The median age was 19 years of age. Sixty-four percent of the participants were White, 26% were African-American, 2% were Asian, and 4% were biracial and Hispanic. Table 1 compares the participants in each of the two groups on demographic variables and all of the baseline measures collected in the study.

Interventions

Mindfulness Meditation

Mindfulness training was modeled on basic Vipassana meditation skills (Wallace, 2006). Training was conducted by a facilitator with ten years of training in mindfulness meditation interventions. Meditators were not asked to complete meditation homework, or practice outside of the intervention setting; contrary to the standard practice in MBSR. Participants were told that the mindfulness intervention had no religious teachings associated with it.

In session one, small groups of four to five participants sat in chairs, and were instructed to close their eyes and relax. They were then instructed to focus on the flow of their breath. If a random thought arose, they were told to passively notice and acknowledge the thought and to simply let “it” go, by bringing the attention back to the sensations of the breath. The last seven minutes of session one were held in silence, so that the participants could effectively practice mindfulness meditation. In session two, the facilitator instructed participants to focus on the “full breath,” (sensations in the nostrils and abdomen); the last seven minutes of session two were held in silence. Sessions three and four were an extension of sessions one and two. As a manipulation check, each subject was asked, individually, “if they felt that they were truly meditating” after each meditation session. Every subject responded with a “yes” to this question across all sessions.

Control Group

Control subjects were instructed to turn off cell-phones and not fall asleep while listening to *The Hobbit* (BBC audiobooks Ltd, 1997) audiotape. The Hobbit is a dramatization of Tolkien's story of Bilbo Baggins, “a comfort-loving hobbit who finds himself swept up by a wizard (Gandalf) and a band of dwarves in a raid on the treasure hoard of Smaug the Magnificent, a large and dangerous dragon” (BBC audiobooks Ltd, 1997). In session 1, subjects listened to the beginning of the story. The subsequent listening sessions (2-4) began where the story was stopped from the previous session. A research assistant sat with the participants throughout the session to monitor the participants’ attentiveness during the listening task.

Materials

Self-Report Measures

We administered the Freiburg Mindfulness Inventory (FMI), State Anxiety Inventory (SAI), the Center for Epidemiological Studies of Depression Scale (CES-D), and the POMS on session 1 before the interventions and on session 4 after the interventions.

1. The POMS (McNair, Loor, & Droppleman, 1971) is a 65-item inventory that measures psychological distress by rating adjective like statements (e.g., I feel calm) on a Likert scale (0-4). The POMS consists of six subscales: tension, depression, confusion, fatigue, anger, and vigor. The POMS was used to compare group differences from baseline. The total POMS computes a total negative mood score by adding tension, depression, anger, fatigue, and confusion, and then subtracting vigor.
2. The CES-D is a 20 item that measures state-like depressive symptomology. This measure has been extensively validated for use in the general population (Radloff, 1977). Responses are based on a four point Likert scale (0=rarely or none of the time and 3=most, or all of the time). Those who score 16 or above are considered clinically depressed (McDowell & Newell, 1996).
3. The FMI is an 18-item assessment that measures the experience of mindfulness (Bucheld, Grossman, & Walach, 2008). The FMI is a psychometrically valid instrument with high internal consistency (Cronbach alpha=.93) (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2007). Statements like “I am open to the experience of the present moment,” are rated on a four-

point scale from 1 (rarely) to 4 (always). Scores ranged from 18-72, with higher scores indicating more skill with the mindfulness technique. The FMI will serve as manipulation check on participants' ability to engage in a "mindful" state.

4. State Anxiety Inventory (SAI) is a 20- item scale designed to measure state anxiety (Spielberger, 1983). The SAI has been reported to exhibit high internal consistency with Cronbach's alpha of .73 (Spielberger, 1983). Statements like "I feel worried," are rated on a four-point scale from 1 (not at all) to 4 (very much so). Scores ranged from 20 to 80 with higher scores indicating more anxiety. We administered the SAI pre and post for each session to examine if 20 minutes of meditation would reduce state anxiety compared to listening to the book.

Cognitive Measures

Standardized cognitive tasks as well as the newly developed computer adaptive n-back task were administered pre intervention on session 1. Alternate versions of all tasks (except SDMT) were employed on post intervention on session 4.

1. Verbal fluency was measured by the Controlled Oral Word Association Test (COWAT) (Jensen & Figueroa, 1975). The COWAT asks subjects to say as many words as they can of beginning with the letters "F, A, and S," or "C, F and L" within one minute. The more words one can report, the higher the verbal fluency. We employed the COWAT because it has been used to assess verbal communication and ability (Diamond, Johnson, Kaufman, & Graves, 2008).

2. The Symbol Digit Modalities Test (SDMT). The SDMT has been employed to assess changes in cognitive functioning following an intervention and/or intervention (Smith, 1968; Lengenfelder, Bryant, Diamond, Kalmar, Moore, & DeLuca, 2006). Using a reference key, the examinee has 90 seconds to pair specific numbers with given geometric figures. Subjects were told that we were measuring speed and accuracy. Scores can range from 1 to 90. Higher scores were related to faster complex visual tracking.
3. Forward and Backward Digit Span (Benton, 1969): Forward digit span is a common measure of short-term memory, i.e. the number of digits a person can absorb and recall in correct serial order after hearing them or seeing them. As is usual in short-term memory tasks, here the person has to remember a small amount of information for a relatively short time, and the order of recall is important. For the “forward” digit span test; the experimenter recalled a sequence of numbers, and the examinee must verbally recall the numbers. For instance, the experimenter would state the numbers, “1 and 2” and the subject must accurately repeat those numbers to receive credit. The length of the sequences increases as the subject progresses through the examination. The lowest amount correct would be one, and the highest would sixteen. The highest sequence of numbers to recall for this test is nine. The “backwards” version of this test requires the subject to verbally recall the words backwards. For instance, if the experimenter stated the numbers, “1 and 2,” the subject would state “2 and 1” to receive credit. The highest sequence of numbers to recall for the backwards version of this test is eight.

4. The computer adaptive 2 back task (V2ASQQQQ) is a newly developed working memory assessment (Diamond, 2009). Subjects are asked to state whether or not a stimulus (e.g. letter) is the “same” or different” as the stimulus from the two previously presented. For instance, if on trial 6, and “A” is presented, and on trial 8 the subject is presented with the letter “H,” then the participant must press the keyboard the represents “different,” to receive credit for this item. This assessment has been considered an advancement from traditional N-back tasks because it corrects for accuracy-speed confounds (Diamond, 2009). For example, traditional N-back tasks are based on “yes or no” responses; giving the participant a 50% chance of being accurate. The proposed N-back task controls for speed-accuracy confounds by controlling for accuracy. This task adapts to the participants responses such that the stimuli are presented faster with each correct response, and slower with incorrect responses (Personal Communication, Bruce Diamond, 2009). Dependent variables were “extreme hit rate;” a measure of a run of correct responses. It is calculated as the mean run of correct responses. “Inter-stimulus interval;” a measure of speed**.**

Cardiovascular Assessment

In order to assess the effects of brief mindfulness meditation training on cardiovascular variables, we employed the Omron HEM-790 automatic blood pressure monitor before and after sessions 1 and 4. Three measurements were taken approximately four minutes apart. The average of the 3 measurements was employed as dependent variable (Zeidan, Johnson, & Goolkasian, 2009). The monitor allowed us to assess diastolic and systolic blood pressure readings, as well as heart rate.

CHAPTER 3: PROCEDURE

Participants were assigned to intervention groups based on the particular week that they signed up for the experiment. A coin toss determined which intervention was used on any given week and the interventions met on the same days of the week at the same time of day. Figure 1 outlines the assessment checklist across sessions.

Session 1

After obtaining consent forms, subjects completed the FMI, POMS, SAI, CES-D in random order. Then, the SDMT, backwards/forward digit span recall test, COWAT, and computer adaptive two-back task were completed in random order. After completion of self-report and cognitive assessments, each subject’s blood pressure and heart rate were measured. Then based on group assignment, subjects were either led in meditation or listened to The Hobbit in a group setting. Afterwards, each subject’s blood pressure, SAI, and heart rate was reassessed.

Session 2-3

Depending on group assignment, subjects either came in for meditation training, or book listening. All subjects completed the SAI before and after the meditation/listening intervention. The meditators continued learning and developing mindfulness meditation skills. Time was spent in silence as well as with instructions. The controls continued to listen to the Hobbit where they left off from the previous session.

Session 4

Subjects in the meditation and listening group completed the SAI before their respective intervention. Each subject's blood pressure and heart rate were then assessed. Then subjects either meditated or listened to the Hobbit. Then cardiovascular and SAI assessment was reevaluated. Subjects then proceeded to complete "post" measures of the FMI, POMS, CES-D, and the cognitive measures. Subjects were then debriefed, assigned credit to their Psychology course requirements, and excused.

Hypotheses

1. We hypothesized, based on previous work (Zeidan, Johnson, & Goolkasian, 2009), that brief mindfulness meditation training would reduce overall negative mood, depression, fatigue, and anger as measured by the POMS, when compared to the listening group.
2. We hypothesized that the meditators would reduce ratings of depression, as measured by the CES-D, when compared to the controls.
3. We expected that the meditators would significantly reduce state anxiety ratings (SAI) after each meditation session, and increase in mindfulness (FMI) when compared to the controls after meditation training (Zeidan, Gordon, Merchant, & Goolkasian, *In Press*).
4. We hypothesized that four days of mindfulness meditation training would improve working memory (computer adaptive 2-back task) (Diamond, 2009), visual-spatial processing (SDMT), verbal fluency (COWAT), and digit span recall, when compared to the listening group.
5. We were interested in examining if meditation practice would reduce blood pressure and heart rate. We hypothesized that the meditation group would reduce

heart rate and blood pressure during sessions 1 and 4, and that listening to a book would not.

Statistical Analyses

Statistical Package for Social Sciences 16.0 was used to conduct all statistical analyses. In general, the analyses tested for the between group effect of intervention training and the within group effect of pre/post (session 1 vs. session 4) intervention training. SAI was administered before and after the intervention in each session (sessions 1-4) and cardiovascular variables were assessed before and after the intervention in sessions 1 and 4. Significant interaction terms were examined with simple effects tests to determine the source of the interaction. A multivariate analyses of variance (MANOVA) was used (with Wilk"s criterion as the test statistic) on the subscale scores on the POMS, cognitive tasks (SDMT, Fluency, Backward/Forward recall tests), and the 3 subscale scores of the computer adaptive 2-back task (VASQQQQ). Follow-up univariate analyses were conducted when appropriate. The Total POMS, SAI, CES-D, and FMI were analyzed with separate mixed analysis of variances (ANOVA). A significance level of .05 was used for all statistical tests.

CHAPTER 4: RESULTS

Demographic information and baseline (session 1) scores for all measured variables are presented for each group in Table 1. There were no group differences on demographic variables (age; gender; ethnicity), although the control group exhibited significantly higher systolic BP at baseline when compared to the meditators.

Mood Measures

Freiburg Mindfulness Inventory

The analysis compared meditators to controls on the mindfulness scale from baseline to post intervention, and found a significant main effect for session, $F(1,45)=11.01$, $p=.002$, $\eta^2 =.20$; and as expected, group interacted with session, $F(1,45)=6.49$, $p=.01$, $\eta^2 =.13$. Figure 2 shows that brief mindfulness meditation training was effective at significantly increasing mindfulness skills, while listening to the hobbit had no noticeable effect on mindfulness.

Profile of Mood States

Table 3 presents group means and standard deviations for total POMS, and the each subscale across sessions. For the total POMS (total negative mood) assessment, both groups significantly reduced on total negative mood from session 1 to session 4, $F(1,45)=19.46$, $p<.001$, $\eta^2=.30$, and the reduction in total negative mood did not vary between groups ($F<1$).

The multivariate analysis conducted on the six subscales of the POMS exhibited a significant main effect for session, $F(1,45)=13.97$, $p=.001$, $\eta^2=.24$. Table 3 indicates that the significant main session effect was exhibited because both groups improved on all the subscales from session 1 to session 4. Session did not interact with group ($F<1$), and as expected, the subscales of the POMS significantly differed from each other, $F(5,41)=45.55$, $p<.001$, $\eta^2=.85$. There was no main effect for group, F (12,34)= 1.42, p =.21. The subscales did vary by group, $F(5,41)=4.90$, $p=.001$, $\eta^2=.37$, but the subscales did interact with session, $F(5,41)=4.90$, $p=.001$, $\eta^2=.37$. The session X subscales interaction resulted from the fact that the negative mood scores decreased and vigor increased. There was also a three way interaction of session, subscales and group, $F(5,41)=2.66$, $p=.04$, $\eta^2=.25$. Follow up univariate analyses examined each subscale for effects by group and session.

The analysis on the fatigue subscale of the POMS found a significant main effect for session, $F(1,45)=5.13$, $p=.03$, $\eta^2=.10$ and the groups did vary by session, $F(4,45)=4.47$, $p=.04$, $\eta^2=.09$. Figure 2 illustrates that brief meditation training was effective at significantly reducing fatigue, while listening to a book does not. We compared both groups on the depression subscale of the POMS, and found that both groups significantly reduced depression ratings after their respective interventions, $F(1,45)=13.28$, $p=.001$, $\eta^2=.23$, and the drop in depression did not vary by group ($F<1$). Both groups significantly reduced tension ratings, $F(1,45)= 26.13$, $p<.001$, $\eta^2=.37$, but the groups did not differ, $F(1,45)= 1.03$, $p=.32$. When comparing groups on the anger subscale of the POMS, we found that both groups lowered their reports of anger from session 1 to 4, $F(1,45)=10.29$, $p=.003$, and that the groups were not different across sessions (*F*<1). Vigor scores increased across sessions, $F(1,45)= 3.93$, $p=.05$, and session did not vary between groups (*F*<1). Both groups reported less confusion from session 1 to 4, $F(1,45)= 7.10$, $p=.01$, $\eta^2=.14$, but there was no difference between the groups, (*F*<1).

State Anxiety Inventory

A two (before/after) X two (group) X four (session) ANOVA was conducted to examine hypothesized differences on state anxiety. Group means and standard deviations are presented across sessions in Table 2. There was a main effect for before/after, $F(1,45)=75.62$, $p<.001$, $\eta^2 =.63$, and before/after interacted with group, $F(1,45)=27.16$, $p<.001$, $\eta^2 =.38$. The two way interaction is presented in Figure 4. Meditators decreased in anxiety when compared to the controls. There was a main effect for session, $F(3,135)=8.95$, $p<.001$, $\eta^2 =.17$, which showed a decline in state anxiety across session. However, there were no other interactions; session did not interact with group, $F(3,135)=1.81$, $p=.15$, before/after (*F*<1), or session and group, $F(3,135)=1.59$, $p=.20$.

Center for Epidemiologic Studies Depression Scale

There was a significant decrease in depression scores from session 1($M=14.40$, $SD=9.10$) to 4 ($M=10.51$, $SD=7.94$), $F(1,45)=7.88$, $p=.007$, $\eta^2=.15$, but there was no significant interaction (*F*<1).

Cognitive tasks

The multivariate analysis on the cognitive tasks (SDMT, digit span forwards and backwards, and COWAT) showed that performance changed across session, $F(1,45)=34.10$, $p<.001$, $\eta^2=.43$, and session did differ by group, $F(1,45)=6.52$, $p=.01$, $\eta^2 =.13$. Not surprisingly, the cognitive tasks were significantly different from each other, *F*(3,43)=559.93, *p*<.001, η^2 =.98, but they did not vary by group, *(*F<1). There was, however, a significant interaction between cognitive tests and session, *F*(3,43)=7.83, *p*<.001, η^2 =.35, but there was no three way interaction between group, session, and cognitive tasks, *F*(3,43)=2.65, *p*=.06. Univariate tests on each of the subtests were conducted in order to understand the two-way interaction between session and cognitive tests.

Symbol Digit Modalities Test

An analysis compared both groups on the SDMT and found a significant main effect for session, *F*(1,45)=28.33, *p*<.001, η^2 =.39, and session varied by group, *F*(1,45)=4.36, *p*=.04, η^2 =.09. There was no main effect for group, *F*(1,45)=1.09, *p*=.30. Figure 5 demonstrates that the meditation group performed significantly faster and more accurately than the controls on the SDMT after meditation training when compared to the control group.

Controlled Oral Word Association Test

As indicated in Figure 6, verbal fluency got better with from session 1 to 4, *F*(1,45)=9.09, *p*=.004, η^2 =.17, and the benefit to performance was obtained only with the group that received meditation training, *F*(1,45)=4.52, *p*=.004, η^2 =.09.

Digit Span

The analysis examining the forward digit span found a significant main effect for session, *F*(1,45)=10.46, *p*=.002, η^2 = .19, but there were no significant differences (*F*<1) between the meditation (*M*=12.42, *SD*=2.86) and the control(*M*=11.61, *SD*=1.85) group on session four. The analysis on the backward digit span found no effect for session, *F*(1,35)=2.75, *p*=.10, and there were no differences between the meditation(*M*=6.83, *SD*=3.00) and the control(*M*=7.48, *SD*=2.02) groups on session four.

Computer Adaptive Two-Back Task

The analysis on the three measures of the computer adaptive 2-back task found no session main effect, *F*(1,45)=2.48, *p*=.12, and group did not vary by session (*F*<1). The measures on the 2-back task differed significantly, *F*(2,44)=53.47, *p*<.001, η^2 = .71, but they did not vary by group, *F*(2,44)=1.47, *p*=.24. However, session varied by the measures of the 2-back task, *F*(2, 44)=9.10, *p*<.002, η^2 = .29. A significant three way interaction between session, group, and measures of the cognitive task was also found, *F*(2,44)=3.40, *p*=.04, η^2 = .13. In order to understand the three way interaction, follow up univariate analyses were conducted on each measure of the 2-back task.

Extended Hit Rate

Figure 7 illustrates group means with 95% confidence intervals across sessions for extended hit rate. The analysis on extended hit rate found a significant change for session, *F*(1,45)=15.97, *p*<.001, η^2 = .26. The group by session interaction, *F*(1,45)=6.79, *p*=.01, η^2 = .13 suggests that the meditation group significantly improved on extended hit rate when compared to the control group on session 4.

Hit Percentage

Hit percentage did not change between session 1 (Table 1) and session 4 (*F*<1), and session did not vary (*F*<1) between the meditation (*M*=.69, *SD*=.08) and control (*M*=.70, *SD*=.05).

Processing Speed

The analysis found no differences across sessions, *F*(1,45)=3.21, *p*=.08, η^2 = .08, and the meditation (M=99.93, *SD* =129.66) and control (M=67.36, *SD* =65.59) group did not vary between session 1 (Table 1) and session 4 (*F*<1) on processing speed.

Cardiovascular Variables

Systolic Blood Pressure

Figure 8 presents group means for systolic BP with 95% confidence intervals. The analysis examined systolic BP between groups, and did not find a main effect for session (*F*<1), and session did not interact with group, *F*(1,45)=1.24, *p*=.27, or before/after (*F*<1), or before/after X group, *F*(1,45)=1.55, *p*=.22. There was a main effect for before/after, *F*(1,45)=10.60, *p*=.002, η^2=.19, but there was no interaction between group and before/after, *F*(1,45)=2.43, *p*=.13.

Because of the variability between groups on Systolic BP, a more focused analysis was conducted on the data from each group alone to test whether training had an effect on systolic BP. The meditation group significantly decreased in systolic BP from before to after sessions 1 and 4, *F*(1,23)=17.12, *p*<.001, η^2=.43, but the controls did not, *F*(1,22)=1.07, *p*=.31 (Figure 8).

Diastolic Blood Pressure

ANOVA compared the two groups on diastolic BP, and found a significant session X before/after X group interaction, *F*(1,45)=5.16, *p*=.03, η^2=.10. There was no main effect for session (*F*<1), or before/after (*F*<1). Session did not interact with group (*F*<1), or before/after, *F*(1,45)=2.23, *p*=.14, and group did not interact with before/after (*F*<1).

Follow-up analyses found no effect for before/after in session 1, (*F*<1) and group did not interact with before/after, $F(1,45)=1.90$, $p=.18$. There was a main effect for group, $F(1,45)=3.79$, $p=.05$, $\eta^2=.08$ because the controls exhibited higher diastolic blood pressure (Figure 9). In session 4, there were no differences between groups, or before/after (*Fs*<1), and there were no interactions between group and before/after, $F(1,45)=2.14$, $p=.15$.

Heart Rate

Group means and standard deviations for heart rate are presented in Table 4. The analysis on heart rate found a significant before/after main effect, $F(1,45)=23.31$, $p<.001$, $\eta^{2=}$ .34, and a main effect for session, $F(1,45)=6.85$, $p=.01$, $\eta^2=.13$, as the meditators and controls exhibited higher heart rate for before the interventions in session 4. There was no interaction between before/after and group (*F*<1), pre/post by session (*F*<1), session by group (*F*<1), or before/after by session by group, $F(1,45)=1.81$, $\eta^2=.19$.

CHAPTER 5: DISCUSSION AND CONCLUSIONS

This study examined the effects of brief mindfulness meditation training on mood, cognition, and cardiovascular variables. We found that four days (20 minutes/day) of mindfulness meditation training had effects on some measures of mood; specifically anxiety and fatigue. Several cognitive tasks were affected by meditation, namely, the symbol digit modality, verbal fluency, and the computer adaptive two back tasks. Brief meditation practice was also effective in reducing systolic blood pressure, a replication of previous research (Ditto et al., 2007). Interestingly, some of our findings have only been exhibited, thus far by other researchers. in adept meditators, suggesting that the benefits of meditation may be realized after a brief format.

Both interventions were successful in improving negative mood. Listening to a book is a pleasurable activity, and it is not surprising that such an activity can reduce negative mood, even when compared to a meditation intervention. However, one distinct difference between groups was the ability for the brief meditation intervention to reduce fatigue ratings. Fatigue has been found to adversely affect cognition and mood (Forgas, 2000). Correlations have been found between reductions in fatigue, and improvements in cognition (Raz & Buhle, 2006). Also, reductions in anxiety and fatigue have been associated with enhanced cognitive functioning (Cahn & Polich, 2006; Diamond et al., 2008). Mindfulness is based on promoting a balance between a relaxed and vigilant state of mind (Wallace, 2006). Reduced anxiety and fatigue may address why the meditation group improved on some of the cognitive tasks, and the controls did not.

Mindfulness training has been associated with improving concentrative attention (Cahn & Polich, 2006). Concentrative attention is the ability to maintain attention on an object or a task (Raz & Buhle, 2007). Our findings suggest that brief mindfulness training develops and improves orienting and conflict monitoring aspects of concentrative attention, results found with adept meditators and extensive training (Jha, Krompinger, & Baime, 2007). The benefits of brief mental training on cognition were realized for some measures in the present study. Brief training was effective at sustaining vigilance and higher order executive functioning, evidenced by improvements on the computer adaptive 2-back task. When controlling for sampled accuracy, the meditation group significantly improved extended hit rates of the stimuli (Figure 7), when compared to the control group. The computer adaptive 2-back task is designed to present stimuli at faster rates after a correct response (Diamond, 2009). After four days of brief meditation training, the meditators were able to hold information in short-term memory, and to successfully allocate that information in the face of faster presentations of stimuli. Meditation training was based on training the mind to attend to dynamic and automatic stimulus (breath). When distraction arose (sound, internal chatter), the meditators were instructed to not react to the distractor, and simply return their attention back to the breath. This practice was the main focus throughout the training. This focus speaks directly to performance on the adaptive 2-back task. Even when the presentation of the stimuli became faster, due to the succession of correct responses, the meditators may have disallowed this fast presentation (e.g. distraction) to affect the high level of concentration required to perform well on the task (Slagter et al., 2007). In other words, the meditators’ increase in mindfulness skills (Figure 2) may have contributed to the ability to sustain attention, and promote top-down cognitive control processes (Cahn & Polich, 2006; Tang et al., 2008).

Improvements were also detected in visuo-spatial processing improvements after the brief mindfulness meditation intervention; such changes have previously only been found in adept meditators (Cahn & Polich, 2006). SDMT is a test of complex visual tracking. The meditation group performed faster and more accurately. In a recent study, long-term meditators (Buddhist monks) performed significantly better on visuo-spatial tasks in comparison to a control group (Embedded Picture Test; Perspective Taking Test) (Kozhevnikov, Louchakova, Josipovic, & Motes, 2009). It is hypothesized, that the improvements in visual spatial processing for mindfulness meditation are associated with activation in executive functioning areas (PFC; ACC). Moreover, these higher-order areas have robust reciprocal relationship with the primary visual system (Kozhevnikov, Louchakova, Josipovic, & Motes, 2009). Therefore, meditation may enhance the connectivity between these areas evidenced by behavioral improvements and neurological activation.

Brief mindfulness meditation training was also found to be effective in improving verbal fluency when compared to the control group, as measured by the COWAT, which assesses participants' ability to employ retrieval from long-term verbal memory, in order to verbalize as many words that start with a specific letter (Benton et al., 1994) in 60 seconds. It appears that the meditators were able to utilize retrieval from long-term memory more efficiently than the group listening to a book. Meditation's involvement in enhancing top-down and executive-functioning control processes was exhibited after a brief training regimen. There were no differences between groups on both digit-span (backward/forward) assessments. Our digit span tasks were not timed, and did not tax subjects on speed of processing skills, which may explain the lack of group differences on digit span recall. It may be that the initial benefits of mindfulness training can be exhibited in more sensitive cognitive tasks that tax participants on time. For instance, brief meditation training's improvements in visuo-spatial, long term memory retrieval and working-memory processes were exhibited when participants were required to perform a cognitive task under time restrictions. The ability to regulate emotions during stressful situations may be associated the meditation's group improved performance on cognitive tasks (Ekman, Davidson, Ricard, & Wallace, 2005).

The emphasis of our mindfulness training protocol was to develop attentional and emotion regulating skills. Our findings indicate that brief mindfulness training was effective in promoting top-down attentional control. Conflict monitoring and orienting skills, of the meditators, significantly improved after training, evidenced by improvements on cognitive tasks that asses higher order executive functioning. The emphasis of our mindfulness meditation intervention was based on focusing on the breath and "gently" reorienting attention back to the breath when distracted has been found to activate dorsal prefrontal and parietal cortices (Jha, Krompinger, & Baime, 2007). Activation in these areas is associated with higher order executive functioning, associated with the ability to implement top-down cognitive control and affective regulatory processes (Cahn & Polich, 2006; Raz & Buhle 2007). Both groups improved on mood, suggesting that including a group that participates in a pleasurable activity, such as listening to a book, serve as a reliable manipulation of promoting positive mood. Previous research employing similar brief interventions (Zeidan, Gordon, Merchant, &

Goolkasian, *In Press*; Zeidan, Johnson, & Goolkasian, 2009) found significant improvements for meditation when compared to control and sham meditation groups, respectively. In the current study, the control manipulation of listening to a book was more effective at improving mood than previous sham meditation and non-active controls (Zeidan, Johnson, & Goolkasian, 2009).

The clear distinction between groups, in information processing, suggests that meditation practice's effectiveness in reducing fatigue and anxiety, and increasing positive mood, promotes self-regulatory processes that may contribute to cognitive enhancement. Reductions in fatigue and anxiety have reliably been found to promote attentional skills (Raz & Buhle, 2007). Moreover, the meditation groups' significant drop in systolic blood pressure for sessions 1 and 4 suggests that brief mindfulness practice may improve cardiovascular functioning, which is an effect that has previously been found only after extensive meditation training (Grossman, Neimann, Schmidt, & Walach, 2004; Ditto et al., 2007).

This is the first study to provide a comprehensive analysis of the effects of brief mindfulness meditation training. More research is needed to understand the neurological activation involved after brief meditation training. Some researchers (Tang et al., 2008) examining brief interventions that include mindfulness meditation practice found improvements in psychological mood and neuro-cognitive processing. Unfortunately, these improvements could not be ascribed solely to mindfulness, as they incorporated a variety of techniques. We suggest that simply training the mind to focus on a dynamic stimulus, in a relaxed manner, can boost cognitive processing, particularly on timed tasks where higher scores reflect speedier processing. Meditation practice may lead to the ability to reappraise sensory and cognitive events as momentary, not requiring affective appraisals that may lead to stress responses (Newberg & Iverson, 2003). Additionally, mindfulness meditation may simply enhance practitioners' ability to focus and sustain attention (Cahn & Polich, 2006; Jha, Krompinger, & Baime, 2007). Ongoing and future studies will examine how brief mindfulness training affects brain activations during sensory and cognitive tasks.

This study can only be generalized to college aged healthy adults. Also, a lack of a non-active control group is a limiting factor for this study. The Hobbit listening group was a more active control than previously employed control groups (Zeidan, Johnson, & Goolkasian, 2009). Although we flipped a coin to assign intervention to group; lack of true random assignment is another limiting factor.

Conclusions

We found that four days (20 minutes/day) of mindfulness meditation training can improve mood, cognition, and blood pressure measures. These findings along with others suggest that the benefits of mindfulness meditation can be directly realized (Zeidan, Gordon, Merchant, & Goolkasian, *In Press*; Zeidan, Johnson, & Goolkasian, 2009; Zeidan and Faust, 2008) in several domains. Hypothetically, these directly perceived improvements may lead to increasing inclinations to continue practice, which will lead to better overall health (Grossman, Neimann, Schmidt, & Walach, 2004). Also, the dissemination of the benefits of meditation may be more clinically attractive when found to be effective after brief training. The time and financial commitments required for meditation interventions (i.e., MBSR) may be too taxing for the average person. This study suggests that some benefits of meditation can be realized after very brief practice.

Moreover, the benefits of brief meditation practice may be more comprehensive than previously thought.

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APPENDIX A: TABLES

TABLE 1

Group comparison on baseline scores for each of the measured variables

	Meditation	*Controls*	t/χ^{2*}	*P*
Baseline Mean (SD)				
Age	22(7.90)	23 (8.70)	.64	.52
Caucasian	67%	57%	7.30	.19
Female	57%	63%	.17	.68
S.B.P	110.88 (10.35)[a]	120.73 (20.26)[b]	2.12	.04
D.B.P	73.17 (9.05)[a]	76.65 (8.91)[a]	1.33	.19
H.R	76.17 (11.05)[a]	77.82 (13.73)[a]	.46	.65
SAI	36.75 (10.72)[a]	35.74 (9.59)[a]	.34	.74
POMS	15.21 (26.39)[a]	13.57 (28.55)[a]	.30	.77
CESD	15.21 (7.82)[a]	13.57(10.38)[a]	.61	.52
SDMT	58.79 (10.78)[a]	58.65 (10.35)[a]	.05	.76
FDS	10.88 (2.58)[a]	10.96 (2.08)[a]	.12	.91
BDS	6.58 (2.60)[a]	6.61 (1.83)[a]	.04	.97
COWAT	35.92 (8.61)[a]	36.70 (10.06)[a]	.29	.78
FMI	43.33 (8.57)[a]	46.91 (8.58)[a]	1.43	.16
EHR	2.38(3.41)[a]	3.48(4.58)[a]	.94	.35
HP	.70(.07)[a]	.68(.13)[a]	.69	.49
PS	130.03(139.76)[a]	104.74(116.74)[a]	.68	.50

df= 2,64. S.B.P *(Systolic Blood Pressure)*, D.B.P *(Diastolic Blood Pressure)*, H.R. *(Heart Rate)*, SAI *(State Anxiety Inventory)*, POMS *(Total Profile Mood State)*.CESD (*Center for Epidemoplogic Studies Depression Scale*), SDMT (*Symbol Digit Modalities Test)*, FDS (*Forward Digit Span)*, BDS(*Backwards Digit Span*), COWAT (*Controlled Oral Word Association Test*), FMI(*Freiburg Mindfulness Inventory)*.EHR(*Extended Hit Rate)*, HP(*Hit Percentage*), PS(*Processing Speed*). Means having the same superscript are not significantly different at $p < .05$.

TABLE 2.

Means and Standard Deviations for Control and Meditation group on SAI

	Control				*Meditation*			
	Pre[a]		*Post*[a]		*Pre*[b]		*Post*[b]	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Session 1	35.74	9.59	35.39	10.79	36.75	10.72	27.58	5.76
Session 2	30.17	6.49	27.09	6.14	33.75	9.08	24.96	5.33
Session 3	31.96	7.91	29.17	8.11	32.67	7.32	25.29	4.15
Session 4	30.43	7.88	28.43	6.42	32.29	8.30	25.67	5.28

Note. Session 1.(State Anxiety Inventory session 1). Session 2 (State Anxiety Inventory session 2).Sesssion 3. (State Anxiety Inventory session 3)Session 4.(State Anxiety Inventory session 4).

TABLE 3

Means and Standard Deviations for Control and Meditation Groups on POMS subscales

	Control				*Meditation*			
	Pre[a]		*Post*[a]		*Pre*[b]		*Post*[b]	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Total POMS	12.83	28.55	-1.43	12.02	15.20	26.39	-4.17	16.38
Tension	6.43	6.34	2.70	2.29	8.50	6.95	2.91	2.75
Depression	4.83	8.68	.52	1.20	6.12	7.94	1.96	3.99
Anger	3.96	5.93	1.26	2.05	4.00	5.59	1.91	2.87
Vigor	13.70	5.98	15.30	6.45	15.87	5.48	18.75	7.17
Fatigue	4.57	5.43	4.43	4.58	5.54	4.33	1.70*	3.17
Confusion	6.74	3.84	4.96	2.27	6.92	3.88	5.45	3.56

Note. * denotes meditation group significantly less fatigue scores than controls.*

[a]*n*=23 , [b]*n*= 24 .

TABLE 4

Means and Standard Deviations for Control and Meditation group on Heart Rate

	Control				*Meditation*			
	Pre[a]		*Post* [a]		*Pre*[b]		*Post*[b]	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Session 1	77.82	13.73	71.74	12.96	76.17	11.05	74.29	10.82
Session 4	80.96	17.66	76.22	15.00	83.29	16.88	77.67	12.61

Note.
[a]*n*=23 , [b]*n*= 24 .

APPENDIX B: FIGURES

FIGURE 1

Session 1	**Session 2-3**	**Session 4**
Before FMI SAI POMS Cardiovascular SDMT COWAT FDS BDS 2-back task Intervention Meditation training or Hobbit Listening After SAI	Before SAI Intervention Meditation training or Hobbit listening After SAI	Before SAI Intervention Meditation training or Hobbit listening After 2-back task FMI SAI POMS Cardiovascular SDMT COWAT FDS BDS

Figure 1. Schedule of experimental protocol and interventions for both group

FIGURE 2

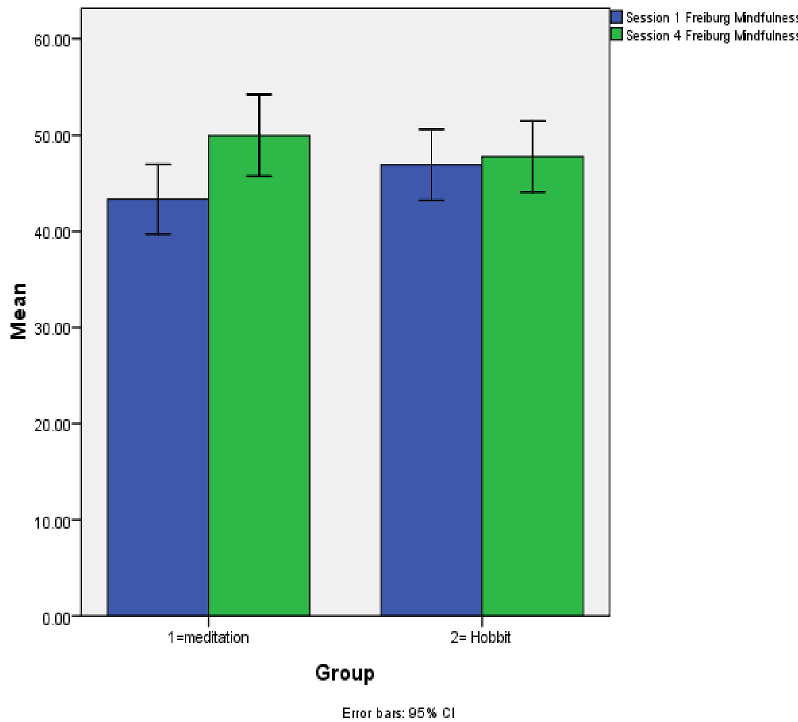


Figure 2. Mean scores on the FMI with 95% confidence scales for the meditation (*n*= 24) and control (*n*= 23) groups on baseline and post-intervention measurements.

FIGURE 3

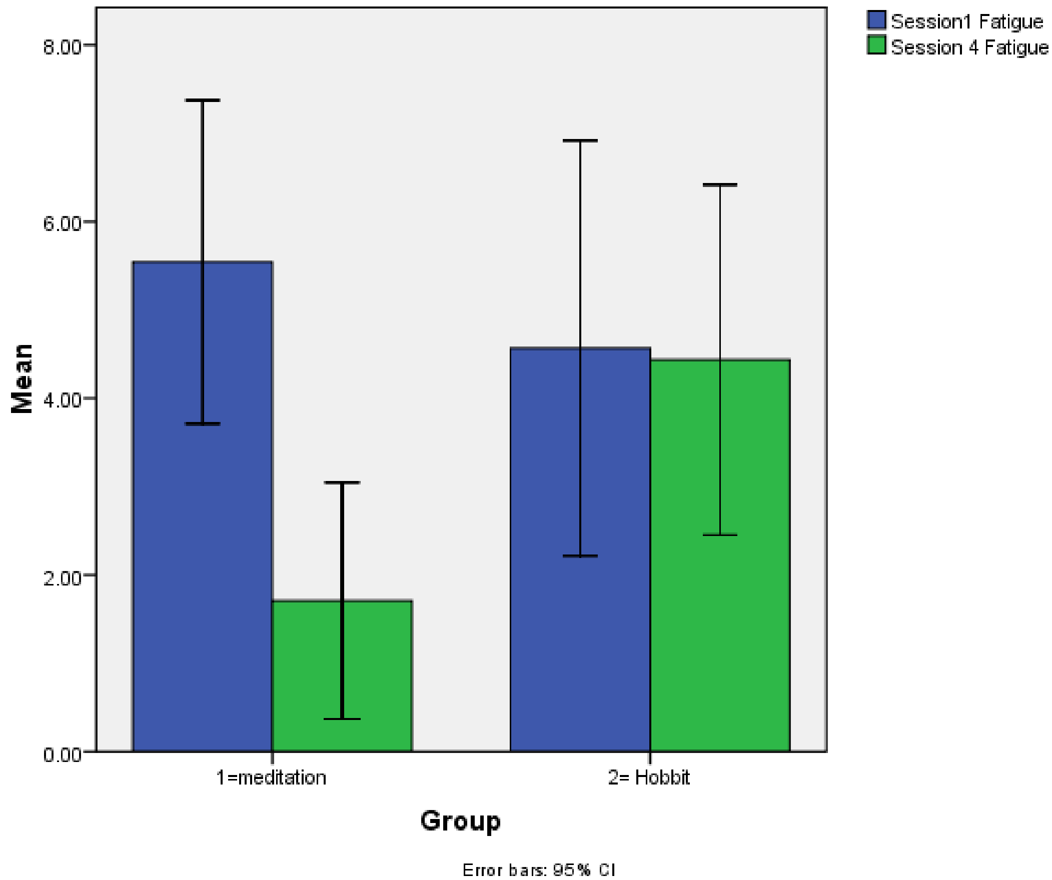


Figure 3. Mean scores on the fatigue subscale of the POMS with 95% confidence scales for the meditation (*n*= 24) and control (*n*= 23) groups on baseline and post-intervention measurements.

FIGURE 4

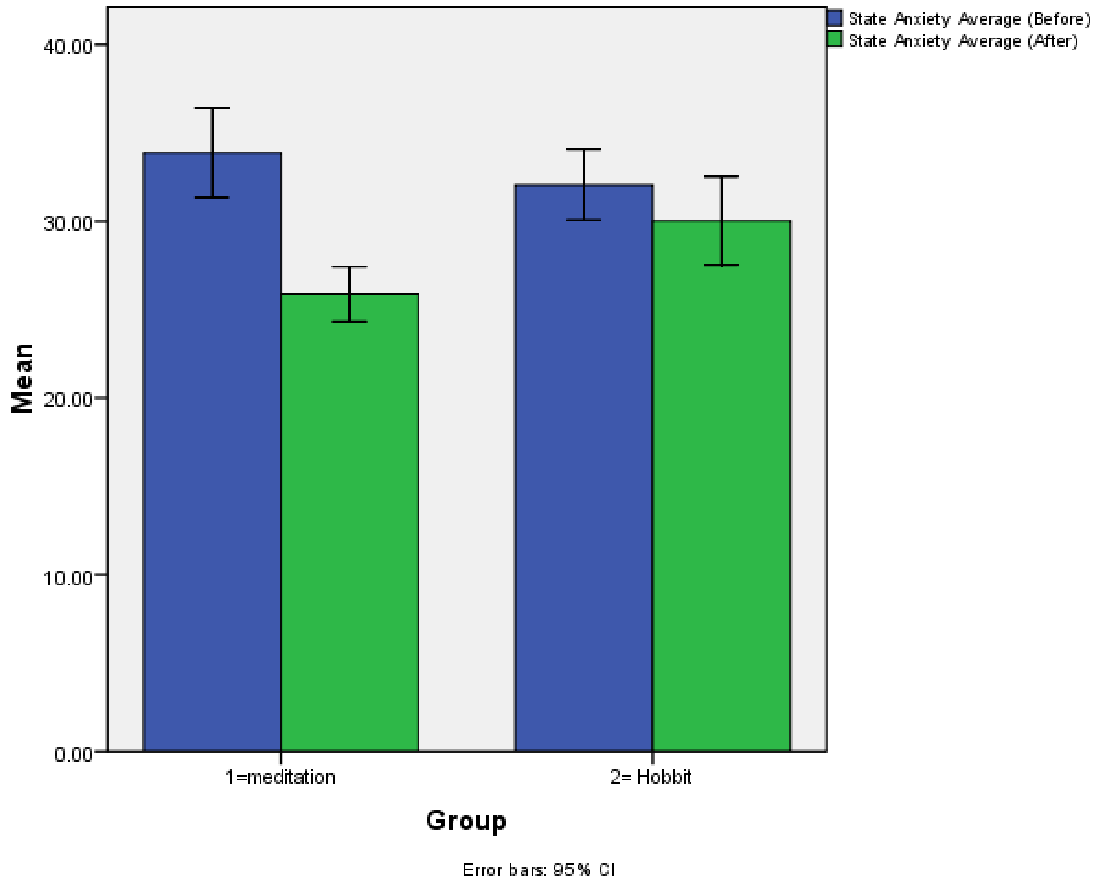


Figure 4. Mean scores on the averaged SAI with 95% confidence scales for the meditation (*n*= 24) and control (*n*= 23) groups on baseline and post-intervention measurements.

FIGURE 5

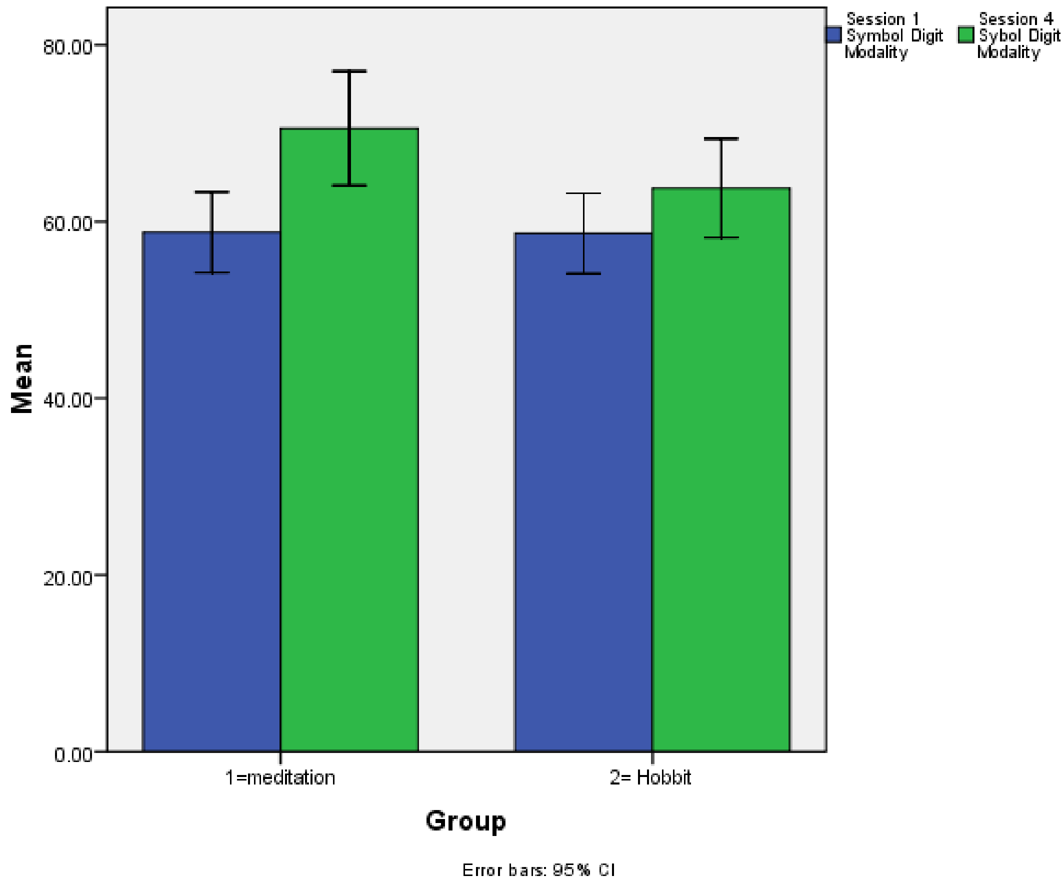


Figure 5. Mean scores on the SDMT with 95% confidence scales for the meditation (*n*= 24) and control (*n*= 23) groups on baseline and post-intervention measurements.

FIGURE 6

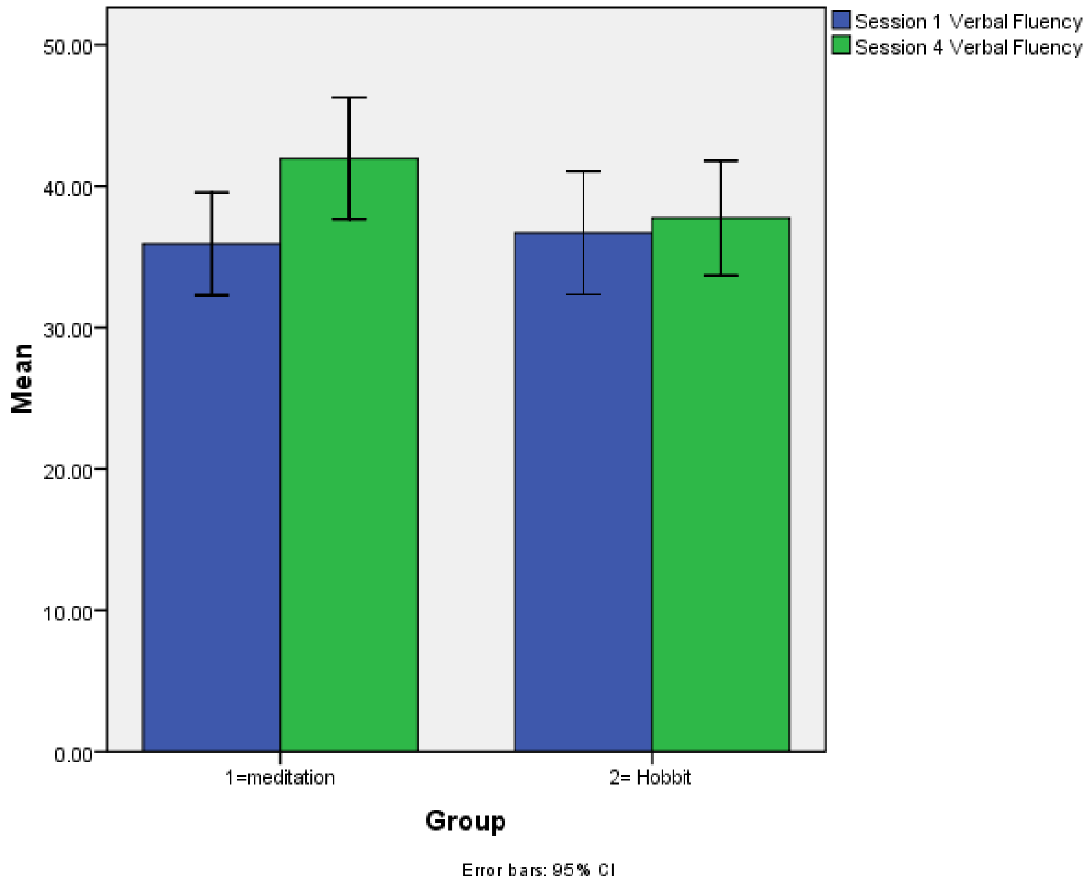


Figure 6. Mean scores on the COWAT with 95% confidence scales for the meditation (*n*= 24) and control (*n*= 23) groups on baseline and post-intervention measurements.

FIGURE 7

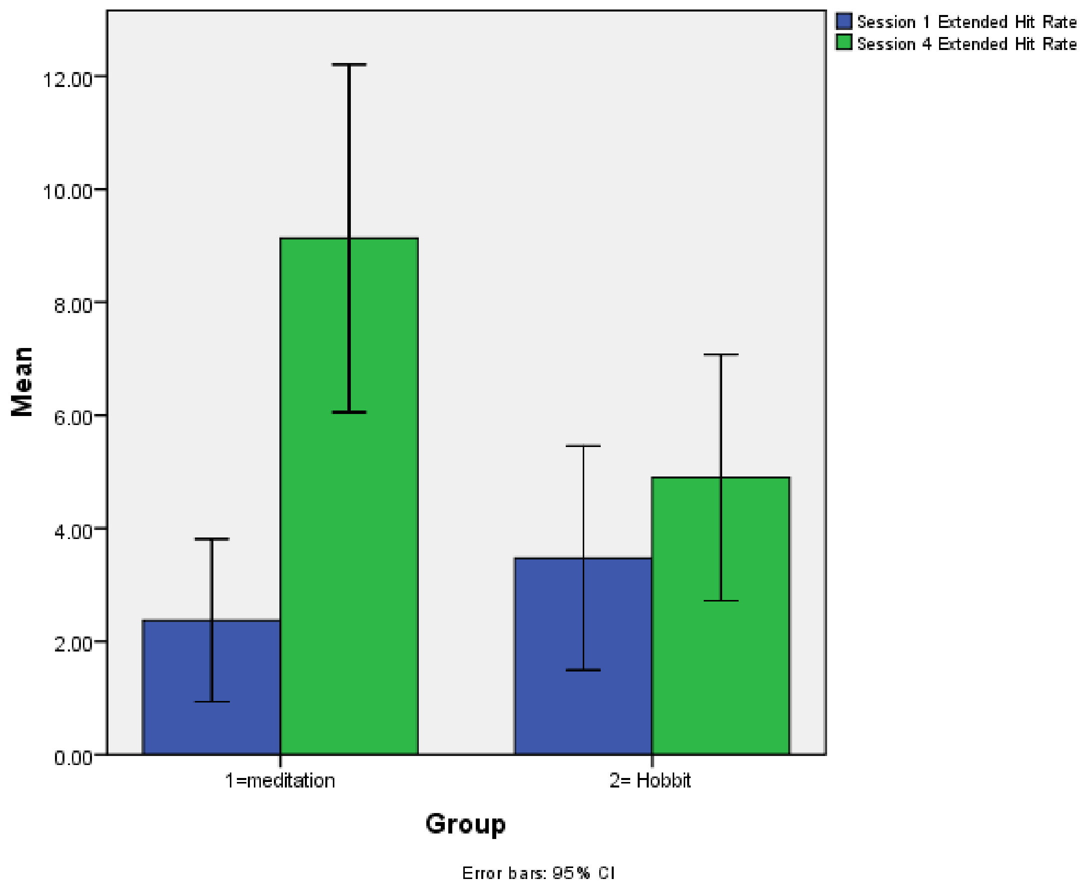


Figure 7. Mean scores on the extended hit rate for the two-back task with 95% confidence scales for the meditation (*n*= 24) and control (*n*= 23) groups on baseline and post-intervention measurements.

FIGURE 8

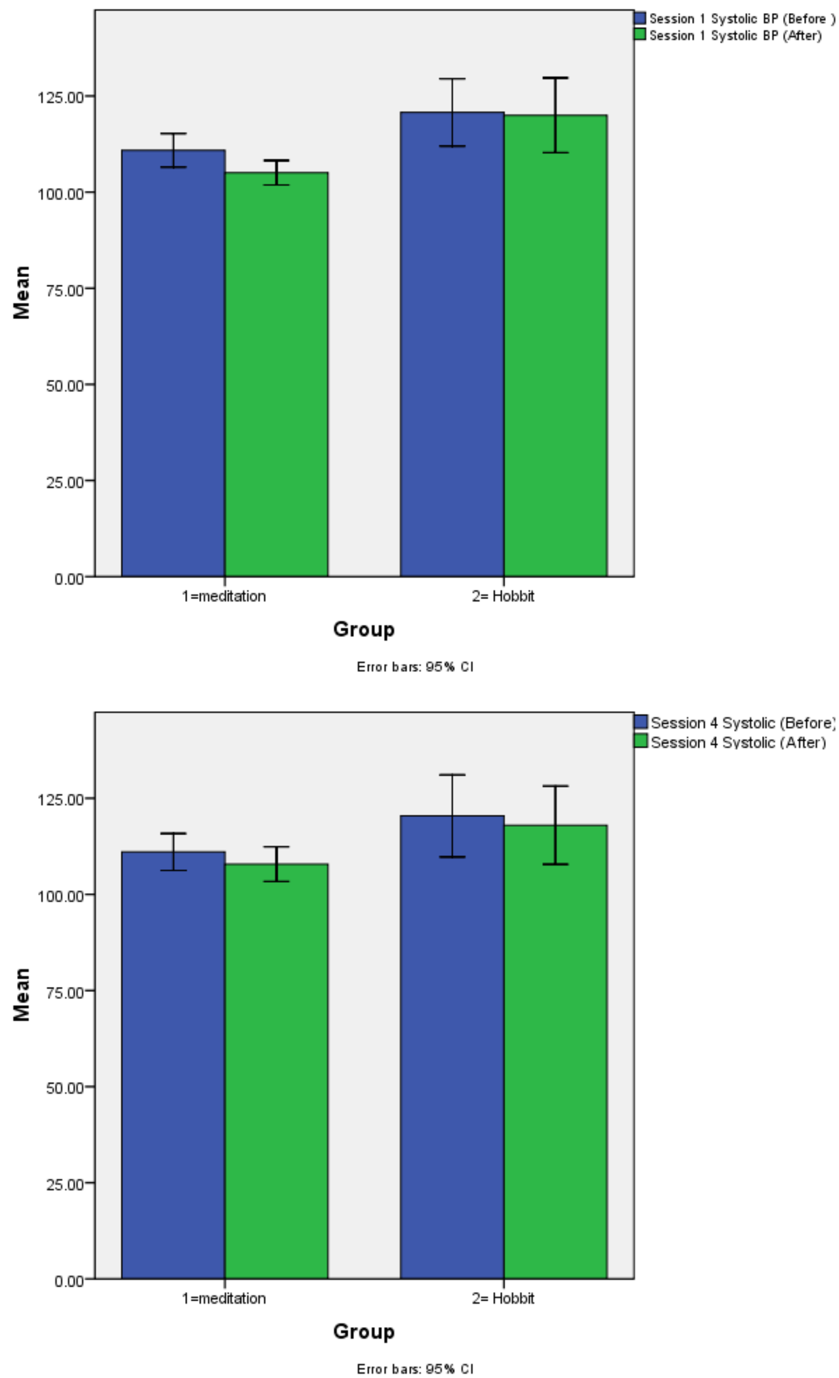
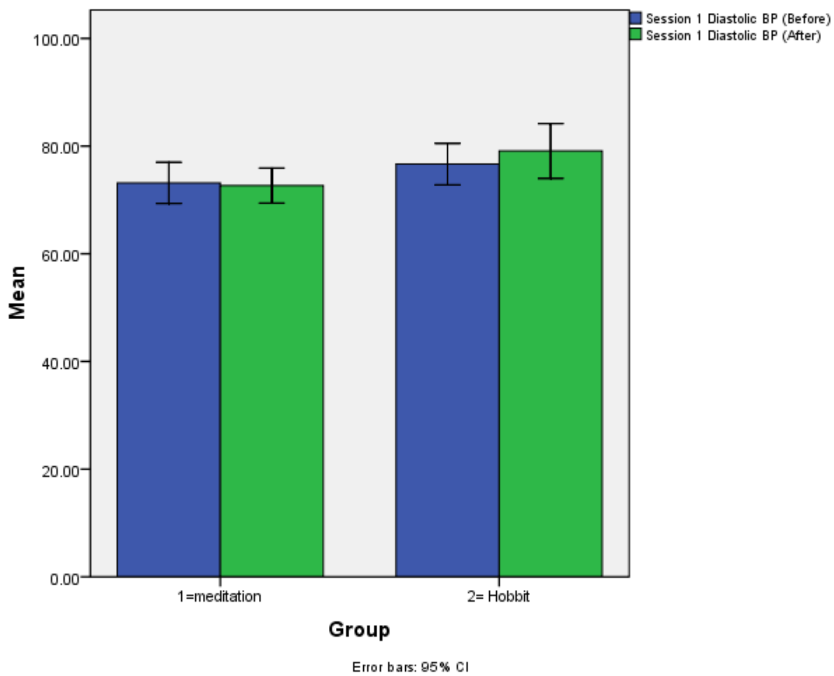


Figure 8. Mean scores on the systolic BP with 95% confidence scales for the meditation (*n*= 24) and control (*n*= 23) groups before and after sessions 1 and 4.

FIGURE 9



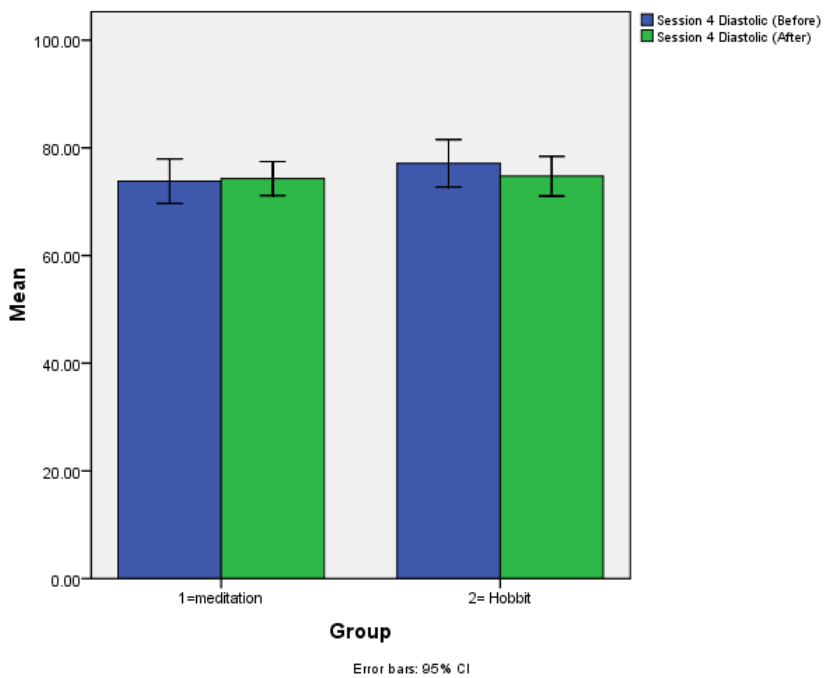


Figure 9. Mean scores on the diastolic BP with 95% confidence scales for the meditation (*n*= 24) and control (*n*= 23) groups before and after sessions 1 and 4.