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Stroop And Mindfulness: An Experimental Multi-Group Comparison

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STROOP AND MINDFULNESS: AN EXPERIMENTAL MULTI-GROUP COMPARISON

by

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Anna L. Schimmelpfennig
October 22, 2018

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ABSTRACT

Mindfulness has been associated with various benefits, including enhanced cognitive performance and disengagement from problematic emotions. Previous research has indicated that engaging in a brief mindfulness exercise may enhance performance on the Color Word Stroop, neutral Stroop, and emotional Stroop. Participants in the current study were 201 students (139 female), mean age 19.7 years (*SD*=1.4) from a Midwestern university, who were randomly assigned to listen to a 9- minute mindfulness exercise, progressive muscle relaxation (PMR) exercise, or interview control condition before completing the Color-Word Stroop, Neutral Stroop, and Emotional Stroop. Preliminary analysis reveal that participants generally had positive attitudes toward mindfulness and many had experience engaging in mindfulness activities. Attitudes and mindfulness experience were correlated with trait mindfulness, however, the brief mindfulness exercise did not appear to induce changes in state mindfulness and heart rate among participants in the mindfulness group. There were no differences between conditions with regard to accuracy on all color-word Stroop, neutral Stroop, and emotional Stroop tasks. Additionally, no differences were found for reaction time on incongruent, neutral, and emotional Stroop tasks. However, participants in the PMR group had slower reaction times on both the congruent and control trials on the Color-Word Stroop. The PMR group members experienced a greater decrease in distress and smaller increase in negative emotions compared to participants in the other conditions. There were no group differences in changes in positive affect. Limitations and directions for future research are discussed.

Keywords: mindfulness, reaction time, Stroop, emotional Stroop, emotional well-being

CHAPTER I

INTRODUCTION

Mindfulness has become increasingly popular in mainstream culture, with Google searches related to mindfulness increasing more than 400% since 2004 (Google Trends). Research interest in mindfulness has also surged (Davis & Hayes, 2011). Mindfulness has been defined as "paying attention in a particular way: on purpose, in the present moment, and non-judgmentally" (Kabat-Zinn, 1994, p. 4). This allows one to be less reactive and more intentional in responding to internal and external events (Didonna, 2009).

Much of the research on mindfulness has focused on health-related outcomes, including emotional well-being (Davis & Hayes, 2011) and psychopathology (Baer, 2003). Significantly less research has investigated the effects of mindfulness interventions on cognitive performance, such as attention (Watier & Dubois, 2016). The parallel distributed processing model (PDP; Rumelhart, Hinton, & McClelland, 1986) provides a potential explanation of how mindfulness may improve attention, especially when one is confronted with threatening or emotionally-relevant information.

Attention and Emotion Processing

The PDP model has been used to explain the relationship between attentional bias and emotion (Williams, Mathews, & MacLeod, 1996). The PDP model assumes that information processing occurs via a network of connected modules (Rumelhart et al., 1986). Within each module are processing units that collect input from other units and continuously adjusts output accordingly. Information is represented as a pattern of activation of the units in a module. Processing occurs when activation spreads from one module to another through the intra- and inter-connections of modules. The speed and accuracy of a task is dependent on the strength of a processing pathway. Interactions between processes occur when two different pathways require the use of a common module, referred to as an intersection of pathways. If the pattern of activation at the point of intersection is different, impairment of one or both pathways will occur, also referred to as interference. If the patterns of activation are similar, facilitation will occur. Attentional control can prevent interactions by controlling the flow of information along a pathway.

The PDP model may explain why the activation of emotionally salient stimuli may be more pronounced than neutral stimuli, as threat-related input units may be under neuromodulatory control which affect responsiveness. Therefore, despite other task demands, emotional salience of concern-related stimuli may have greater activation levels and stronger pathways. Thus, although an individual may make attempts to prevent attending to the emotionally salient input, the intensity of the stimuli may override preventative measures and information will flow along the pathway anyway.

Attentional bias is considered to be a causal and maintenance factor of emotional disorders (Williams et al., 1996). Emotional disturbances lead to increases in the salience of certain stimuli, which serve to increase the estimate of danger and further increase emotional disturbance. This further strengthens those pathways and increases baseline activation. One example of emotionally salient and threat-related stimuli is emotionally valenced words. According to the PDP model, stimuli such as words that have an emotional charge, especially when they are threat relevant, would have higher activation levels and stronger pathways than neutral words. Therefore, even if effortful attention is being allocated elsewhere, the pathway will still be activated. An applied example of this phenomenon is the emotional Stroop task.

The Stroop Test

In his classic dissertation, Stroop (1935) investigated inhibition of automatic processes by having participants name the color of the print of consistent (e.g., the word "blue" printed in blue ink) and inconsistent color names (e.g., the word "blue" printed in red ink). It was determined that reading the word (e.g. "blue") was a more automatic process than naming the color (e.g. red) and therefore the difference in reaction time to name the color words printed in black ink and naming the color of ink of color words printed in different represented the interference of the more automatic process of reading, thus requiring the participants to inhibit the more automatic process. This effect has not been found in younger children, for whom the process of reading has not yet become automatic, and the preference to perceive color over form (Arochova, 1971).

The Stroop test is thought to measure interference created by the more automatic processing of language due to the competing stimuli of word meaning and color, and, in order to perform the task, participants must suppress distraction from irrelevant, albeit competing, stimuli. When the color words are replaced by non-competing words, i.e., words with no association with color; in theory, there should be little effect on performance (Dawkins & Furnham, 1989). This is supported by research using 'neutral' words (Dawkins & Furnham, 1989; Hintzman et al., 1972).

The concept of the Stroop test has been extended to color naming of specific threat words as part of an emotional Stroop test. The first emotional Stroop test, called the Spider Stroop, was designed using spider related words administered to participants with spider phobias (Watts, McKenna, Sharrock, & Trezise, 1986). In this initial study, the results revealed that having a spider phobia greatly increased reaction time to color naming of spider words, but not on the original Stroop color-word task or on a task with general threat words. Additionally, once treated using desensitization, interference due to spider related words decreased. While the Spider Stroop was modeled on the original Stroop test, the authors do not claim that the effects in this study are due to the same mechanisms, specifically response competition, as the original Stroop. The authors suggest this phenomenon may result from difficulty maintaining attention to the relevant stimuli.

The emotional Stroop test is one of the most frequently used measures of selective attention to emotionally relevant stimuli (Williams et al., 1996). Many studies suggest color naming interference for personally relevant concerns. Additionally, studies have demonstrated that color naming of negatively-valenced emotional words (e.g., *embarrassed, disease, assault, lonely*) deteriorated in people who have emotional disturbances above and beyond the attentional bias for personally relevant concerns. This method has been used across a range of different psychopathologies, including anxiety and depression (for a comprehensive review on the use of the emotional Stroop test with anxiety and depressive disorders, see Williams et al., 1996). From this point forward, references to the Stroop test will be used to describe the original color-word administration procedure; whereas, references the emotional Stroop will be used to describe the version that includes emotionally-valenced words.

The PDP model has been applied to explain the results of the emotional Stroop. Specifically, attentional bias of personally relevant concerns can be explained by differences in resting activation of associated input units. Additionally, the added interference for persons with emotional disturbances may result from neuromodulatory control of input units associated with threat. Mindfulness may provide one way of reducing activation of threat-related input, by lessening reactivity to emotional stimuli and increasing attention.

Mindfulness

Various models of mindfulness have been offered to explain the facets, correlates, and outcomes of mindfulness. A two-component model of mindfulness has been proposed, consisting of self-regulation of attention and orientation to experience (Bishop et al., 2004). Self-regulation of attention refers to the ability to maintain awareness on present moment experiences. This involves the ability to switch one's focus between objects and inhibit secondary processing of thoughts, feelings, and sensations. Orientation to experience refers to a curiosity about and acceptance of one's experience. Therefore, a mindful disposition allows one to view thoughts and feelings as temporary occurrences rather than as a reflection of the oneself or reality, thereby allowing disengagement from negative thoughts and feelings. This mindful stance contrasts with many psychopathologies that involve avoidance and/or rumination of negative private experiences. For example, an anxious person may vacillate between avoidance of thinking upcoming potentially anxiety-provoking events and perseverating on them, which can serve to maintain and increase anxiety (Borkovec, Shadick, & Hopkins, 1991; Wells, 1999). Similarly, depressive rumination can be viewed as an attempt to change perceived faults (Pyszcynski & Greenberg; 1987) which worsens depressive affect and can lead to a major depressive episode (Tesdale & Bernard, 1993). Thus, mindful acceptance of these private experiences allows one to limit the impact of and reaction to thoughts and feelings.

Another model suggests the three mechanisms of action underlying mindfulness include intention, attention, and attitude (IAA; Shapiro, Carlson, Astin, & Freedman, 2006). Intention refers to the reasons for engaging in mindfulness. Attention represents observing one's internal and external experiences. Lastly, attitude refers to the qualities of attention, specifically, a compassionate, non-judging curiosity and interest. These elements are thought to occur simultaneously and do not represent separate processes or stages. Together, they represent a cyclical process that leads to a shift in perspective that is thought to be a meta-mechanism of action, called reperceiving. Reperceiving represents a continual process of more objectively observing internal experiences. Mindfulness perpetuates this process. This model differs from the previous model with the focus on intention, which is not included in Bishop et al.'s (2004) model.

Cognitive Benefits of Mindfulness

Mindfulness may have the potential to enhance cognitive performance, specifically within the areas of memory, attention, problem solving, and academic achievement (Benson, et al., 2000; Bonamo, Legerski, & Thomas, 2014; Mrazek, Franklin, Phillips, Baird, & Schooler, 2013; Ostafin & Kassman, 2012). Research suggests that mindfulness may improve performance in these areas through its effects on attention and memory, specifically, by enhancing task-related attention despite distractions (Sarason, Pierce, & Sarason, 1996; Shao & Skarlicki, 2009; Vroom, 1964).

Mindfulness has been associated with many aspects of attention, including selective attention (Chiesa, Calati, & Serretti, 2011; Jha, Krompinger, & Baime, 2007), executive attentional control (Chan & Woollacott, 2007; Chiesa et al., 2011; van den Hurk, Giommi, Gielen, Speckens, & Barendregt, 2010; Zeidan, Johnson, Diamond, David, & Goolkasian, 2010), sustained attention (Chiesa et al., 2011; MacLean et al., 2010), non-directed attention (Anderson, Lau, Segal, & Bishop, 2007), and attentional readiness (Jha et al., 2007). Moore and Malinowski (2009) suggested that mindfulness may lead to enhanced cognitive flexibility, accuracy, and efficiency in attention-based tasks. Mindfulness may enhance cognitive flexibility through acceptance, or nonjudgmental awareness. This refers to a specific mindset that encourages the recognition of stimuli without automatically responding to stimuli. This aspect of mindfulness may lead to increased cognitive flexibility and novel, non-automatic responding (Moore & Malinowski, 2009).

The Stroop task has been used as one way to investigate the cognitive effects of mindfulness. Researchers found that a seven-week combined goal management and mindfulness treatment was superior to standard treatment of persons with addictions in regard to improved response inhibition abilities measured by the Stroop (Alfonso, Caracuel, Delgado-Pastor, & Verdejo-Garcia, 2011). Other studies have found increased performance on the Stroop for experienced meditators compared to controls (Chan & Woollacott, 2007; Moore & Malinowski, 2009). Zylowska et al. (2007) found improvements in Stroop performance in adults and adolescents with ADHD after an 8-week mindfulness training program.

Teper & Inzlicht (2012) investigated the effects of meditation practice on executive control and emotion acceptance, using EEG to measure anterior cingulate cortex (ACC) activity while the participants completed the Stroop task. The researchers also measured error-related negativity (ERN), which is a neurophysiological response generated by the ACC within 100ms of making an error. The results indicated that meditators had a higher ERN amplitude, suggesting that, possibly due to their increased emotional awareness, they have improved executive functioning. Additionally, the executive control benefits were more related to affect than attention. Mindful participants also made less errors in the Stroop task, and this was related to greater mindful acceptance. These results indicate that meditation may improve executive functioning though the acceptance of emotions.

The observe aspect of mindfulness, as measured by the Kentucky Inventory of Mindfulness Skills (KIMS), has been associated with enhanced performance on the Stroop (Galla, Sigi Hale, Shrestha, Loo, & Smalley, 2012). These results suggest that the non-judgmental awareness facet of mindfulness may enable more adaptive responding by preventing automatic behaviors. In terms of the Stroop task, this would enable the respondent to inhibit the automatic response of word reading and facilitate color naming. Another study suggests that the describe aspect of mindfulness, as measured by the Five Facet Mindfulness Questionnaire (FFMQ) was associated with lower Stroop interference, however, no differences were found between experienced meditators and non-meditators on Stroop performance (Josefsson & Broberg, 2011).

Not all studies have found enhanced Stroop performance after a mindfulness intervention. An 8-week Mindfulness-Based Stress Reduction (MBSR) course did not show improvements in Stroop performance compared to a control group (Anderson, Lau, Segal, & Bishop, 2007). A three-hour instruction in mindfulness followed by a 16-week at-home practice with at least 10 minutes of mindfulness meditation per day at least five days per week was compared to a wait-list control on Stroop performance (Moore, Gruber, Derose, & Malinowski, 2012). Results revealed no differences in Stroop performance; however, the mindfulness group was associated with increased FFMQ scores and improved electrophysiological markers of attentional control. Therefore, although some studies have noted links between mindfulness and enhanced performance on the Stroop and mindfulness (Holzel et al., 2011; Kang, Gruber, & Gray, 2013; Malinowski, 2013; Moore et al., 2012; Moore & Malinowski, 2009), these findings have not consistently been replicated and require further investigation.

Emotional Benefits of Mindfulness

Mindfulness has also been shown to have emotional benefits as well. Researchers De Raedt et al. (2012) investigated the effects of Mindfulness-Based Cognitive Therapy (MBCT) on facilitation and inhibition of attention for positive and negative information. The participants in this study had a previous diagnosis of depression who engaged in MBCT and a comparison group of participants who had a previous diagnosis of depression but did not receive MBCT. Using the Negative Affective Priming task, the researchers presented two pictures: a target and a distracter picture consisting of positive, negative, or neutral expressions, and were asked to categorize the emotional valence of the target picture. The results revealed that lower mindfulness was related to facilitation of attention for negative stimuli and increased severity of depressive symptoms, whereas higher mindfulness was related to less inhibition of attention for positive information.

Over the course of MBCT, facilitation for negative information and inhibition for positive information was reduced, indicating that those who received mindfulness training were more open to all emotional information.

Levitt, Brown, Orsillo, and Barlow (2004) investigated panic disorder participants' response to a biological challenge consisting of inhaling carbon dioxide-enriched air (CO_2 challenge) which seeks to mimic the interoceptive cues in panic disorder. Participants were assigned to an emotional acceptance, emotional suppression, or a neutral control group. The emotional acceptance group reported significantly lower anxiety during the CO_2 challenge compared to the other groups. Emotional acceptance participants were also more willing to participate in an additional CO_2 challenge. A similar study conducted by Eifert and Heffner (2003) compared breathing retraining, emotional acceptance, and inactive control conditions on a CO_2 challenge for participants who scored high on a measure of anxiety sensitivity. The emotional acceptance condition reported less fear, reduced catastrophic thoughts, and lower behavioral avoidance than the other conditions. These studies suggest that mindful acceptance of emotions may be a useful strategy for reducing anxiety and avoidance during physiological arousal.

Waters et al. (2009) used an emotional Stroop test to investigate the ability of participants who are trying to quit smoking to disengage attention from smoking or affective stimuli. Three emotional Stroop tests consisted of smoking words (e.g., cigarette) and neutral words, anxiety words (e.g., stressed) and neutral words, and depression (e.g., sad) and neutral words. The authors found no evidence that more mindful individuals were better able to disengage from problematic stimuli.

Sauer et al. (2011) used an emotional Stroop test, among other methods, to investigate whether the acceptance facet of mindfulness resulted in less emotional behavior as measured by reaction time on the emotional Stroop and ratings of the emotional valence of words. Results revealed that the acceptance facet of mindfulness was positively associated with a more positive emotional valence when rating words, however, contrary to expectations, the presence facet was related to faster reaction times and lower error rates in the emotional Stroop task. Therefore, aspects of mindfulness may play different roles in emotion regulation. The authors suggest that future research investigate the effect of manipulating state mindfulness levels on emotional behavior.

Another study found benefits to emotional Stroop performance and addressed one of the limitations of the previous study. Allen et al. (2012) compared performance on an affective Stroop in a 6-week meditation and active control (group reading) conditions. The affective Stroop consisted of positive, negative, or neutral images presented after a congruent or incongruent number-counting task. The pictures are designed to serve as distractors and interfere with performance by accessing affective-cognitive resources. Results revealed decreased affective Stroop conflict for the mindfulness condition. The researchers stressed the importance of using an active control condition in future mindfulness training research.

While most studies have found effects of mindfulness on emotional Stroop performance, some have not. Lykins, Baer, and Gottlob (2012) compared experienced meditators with demographically matched controls on measures of attention and memory, including the Stroop and the emotional Stroop test. The emotional Stroop task consisted of responding to the color of neutral words, then emotional words. No differences were found between groups on either the Stroop or emotional Stroop. However, the study by Lykins and colleagues failed to include a measure of state mindfulness, making it unclear whether changes in state mindfulness may have contributed to these findings.

Physiological Indicators

Studies investigating physiological indicators during Stroop performance have found increased heart rate among individuals engaging in the task, which may reflect heightened arousal, stress, or even anxiety associated with the task (Bremner et al., 2004; Renaud & Blondin, 1997; Silva & Leite, 2000). Others have found increased skin conductance (Eilola & Havelka, 2010; Silva & Leite, 2000). Alternatively, studies on physiological indicators of mindfulness have found decreased blood pressure and blood pressure reactivity, decreased skin conductance, increased heart rate control, and increased pain tolerance (Campbell-Sills, Barlow, Brown, & Hofmann, 2006; de la Fuente, Franco, & Salvator, 2010; Delizonna, Williams & Langer 2009; Ditto, Eclache, & Goldman, 2006; Kingston, Chadwick, Meron, & Skinner, 2007; Nyklicek et al., 2013; Zeidan, Johnson, Gordon, & Goolkasian, 2010). Although some studies have failed to replicate these findings (Erisman & Roemer, 2010), fluctuations in physiological indicators are thought to accompany changes in statement mindfulness. Therefore, physiological reactivity may be an important consideration when monitoring links between mindfulness and Stroop performance.

Brief Interventions

The majority of mindfulness research uses experienced meditators or mindfulness trainings which typically last 8 weeks or longer (e.g., Benson et al., 2000; Lykins et al., 2010; Roberts-Wolfe, Sacchet, Hastings, Roth, & Britton, 2012; Zylowska et al., 2008).

Fewer studies have investigated the effects of a single, brief mindfulness exercise. One such study compared emotional Stroop performance in 20-minute mindful-breathing, music-assisted relaxation, and thought wandering conditions in a sample of participants with elevated generalized anxiety symptoms (Lee & Orsillo, 2014). Results revealed improved performance in the mindful compared to the thought wandering condition, but not the relaxation condition. However, the mindfulness induction did not significantly increase state mindfulness as measured by the self-report Mindful Attention Awareness Scale – State Version. Limitations of this study include a small sample size (N = 63) which may have been insufficient to produce significant results. Furthermore, the results are not generalizable due to the analog sample of generalized anxiety disorder that was collected. Additionally, due to the nature of the relaxation control group, the exercise may have unintentionally elicited mindfulness skills similar to the experimental group; specifically, focused attention on the present moment, in this study, music.

Another study compared a 10-minute mindful breathing and mindful awareness of emotions exercise, attention exercise, and arithmetic exercise on state mindfulness, emotional Stroop, and recognition memory (Watier & Dubois, 2016). They also investigated whether trait mindfulness moderated these effects. Results revealed that the mindfulness and attention conditions were effective at increasing levels of self-reported state mindfulness and this effect was not moderated by self-reported trait mindfulness. While there was an effect of the mindfulness exercise on emotional interference compared to the attention exercise, trait mindfulness was found to be a moderator of this effect; specifically, only those low in trait mindfulness experienced benefits of a mindfulness exercise. The researchers suggest that those low in trait mindfulness may have more to gain from a brief mindfulness exercise than those who are high in trait mindfulness. The researchers suggested that future research investigating the effects of a brief mindfulness exercise should include trait mindfulness as a covariate. Additionally, the researchers did not control for mood and anxiety symptoms, which can affect emotional Stroop performance. This study was primarily composed of female participants; therefore, future studies are suggested to investigate these effects with male participants. It was also suggested that future studies use alternative control conditions.

Current Study

Limited research has assessed the effects of state mindfulness on emotional attention. The current study intends to fill this gap by inducing a mindful state in participants using a single, brief mindfulness exercise. This study also used an active control condition, which other studies have lacked (Bonamo, Legerski, & Thomas, 2014; Chiesa & Malinowski, 2011; Erisman & Roemer, 2010). This study also sought to address the limitations of Watier & Dubois (2016) and Lee & Orsillo (2014). Specifically, a sufficient sample of males and females will be investigated, a relaxation exercise that does not specify enhanced attention was used as an active control, and trait mindfulness, anxiety, and depressive symptoms were used as covariates. Also, in addition to self-report measures of state mindfulness, physiological indicators were used as a validity check.

The current study sought to investigate the cognitive and emotional effects of a brief mindfulness exercise on participants' performances on the classic Color Word Stroop, a neutral Stroop task, and an emotional Stroop task. An associated goal was to monitor variability in heart rate, self-report positive and negative affect, and levels of distress before and after this exercise. The hypotheses in this study included:

1. Participants who receive the mindfulness exercise condition would show improved performance, specifically, faster reaction times and decreased errors, on all tasks as compared to the relaxation and control groups due to the cognitive benefits of mindfulness. Based on findings from previous research (Bonamo et al., 2014), we predicted these improvements in performance would coincide with differences in state mindfulness across the three groups, with state mindfulness showing an increase for those in the mindfulness condition and not changing among participants in the remaining conditions.
2. The mindfulness intervention would buffer against the effects of negative emotionality on the Emotional Stroop task, resulting in faster reaction times and decreased errors, due to the emotional benefits of mindfulness.
3. Heart rate was used as a validity check of the mindfulness intervention, as previous studies have shown an increase in heart rate as a result of Stroop task demands, while mindfulness interventions are associated with lower heart rate. Therefore, it is hypothesized that the control conditions would have higher heart rates after the Stroop tasks than the mindfulness conditions.
4. It is expected that those in the mindfulness group would experience an increase in positive emotions and a decrease in negative emotions, while the control group will remain the same, as previous research suggests that mindfulness interventions improve well-being (Alberts & Thewissen, 2011; Roberts-Wolfe, Sacchet, Hastings, Roth, & Britton, 2012).

5. Finally, it was hypothesized that mindfulness would help to buffer against the effects of distress elicited by the Stroop tasks. Therefore, it was expected that those in the mindfulness group would experience a smaller change in levels of distress compared to the control group, as previous research has shown decreases in anxiety following a mindfulness intervention (Beauchemin, Hutchins, & Patterson, 2008). Also, it is suggested that mindfulness invokes a relaxation response, which enables individuals to better cope with stressors (Benson et al., 2000).

CHAPTER II

METHOD

Participants

After receiving approval from the Internal Review Board at a Midwestern University, participants were recruited from the undergraduate research pool that included students from various psychology classes taught on campus. The study was described to students as an investigation of whether relaxation can improve reaction times. Potential participants were informed that the study would include answering survey questions about identity, emotions, attitudes, and behaviors, recording heart rate, listening to a recording, and completing a reaction time task. No initial description of the study mentioned the term mindfulness in an effort to minimize sampling bias. Colorblindness was the only exclusion criteria used in the study.

Participants were 201 undergraduate students (139 female, 62 male) from a Midwest university recruited from various psychology classes. The majority identified as cis-gender (N=200). The mean age of participants was 19.7 (*SD*=1.4), with a range of 18-29 years. Thirty participants did not disclose their age. Participants were primarily non-Hispanic White (81.8%), followed by Hispanic White (7.9%), Asian and multi-racial (both 2.5%), Black or African American (2%), Native American or Alaska Native (1.5%), Native Hawaiian or Pacific Islander (0.5%), and Other (0.5%). Two participants did not indicate their ethnicity. One participant was excluded after being identified as being color blind. Participants received class credit or extra credit for their participation

Objective Measures

Color Word Stroop. Participants were asked to identify the color of color words (e.g., red, blue, green, yellow) or rectangles consisting of 84 total trials. Trials consisted of congruent, incongruent, and control stimuli. Congruent trials are characterized by a color word presented in the same color font (e.g., "blue" presented in blue font). Incongruent trials consist of a color word presented in a different color font (e.g., "blue" presented in red font). Control trials consist of a colored rectangle. Trials were presented on a computer screen using InquisitWeb. Participants selected their response using assigned keys on the keyboard. Seven trials for each congruent, incongruent, and control categories were randomly presented for each color. Number of errors and reaction time for each type of trial was measured. Reaction time is defined as the time period between the onset of a stimulus and the time the participant pressed the button.

Neutral Stroop. Participants were asked to identify the color of 40 neutral words (e.g., field). The study's principal investigator selected the words for the neutral Stroop using Whissell's Dictionary of Affect in Language (DAL), which provides words that have been rated on their pleasantness, activation, and imagery (Whissell, 2009). Based on pleasantness rating, words were selected to approximate the mean, thus neither pleasant nor unpleasant. Number of errors and reaction time were measured for each participant.

Emotional Stroop. Participants were asked to identify the color of 40 negatively valenced words (e.g., "death") presented on a computer screen. Similar to the section process used for identifying the neutral terms, words were selected using DAL to minimize pleasantness ratings (Whissell, 2009). Number of errors and reaction time were measured for each participant.

Neutral and negatively valenced words were significantly different on pleasantness ratings, $t(78) = 13.331$, $p = .000$. Words were also compared using the English Lexicon Project (Balota et al., 2007). There were no significant differences between neutral and negatively valenced words for length, $t(78) = -0.340$, $p = .735$, frequency, $t(78) = 1.701$, $p = .095$, syllables, $t(78) = -1.075$, $p = .285$, and lexical decision reaction time, $t(78) = .127$, $p = .899$.

Finger Pulse Oximeter. Heart rate (beats per minute) will be measured using a finger pulse oximeter, which has been used in previous studies (Gosselin et al., 2016; Paul et al., 2013). Heart rate as measured by the oximeter (Deluxe Fingertip Pulse Oximeter, Model IP900AP, Innovo Medical, Stafford TX) was obtained for a baseline period, immediately following the recording, and immediately following the Stroop tasks, which is similar to other studies (Feldman et al., 2014; Prinsloo et al., 2010).

Ishihara Test. The Ishihara test is the most commonly used screening for red-green color deficiency (Birch, 1997). It has demonstrated high sensitivity (97.7% when using the 3-error cutoff; Birch, 2010). The 14 plate edition of the Ishihara test was used to screen participants for color-blindness prior to participation in this study. The 14 plate edition has been shown to successfully predict passing the Farnsworth Lantern test used in the Navy (Hackman, Holtzman, & Walter (1992). Participants were determined to have normal color vision if they correctly identified 10 or more of plates 1-11, as stated in the manual (Ishihara, 1995).

Recordings

Mindful Breathing and Awareness of Emotions. A mindful breathing exercise has been shown to increase decentering (Feldman, Greeson, & Senville, 2010) which may be an effective way to disengage from thoughts and actions (Keng, Smoski, & Robins, 2011). Additionally, a concentrative practice, such as focus on the breath, has been suggested as an easier approach to mindfulness for novices (Chiesa et al., 2011). A 9-and-a-half-minute mindful breathing and awareness of emotions exercise, as used in Watier & Dubois (2016), was used for the mindfulness intervention.

Progressive Muscle Relaxation (PMR). Progressive muscle relaxation is a stress management technique that has been used as an active control condition in previous studies (Feldman et al., 2010; Ditto et al., 2006). A PMR exercise will be used for the active control group, publicly available from the McKinley Health Center (http://mckinley.illinois.edu/health-education/stress-management/relaxation-techniques/relaxation-exercises). It was edited for length to match the mindfulness recording.

Control. An interview with a mindfulness researcher was used as the inactive control condition, publicly available from NPR (https://www.npr.org/2012/08/02/157809852/ mindfulness-using-your-brain-to-beat-stress). In this interview, Dr. Ellen Langer discussed studies she has conducted evaluating the effectiveness of mindfulness. It was edited for length to match the other recordings.

Self-Report Measures

Perceived Stress Scale (PSS). The PSS is a 14-item self-report measure that measures the extent to which events within the past month in a person's life are perceived as stressful (Cohen, Kamarck, & Mermelstein, 1983). This scale is used to determine trait stress and is assessed on a five-point Likert-type scale (1 – "Never" to 5 – "Very often").

An example item is, “In the past month, how often have you felt nervous and ‘stressed’?” Cronbach’s alpha reliability for the 14 item PSS in this study is .84.

Subjective Units of Discomfort Scale (SUDS). The SUDS is a frequently used one-item scale, which measures the participant’s subjective level of distress, originally evaluated on a 100-point scale (0 – “Feeling completely calm with no anxiety” to 100 – “The most extreme anxiety you’ve ever felt,” Wolpe, 1958).

Positive and Negative Affect Schedule (PANAS). The PANAS is a frequently used, 20-item scale that measures participants’ current mood states (Watson, Clark, & Tellegen, 1988). Items are assessed on a five-point Likert-type scale (1 – “Very slightly or not at all” to 5 – “Extremely”). Cronbach’s alpha reliability in the present study was .75 and .78 for the negative items pre- and post-intervention, respectively, and .89 and .92 for the positive items, pre- and post-intervention, respectively.

Barkley Current Symptoms Scale (BCSS) Self-Report Form. The BCSS is a rating scale used to assess attention deficit hyperactivity disorder (ADHD) symptoms (Barkley & Murphy, 2006) but was used in this study to assess for general attention problems, not to diagnose ADHD. It consists of 18 items, nine of which assess inattention, six assessing hyperactivity, and three items assessing impulsive symptoms. The scale uses a four-point Likert-type scale (0 – “Never or rarely” to 3 – “Very often”). An example item is, “I fail to give close attention to details or make careless mistakes in my work.” Cronbach’s alpha reliability in this study was .88.

Toronto Mindfulness Scale (TMS). The TMS is a state measure of mindfulness that is used to assess differences in state mindfulness between groups (Lau et al., 2006). It is a 13-item self-report measure of statements of mindful experiences rated on a 5-point scale from 0 ("Not at all") to 4 ("Very much"). An example item is, "I was curious about each of the thoughts and feelings that I was having." TMS had high internal consistency reliability in this study .93.

Five Facet Mindfulness Questionnaire (FFMQ). The FFMQ is a trait measure of mindfulness that is included to account for differences in experience and trait mindfulness. It is a 39-item self-report measure of statements rated from 1 ("never or very rarely true") to 5 ("always true") related to facets of mindfulness including observing, nonreactivity, nonjudging, describing, and acting with awareness (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006). A sample item is, "I perceive my feelings and emotions without having to react to them." Internal consistency for the total scale was .86 in this study.

Center for Epidemiological Studies Depression Revised (CESD). The CESD is a 20-item self-report measure of depressive symptoms evaluated on a five-point scale from 0 ("Not at all or less than 1 day") to 4 ("Nearly every day for 2 weeks;" Eaton, Smith, Ybarra, Muntaner, & Tien, 2004). An example item is "Nothing made me happy." Chronbach's alpha reliability in this study was .92.

NIH Toolbox Fear-Affect Short-Form (FASF). This is a 7-item self-report measure of anxiety symptoms rated on a 5-point scale from 1 ("Never") to 5 ("Always," Gershon et al., 2013). An example item is "I felt worried." Internal consistency reliability in this study was high .93.

An additional demographics questionnaire was included, consisting of self-report questions regarding age, sex, ethnicity, number of hours of sleep the previous night, and number of servings of caffeine consumed during the current day. Participants were also asked to rate their experience with mindfulness ("How much experience do you have with mindfulness?") on a scale from 1 ("Not at all") to 5 ("A great deal"). They were also asked to rate their attitudes toward mindfulness ("What are your attitudes toward mindfulness?") on a scale from 1 ("Extremely Negative") to 5 ("Extremely Positive"). They were asked to select all activities they had engaged in, including yoga, meditation, mindfulness, Tai Chi, Mindfulness Based Stress Reduction, and Mindfulness Based Cognitive Therapy. There were also options to select "None of the above" and "other" in which they had the option to write-in a response.

Procedure

Informed consent procedures were completed with all participants. They then were screened for color-blindness using the Ishihara plates. Participants who passed the color-blindness screening completed the demographics questionnaire. A finger pulse oximeter measured baseline values of heart rate and oxygen saturation. Next, participants completed the CESD, FASF, BCSS, PANAS, PSS, SUDS, and FFMQ. Following the completion of the self-report measures, the participants were randomly assigned to one of three groups using Qualtrics randomize function. Participants in group 1 (experimental) listened to the 9-minute mindful breath and emotions exercise. Participants in group 2 (active control) listened to the 9-minute progressive muscle relaxation exercise. Participants in group 3 (inactive control) listened to an 8-and-a-half-minute recording of an interview with a mindfulness researcher. Following the intervention, pulse and oxygen saturation measurements were recorded. The participants then completed 200 practice items to familiarize them with the colors and corresponding keys on the keyboard. The Stroop, neutral Stroop, and emotional Stroop were completed on a computer. The order was counterbalanced across participants. The final pulse and oxygen saturation measurements were recorded. Lastly, the participants completed the SUDS, TMS, and PANAS.

CHAPTER III

RESULTS

Mindfulness Experience and Attitudes

The majority of participants (52%) in this study had at least “Moderate” experience with mindfulness. Less than 20% of participants reported no experience with mindfulness and indicated that they had not engaged in any of the mindfulness activities listed. The modal number of mindfulness activities engaged in was one (43.3%). 35.8% of participants endorsed engaging in two or more mindfulness activities. The most common mindfulness activity endorsed was yoga (70.1%), followed by meditation (35.3%), mindfulness (12.4%), Mindfulness Based Stress Reduction (3%), and Tai Chi and Mindfulness Based Cognitive Therapy (both 1.5%).

The majority of participants also had “somewhat positive” (47.2%) or “extremely positive” (15.9%) attitudes toward mindfulness. 35.3% of participants had “neither positive nor negative” attitudes toward mindfulness, and 0.5% had “somewhat negative” attitudes toward mindfulness.

Bivariate Correlations

Bivariate correlations were conducted to investigate relationships among variables (Tables 1 & 2). Contrary to expectations, condition was not correlated with any of the outcome variables: Color Word Stroop performance, Emotional Stroop performance, Neutral Stroop performance, state mindfulness, distress, positive and negative emotions, and heart rate. Also unexpected was that anxiety and depressive symptoms were not

Table 1. Correlations between demographic variables and covariates.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Age	1.00																	
2. Sex[a]	-.27**	1.00																
3. Ethnicity[b]	0.09	0.10	1.00															
4. Sleep	0.00	0.09	-0.03	1.00														
5. Caffeine	-0.06	0.01	-0.03	-0.11	1.00													
6. MindExp	-0.06	.20**	-0.08	-0.03	0.06	1.00												
7. MindAtt	-0.04	.28**	0.07	-0.01	0.01	.48**	1.00											
8. MindAct	0.01	.34**	0.05	0.04	0.01	.34**	.41**	1.00										
9. CESD	0.06	0.02	0.08	-.14*	0.13	-0.03	0.04	0.04	1.00									
10. FASF	0.02	.17*	0.12	-0.05	0.13	-0.01	0.09	0.11	.66**	1.00								
11. PSS	0.02	0.10	0.13	-0.01	0.06	-0.06	0.05	0.10	.59**	.60**	1.00							
12. BCSS	0.00	-0.01	0.00	-0.03	-0.07	0.10	0.10	0.07	-0.02	-0.02	-0.10	1.00						
13. FFMQ-O	-0.01	0.04	0.07	-.23**	0.09	0.12	.25**	.19**	.15*	.17*	-0.06	0.01	1.00					
14. FFMQ-D	-0.12	0.12	-0.06	-0.04	0.13	.17*	.24**	.16*	-.29**	-.31**	-.43**	0.02	.16*	1.00				
15. FFMQ-A	0.06	-0.09	-.16*	-0.11	-.14*	0.13	-0.02	0.01	-.49**	-.44**	-.50**	0.10	-.16*	.34**	1.00			
16. FFMQ-J	-0.10	-0.05	-.26**	0.09	-0.02	0.11	-0.04	0.07	-.56**	-.56**	-.56**	.149*	-.22**	.42**	.55**	1.00		
17. FFMQ-R	-0.09	-0.07	-0.08	-.19**	0.03	.14*	0.09	-0.10	-.16*	-.19**	-.42**	0.11	.38**	.40**	0.08	.15*	1.00	
18. FFMQ	-0.09	-0.02	-.17*	-.14*	0.03	.22**	.16*	0.12	-.47**	-.46**	-.66**	0.13	.35**	.76**	.62**	.68**	.62**	1.00

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
[a] Male = 1, Female = 2.
[b] White Hispanic = 1, White Non-Hispanic = 2, Black or African American = 3, American Indian or Alaska Native = 4, Asian = 5, Native Hawaiian or Pacific Islander = 6, Other = 7

Notes: MindExp – Minfulness experience, MindAtt – Attitude toward mindfulness, MindAct – Number of mindfulness activities engaged in, CESD – depressive symptoms, FASF – anxiety symptoms, PSS – perceived stress, BCSS – attention problems, FFMQ-O – Observe scale, FFMQ-D – Describe scale, FFMQ-A – Awareness scale, FFMQ-J – Judgment scale, FFMQ-R – React scale, FFMQ – trait mindfulness total score.

Table 2. Correlations between outcome variables, demographic variables, and covariates

	Age	Sex	Ethnicity	Sleep	Caffeine	MindExp	MindAtt	MindAct	CESD	FASF	PSS	BCSS	FFMQ	FFMQ-O	FFMQ-D	FFMQ-A	FFMQ-J	FFMQ-R	Condition
T1 Pos Emo	0.02	-.20**	0.05	-0.02	0.03	0.04	0.11	-0.04	-.15*	-0.13	-.18*	0.02	.17*	.16*	0.11	.15*	0.06	0.04	0.02
T1 Neg Emo	-0.06	-0.05	.19**	-0.03	0.06	-0.05	0.11	0.05	.44**	.43**	.36**	0.05	-.33**	0.13	-.20**	-.35**	-.36**	-.18**	0.01
T3 Pos Emo	0.11	-.18*	-0.05	-0.03	0.00	-0.02	0.08	-0.02	-0.02	0.05	-0.04	0.01	0.12	.24**	0.02	0.04	0.01	0.07	0.03
T3 Neg Emo	-0.03	0.06	0.00	0.04	.15*	0.07	.15*	0.13	.36**	.44**	.38**	0.01	-.24**	.18*	-.15*	-.28**	-.27**	-.18*	0.09
T1 SUDS	0.01	0.01	0.02	-0.12	0.11	-0.01	0.01	0.11	.34**	.34**	.43**	0.01	-.25**	0.01	-.15*	-.27**	-.18*	-.17*	0.04
T3 SUDS	-0.03	0.08	0.05	-0.06	.18*	0.02	0.00	0.07	.36**	.45**	.46**	-0.09	-.28**	0.02	-0.09	-.30**	-.22**	-.25**	0.06
T1 Pulse	-0.10	.17*	0.01	.14*	0.09	-0.11	-0.09	0.02	0.11	0.10	0.14	0.02	-0.11	-0.03	-0.02	-.16*	-0.03	-0.08	-0.07
T2 Pulse	-0.10	0.12	0.00	0.12	0.03	0.00	-0.03	-0.04	0.04	0.03	0.02	-0.04	-0.07	-0.08	-0.05	-0.08	0.00	-0.01	0.07
T3 Pulse	-0.15	.24**	-0.02	0.08	0.08	0.00	-0.04	0.01	0.07	0.11	0.07	-0.01	-0.07	-0.06	0.00	-0.10	-0.01	-0.02	0.01
TMS	-0.04	0.11	0.05	-0.06	-0.05	0.05	.32**	0.07	.20**	.21**	0.08	-0.05	0.00	.38**	0.01	-.24**	-.24**	.16*	-0.11
%Cong	-0.08	0.14	-0.02	-0.03	-0.07	0.02	-0.10	0.05	-.17*	0.02	-0.08	0.07	0.08	0.03	-0.02	0.05	0.09	0.09	-0.10
%Incong	0.03	0.01	-0.02	0.08	-0.05	0.07	0.06	0.03	-0.02	-0.01	0.13	-0.04	0.00	0.01	-0.04	0.05	0.04	-0.10	0.04
%Control	0.08	0.01	0.04	0.07	0.00	-0.03	-0.06	0.06	0.10	0.09	0.10	-0.12	-0.08	0.08	-0.10	-0.09	-0.08	-0.04	-0.11
MRT Congr	-0.01	0.03	0.10	-0.08	0.04	0.03	0.14	0.11	-0.04	0.04	-0.04	0.11	0.02	-0.06	0.10	-0.06	0.10	-0.04	-0.01
MRT Incong	-0.01	0.13	0.04	-0.06	0.03	0.03	0.07	0.12	-0.04	0.03	0.00	0.03	0.05	-0.05	.18*	-0.04	0.10	-0.09	-0.02
MRTControl	0.02	0.05	0.01	-0.01	-0.02	0.05	0.04	0.13	-0.07	-0.03	-0.09	0.09	0.05	-0.06	.15*	-0.04	0.10	-0.01	-0.12
%Neutral	-0.05	0.11	0.08	0.03	0.02	.14*	0.11	0.12	-0.08	0.08	0.07	-0.03	0.05	0.08	0.08	0.02	-0.01	-0.03	0.03
MRT Neutral	0.01	-0.02	-0.03	0.01	-0.02	-0.06	0.03	0.05	-0.02	0.07	-0.04	0.05	-0.03	-0.05	0.01	-0.01	0.06	-.15*	-0.-5
%Emotion	-0.01	0.03	0.08	0.04	-0.03	0.01	-0.06	0.12	-0.14	0.01	-0.06	0.03	0.04	-0.06	0.06	0.06	0.12	-0.10	-0.11
MRTEmotion	0.06	0.08	0.03	-0.11	0.05	-0.04	0.03	0.04	0.03	0.04	-0.02	0.01	0.00	-0.01	0.09	-0.08	0.03	-0.04	-0.11

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed). [a] Male = 1, Female = 2. [b] White Hispanic = 1, White Non-Hispanic = 2, Black or African American = 3, American Indian or Alaska Native = 4, Asian = 5, Native Hawaiian or Pacific Islander = 6, Other = 7 *Notes:* T1 = Baseline, T2 = Post-intervention T3 = Post-Stroop. Pos Emo – positive emotions, Neg Emo – negative emotions, MindExp – mindfulness experience, MindAtt – Attitudes toward mindfulness, MindAct – Number of mindfulness activities engaged in, CESD – depressive symptoms, FASF – anxiety symptoms, PSS – perceived stress, BCSS – attention problems, FFMQ – trait mindfulness, FFMQ-O – Observe scale, FFMQ-D – Describe scale, FFMQ-A – Awareness scale, FFMQ-J – Judgment scale, FFMQ-R – React sale, SUDS – distress, TMS – state mindfulness, % - percent correct, Cong – congruent trials, Incong – incongruent trials, Control – control trials, MRT – Mean reaction time correlated with performance on the Emotional Stroop, and attention problems was not correlated with performance on any of the Stroop tasks.

Trait mindfulness scores were positively correlated with mindfulness experience, attitudes toward mindfulness, positive emotions prior to the intervention; and negatively correlated with hours of sleep the previous night, depressive symptoms, anxiety symptoms, perceived stress, negative emotions prior to and after the intervention, and distress before and after the intervention. Trait mindfulness was also negative correlated with ethnicity, suggesting that trait mindfulness is lower in minority populations.

State mindfulness following the intervention was positively correlated with attitude toward mindfulness, anxious and depressive symptoms, perceived stress, negative emotions before the intervention, and positive emotions after the intervention. Depressive symptoms were positively correlated with anxiety symptoms, perceived stress, and negative emotions prior to and following the intervention. Depressive symptoms were negatively correlated with sleep, positive emotions prior to the intervention, and percent correct on congruent trials of the color Stroop. Anxiety symptoms were positively correlated with sex, perceived stress, negative emotions prior to and following the intervention, and distress prior to and following the intervention.

Attitudes toward mindfulness, mindfulness experience, and number of mindfulness activities engaged in were significantly correlated with sex. Specifically, females were more likely to have higher attitudes toward mindfulness, more experiences with mindfulness-based practices, and to have engaged in more mindfulness activities. Attitudes toward mindfulness and mindfulness experience were significantly correlated with trait mindfulness. Attitudes toward mindfulness was significantly correlated with state mindfulness after the intervention. Age was not correlated with any variables.

Pre-Analysis Data Screening

For missing data, such as not answering one question on a measure, mean substitution was used. This was done for less than 1% of the data. Data was inspected for outliers, which were recoded to the minimum or maximum acceptable value, depending upon the direction of the outliers. Outliers were present for all variables except baseline pulse, attitudes toward mindfulness, and TMS.

Following the adjustment of outliers, normality was assessed using the Kolmogorov-Smirnov statistic, examination of skewness and kurtosis values, and examination of histograms and Q-Q plots. In order to meet normality assumptions, square root transformations were applied to FFMQ, PANAS post-intervention positive emotions, and pre-intervention and post-intervention SUDS to correct for mild positive skew. Log 10 transformations were applied to FASF, CESD, PANAS pre- and post-intervention positive and negative emotions, mean reaction time for color congruent, incongruent, and control Stroop trials, and reaction time for emotional and neutral Stroop trials, in order to correct for moderate positive skew. Percent correct on the color Stroop control trials demonstrated moderate negative skew and was transformed using a reciprocal Log 10 transformation (See Table 3 for untransformed means and standard deviations).

Independence of covariates and condition was confirmed by running one-way ANOVAs. All covariates were independent of condition, $F_{\text{Sleep}}(2,197)=.054$, $p=.948$; $F_{\text{Caffeine}}(2,197)=.520$, $p=.595$; $F_{\text{CESD}}(2,197)=.642$, $p=.527$; $F_{\text{FASF}}(2,197)=.166$, $p=.848$;

$F_{PSS}(2,197)=.323$, $p=.724$; $F_{BCSS}(2,197)=.801$, $p=.451$; $F_{FFMQ}(2,197)=.488$, $p=.615$; $F_{MindAtt}(2,197)=.026$, $p=.974$; $F_{MindExp}(2,197)=.587$, $p=.557$.

Table 3. Untransformed Means for Dependent Variables and Covariates (with Standard Deviations in Parentheses)

Measure	Condition		
	Mindfulness	PMR	Control
Dependent Variables			
Color % Congruent	.98 (.03)	.98 (.02)	.97 (.03)
Color % Incongruent	.91 (.08)	.90 (.08)	.92 (.06)
Color % Control	.96 (.04)	.96 (.04)	.95 (.04)
Color MRT Congruent	863.39 (168.01)	942.35 (190.64)	859.37 (178.29)
Color MRT Incongruent	1101.68 (247.03)	1148.31 (264.41)	1080.38 (252.31)
Color MRT Control	910.22 (181.46)	932.42 (194.50)	851.26 (173.69)
Neutral %	95.55 (3.94)	96.10 (3.65)	95.70 (3.82)
Neutral MRT	747.59 (183.27)	774.51 (180.71)	729.63 (173.34)
Emotional %	96.25 (3.89)	95.55 (4.04)	95.25 (3.87)
Emotional MRT	826.96 (204.50)	829.32 (199.07)	778.14 (192.30)
T1 Pulse	79.16 (14.31)	79.28 (14.51)	77.20 (13.35)
T2 Pulse	75.05 (12.98)	77.58 (13.18)	77.11 (13.64)
T3 Pulse	74.89 (14.10)	77.31 (13.22)	75.06 (12.96)
T1 SUDS	27.32 (20.64)	33.81 (21.98)	29.51 (21.27)
T3 SUDS	25.00 (16.99)	27.60 (21.07)	28.01 (19.26)
T1 Positive Emotions	24.44 (7.80)	24.28 (7.39)	24.80 (8.16)
T3 Positive Emotions	22.97 (7.65)	23.70 (7.85)	23.48 (8.28)
T1 Negative Emotions	12.85 (2.76)	13.73 (3.45)	12.85 (3.24)
T3 Negative Emotions	16.13 (1.94)	16.25 (1.59)	16.44 (1.23)
TMS	36.79 (9.77)	34.12 (9.63)	34.09 (10.45)
Covariates			
FFMQ	128.39 (17.53)	126.00 (16.23)	128.76 (16.89)
PSS	43.82 (3.00)	43.97 (3.13)	44.23 (2.94)
BCSS	25.27 (5.46)	25.81 (5.96)	24.80 (5,81)
CESD	28.50 (7.31)	28.90 (6.55)	27.86 (7.49)
FASF	14.00 (5.60)	14.18 (5.66)	13.81 (6.07)

Note: % - percent correct, MRT – mean reaction time, T1 – baseline, T2 – post-intervention, T3 – post-Stroop, SUDS – distress, TMS – state mindfulness, FFMQ – trait mindfulness, PSS – perceived stress, BCSS – attention problems, CESD – depressive symptoms, FASF – anxiety symptoms

Color Word Stroop

The Color Word Stroop consisted of three types of trials. Congruent trials depicted the word in the same color (e.g., "Blue" in blue font). Incongruent trials depicted the word in a different color (e.g., “Blue” in red font). Control trials depicted a colored rectangle. Two variables were assessed for each of these trials: percent correct and mean reaction time.

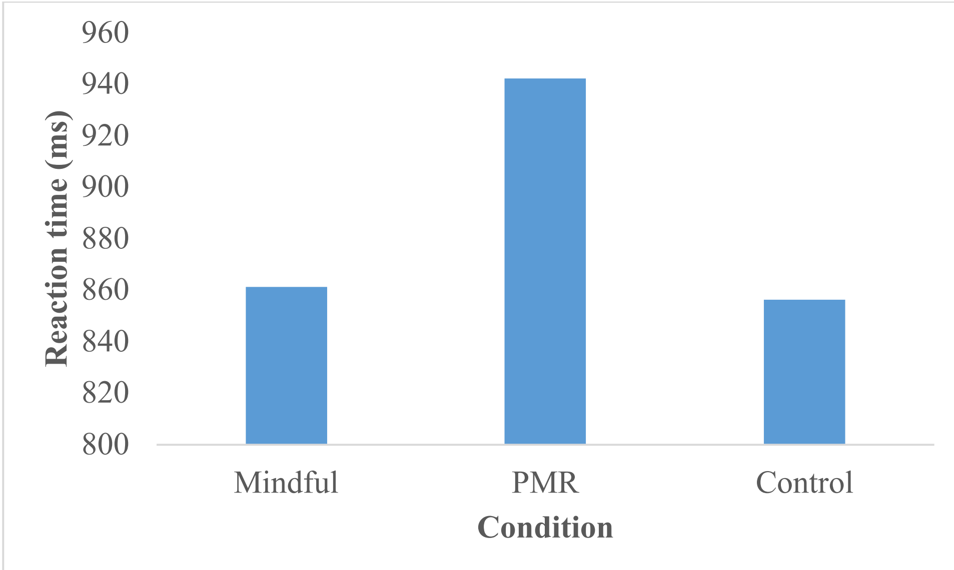
Congruent Percent Correct. The data were evaluated to determine whether the assumptions of ANCOVA were met. Multicollinearity was assessed by examining bivariate correlations between covariates. All correlations were within an acceptable limit (i.e., $r<.90$, Tabachnick & Fidell, 2007). Residual plots comparing standardized residuals to predicted values were examined to check for linearity. No curvilinearity was detected. Homogeneity of regression slopes was assessed using a preliminary ANCOVA to test the interaction between the independent variable and each covariate. The interaction terms were not significant; therefore, homogeneity of regression slopes was met for all covariates, $F_{Sleep}(3, 183) = .704$, $p = .551$; $F_{Caffeine}(3, 183) = .572$, $p = .634$; $F_{BCSS}(3, 183) = .654$, $p = .581$; $F_{FFMQ}(3, 183) =.859$, $p = .463$. Homogeneity of variance was assessed using Levene’s Test of Equality of Error Variances, $F(2,193)=.806$, $p=.448$.

An ANCOVA was conducted to determine the effect of group (mindfulness, PMR, and control) on performance on percent correct on congruent trials, when controlling for trait mindfulness, sleep, caffeine consumption, .and attention problems. Results indicated no main effect of group on percent of congruent trials correct $F(2, 189) = 2.195$, $p=.114$. None of the covariates significantly influenced performance, $F_{Sleep}(2,189)=.886$, $p=.348$; $F_{Caffeine}(2,189)=.540$, $p=.348$; $F_{BCSS}(2,189)=.741$, $p=.390$; $F_{FFMQ}(2,189)=.125$, $p=.724$. Because depressive symptoms were significantly correlated with percent correct on congruent trials, another ANCOVA was run using depressive symptoms as a covariate. Homogeneity of regression slopes was met, $F(3,192)=1.813$,

p=.146. Levene's test indicated homogeneity of variance, $F(2,193)=1.158$, p=.316. There was no main effect of condition, $F(1,192)=2.158$, p=.118; or depressive symptoms, $F(1,192)=1.351$, p=.247. An ANOVA investigating the effects of condition on percent correct in the congruent trials without covariates also did not indicate a main effect of condition, $F(2,193)=1.950$, p=.145.

Congruent Reaction Time. Assumptions for multicollinearity and linearity were met. Homogeneity of regression slopes was met for the following covariates: $F_{\text{Sleep}}(3,183)=.278$, p=.841; $F_{\text{Caffeine}}(3,183)=.546$, p=.652; $F_{\text{FFMQ}}(3,183)=1.350$, p=.260. Homogeneity of regression slopes was not met for BCSS, $F_{\text{BCSS}}(3,183)=2.707$, p=.047; therefore, it will not be included in the analysis. Levene's test of equality of error variances was not significant, $F(2, 193)=.398$, p=.672. An ANCOVA testing for the effect of condition on reaction time on congruent trials while controlling for sleep, caffeine consumption, attention problems, and trait mindfulness was conducted. There was a main effect of condition, $F(2, 189)=5.005$, p=.008, η^2=.050. None of the covariates significantly influenced reaction time. Pairwise comparisons reveal mindfulness (M=860.642 untransformed) and PMR conditions (M=942.993 untransformed) were significantly different (p=.030). Additionally, PMR was significantly different from the control condition (M=856.390 untransformed, p=.016). An ANOVA excluding covariates indicated a significant effect of condition, $F(2, 193)=5.021$, p=.009. Levene's test indicated homogeneity of variances, $F(2, 193)=.451$, p=.637. LSD post hoc tests indicate that the PMR condition was significantly slower than both the mindfulness (p=.011) and control conditions (p=.005), see Figure 1.

Figure 1. Reaction Time by Condition on Congruent Trials of the Color-Word Stroop



Incongruent Percent Correct. No multicollinearity or curvilinearity was detected. Homogeneity of regression slopes was met for all covariates, $F_{\text{Sleep}}(3,183)=.224$, $p=.879$; $F_{\text{Caffeine}}(3,183)=.857$, $p=.465$; $F_{\text{BCSS}}(3,183)=1.165$, $p=.325$; $F_{\text{FFMQ}}(3,183)=.134$, $p=.940$. Levene's test of equality of error variances was not significant, $F(2, 193)=2.706$, $p=.069$. An ANCOVA was conducted to determine the effect of group on percent correct on incongruent trials, when controlling for trait mindfulness, sleep, caffeine consumption, .and attention problems. Results indicated no main effect of group, $F(2, 189)=.681$, $p=.507$. None of the covariates significantly influenced performance. Therefore, an ANOVA was run excluding the covariates. There was no main effect of condition, $F(2, 193)=.770$, $p=.465$.

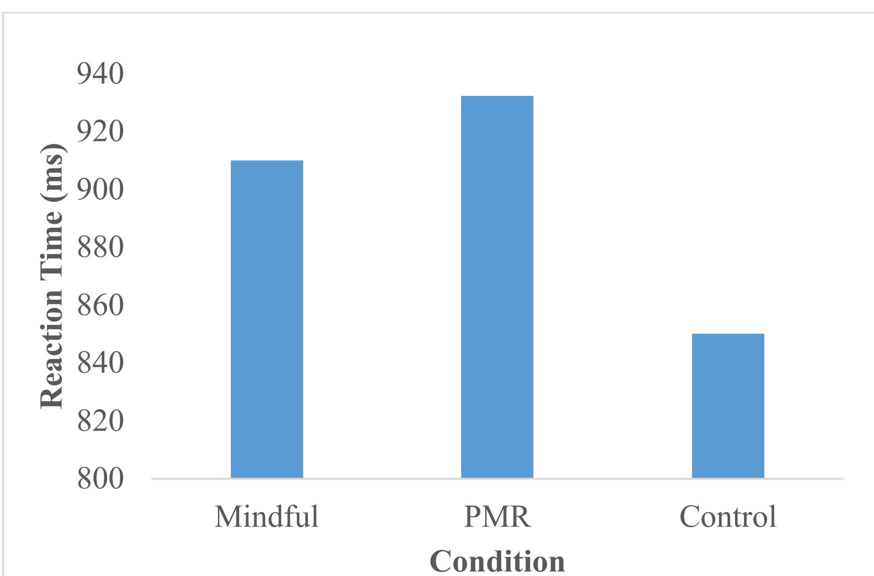
Incongruent Reaction Time. Assumptions were met for multicollinearity and linearity. Homogeneity of regression slopes was met for all covariates, $F_{\text{Sleep}}(3,183)=.074$, $p=.974$; $F_{\text{Caffeine}}(3,183)=1.386$, $p=.248$; $F_{\text{BCSS}}(3,183)=.775$, $p=.509$; $F_{\text{FFMQ}}(3,183)=.761$, $p=.517$. Levene's test of equality of error variances was not significant, $F(2, 193)=.468$, $p=.627$. An ANCOVA investigating the effect of condition on reaction time on incongruent trials while controlling for sleep, caffeine consumption, attention problems, and trait mindfulness indicated a non-significant effect of condition, $F(2, 189)=1.618$, $p=.201$. Additionally, none of the covariates significantly influenced reaction time. Therefore, an ANOVA was run. Homogeneity of variance was met, $F(2, 193)=.172$, $p=.842$. Condition was not significant, $F(2, 193)=1.488$, $p=.228$. Because of the significant correlation between FFMQ Describe scale and reaction time on incongruent trials, another ANCOVA was conducted using FFMQ Describe scale as a covariate. Homogeneity of regression slopes was not met, $F(3, 192)=3.128$, $p=.027$; therefore the ANCOVA was not conducted.

Control Percent Correct. No multicollinearity or curvilinearity was detected. Homogeneity of regression slopes was met for all covariates, $F_{\text{Sleep}}(3,183)=.266$, $p=.850$; $F_{\text{Caffeine}}(3,183)=.359$, $p=.783$; $F_{\text{BCSS}}(3,183)=.395$, $p=.757$; $F_{\text{FFMQ}}(3,183)=.182$, $p=.909$. Levene's test of equality of variances was not significant, $F(2, 193)=1.766$, $p=.174$. An ANCOVA was conducted to determine the effect of condition on percent correct of control trials, while controlling for sleep, caffeine consumption, attention problems, and trait mindfulness. There was no main effect of condition, $F(2, 189)=1.143$, $p=.321$. Additionally, none of the covariates significantly influenced performance. Therefore, an ANOVA was run excluding the covariates. There was no main effect of condition, $F(2, 193)=1.271$, $p=.283$.

Control Reaction Time. There was no evidence of multicollinearity or curvilinearity. Homogeneity of regression slopes was met for all covariates, $F_{\text{Sleep}}(3,183)=.207$, $p=.891$; $F_{\text{Caffeine}}(3,183)=1.121$, $p=.342$; $F_{\text{BCSS}}(3,183)=.529$, $p=.663$;

$F_{FFMQ}(3,183)=.927$, $p=.429$. Levene's test of equality of variances was not significant, $F(2, 193)=.264$, $p=.768$. An ANCOVA was conducted to determine the effect of condition on reaction time of control trials, while controlling for sleep, caffeine consumption, attention problems, and trait mindfulness. There was a significant main effect of condition, $F(2, 189)=3.990$, $p=.020$, $\eta^2=.041$. None of the covariates significantly influenced reaction time. Pairwise comparisons indicated a significant difference between the PMR ($M=934.234$ untransformed) and control conditions ($M=848.275$ untransformed, $p=.021$). An ANOVA was run to investigate the effect of condition excluding the covariates. Levene's test of homogeneity of variances was not significant, $F(2, 193)=.106$, $p=.900$. Results revealed a significant effect of condition, $F(2, 193)=3.672$, $p=.027$. LSD post hoc tests indicated the PMR condition was significantly slower than the control condition, $p=.010$, see Figure 2. Post hoc tests also indicate that the difference between the mindfulness and control conditions was approaching significance, $p=.053$.

Figure 2. Reaction Time by Condition on Control Trials of the Color-Word Stroop



Because of the significant correlation between FFMQ Describe scale and reaction time on incongruent trials, another ANCOVA was conducted using FFMQ Describe scale as a covariate. Homogeneity of regression slopes was not met, $F(3, 192)=3.936$, $p=.009$; therefore the ANCOVA was not conducted.

In order to examine whether the traditional Stroop effect was present, a 3 (word type: congruent, incongruent, control) by 3 (condition: mindful, PMR, control) repeated measures ANOVA was conducted. Mauchly's test of sphericity was significant, $X^2(2) = 20.682$, $p=.000$. Therefore, the Greenhouse-Geisser correction was used. There was a significant main effect of word type, $F(1.815,350.234)=250.308$, $p=.000$, $\eta^2=.565$. Specifically, pairwise comparisons reveal that reaction time on incongruent trials ($M=1108.01$, $SD=249.47$) was significantly slower than both congruent trials ($M=887.40$, $SD=178.76$, $p=.000$) and control trials ($M=898.17$, $SD=184.54$, $p=.000$). This result indicates that the Stroop effect was replicated in the current study. There were no significant differences between congruent and control trials, $p=.237$). The interaction between word type and condition was not significant, $F(3.629, 350{,}234)=1.488$, $p=.210$.

Neutral Stroop

Percent Correct. Inspection of bivariate correlations indicated acceptable correlation between covariates (<.90). Plots comparing standardized to predicted residuals did not indicate curvilinearity. The assumption of homogeneity of regression slopes was met for sleep, $F(2, 181)=1.199$, $p=.312$; caffeine consumption, $F(2, 181)=.216$, $p=.885$; attention problems, $F(2, 181)=1.710$, $p=.166$, and trait mindfulness, $F(2, 181)=1.833$, $p=.143$. Homogeneity was met as assessed by Levene's test, $F(2, 191)=.132$, $p=.876$. An ANCOVA investigating the effect of condition on percent correct on neutral word trials indicated no significant effect of condition, $F(2, 188)=.449$, $p=.639$. None of the covariates significantly influenced performance. Therefore, an ANOVA was run investigating the effect of condition excluding covariates. There was no effect of condition on performance, $F(2, 191)=.389$, $p=.678$.

Based on the significant bivariate correlation between percent correct on neutral trials and mindfulness experience, another ANCOVA was conducted using mindfulness experience as a covariate. Homogeneity of regression slopes was met, $F(3, 190)=1.450$, $p=.230$. Homogeneity was met as assessed by Levene's test, $F(2, 191)=.069$, $p=.933$. There was no main effect of condition, $F(2, 190)=.284$, $p=.753$.

Reaction Time. Assumptions of collinearity and linearity were met. Homogeneity of regression slopes was met for all covariates, $F_{Sleep}(3,181)=.212$, $p=.888$; $F_{Caffeine}(3,181)=.399$, $p=.754$; $F_{BCSS}(3,181)=.661$, $p=.577$; $F_{FFMQ}(3,181)=.152$, $p=.929$. Levene's test of equality of variances was not significant, $F(2, 191)=.210$, $p=.811$. An ANCOVA investigation the effect of condition on reaction time while controlling for sleep, caffeine consumption, attention problems, and trait mindfulness was conducted. Results reveal no main effect of condition, $F(2, 187)=1.368$, $p=.257$. None of the covariates significantly influenced reaction time. Therefore, an ANOVA was conducted investigating the effect of group excluding the covariates from the analysis. There was no effect of condition on reaction time, $F(2, 193)=1.191$, $p=.306$.

Based on the significant correlation between reaction time on neutral trials and FFMQ React subscale, another ANCOVA was conducted using FFMQ React scores as a covariate. Homogeneity of regression slopes was met, $F(3, 190)=1.865$, $p=.137$. Levene's test indicated equality of variance, $F(2, 191)=.157$, $p=.855$. Scores on the FFMQ React subscale significantly influenced reaction time, $F(1, 190)=3.976$, $p=.048$, $\eta^2=.020$. However, there was no main effect of condition on reaction time, $F(2, 190)=1.162$, $p=.315$.

Emotional Stroop.

Percent Correct. Data met the assumptions of ANCOVA including collinearity and linearity. Homogeneity of regression slopes was investigated for covariates. The assumption was met for all covariates, $F_{Sleep}(3,173)=.146$, $p=.932$; $F_{Caffeine}(3,173)=.227$, $p=.877$; $F_{BCSS}(3,173)=1.985$, $p=.118$; $F_{FFMQ}(3,173)=.559$, $p=.643$. Levene's statistic was not significant, indicating homogeneity of variance, $F(2, 183)=.298$, $p=.743$. An ANCOVA was conducted in order to investigate the effect of condition on percent correct on emotional Stroop trials. Results revealed a non-significant effect of condition on performance, $F(2, 179)=1.398$, $p=.250$. None of the covariates significantly influenced performance. Therefore, an ANOVA investigating the effect of condition excluding the covariates was conducted. The effect of condition remained non-significant, $F(2, 183)=1.280$, $p=.280$.

Another ANCOVA was run to control for effects of depressive and anxiety symptoms on performance. Homogeneity of regression slopes was met for depressive symptoms, $F(3, 179)=1.781$, $p=.152$; and anxiety symptoms, $F(3, 179)=.818$, $p=.485$. Levene's statistic was not significant, indicating homogeneity of variance, $F(2, 183)=.399$, $p=.671$. Results revealed a non-significant effect of condition on performance, $F(2, 181)=1.419$, $p=.245$. Anxiety symptoms did not significantly influence performance, $F(1, 181)=1.266$, $p=.262$. However, depressive symptoms was approaching significance, $F(1, 181)=3.815$, $p=.052$.

Reaction Time. Data was examined to determine whether it met the assumptions of ANCOVA. Correlations between covariates did not indicate multicollinearity. Residual plots did not indicate curvilinearity. Homogeneity of regression slopes was met for all covariates, $F_{\text{Sleep}}(3,173)=.436$, $p=.727$; $F_{\text{Caffeine}}(3,173)=.325$, $p=.807$; $F_{\text{BCSS}}(3,173)=1.081$, $p=.359$; $F_{\text{FFMQ}}(3,173)=.994$, $p=.397$. Levene's statistic was not significant, indicating homogeneity of variance, $F(2, 183)=.334$, $p=.716$. An ANCOVA investigating the effect of condition on reaction time on emotional Stroop trials while controlling for sleep, caffeine consumption, attention problems, and trait mindfulness was conducted. Results revealed a non-significant effect of condition on reaction time, $F(2, 179)=1.459$, $p=.235$. Additionally, none of the covariates significantly influenced reaction time. Therefore, an ANOVA investigating the effect of condition on reaction time was conducted. This also showed a non-significant effect of condition, $F(2, 183)=1.450$, $p=.237$.

Another ANCOVA was conducted to investigate the effect of condition on reaction time while controlling for anxiety and depressive symptoms. Homogeneity of regression slopes was met for anxiety symptoms, $F(3,179)=.505$, $p=.680$; and depressive symptoms, $F(3.179)=.396$, $p=.756$. Homogeneity of variances was met, $F(2, 183)=.298$, $p=.743$. Results revealed a non-significant effect of condition on reaction time, $F(2, 181)=1.497$, $p=.227$. Neither depressive symptoms, $F(1, 181)=.985$, $p=.322$; nor anxiety symptoms, $F(1, 181)=1.075$, $p=.301$; significantly influenced reaction time.

In order to determine whether the Emotional Stroop effect was present, a 2 (word type: emotional, neutral) by 3 (condition: mindful, PMR, control) mixed ANOVA was conducted. There was a main effect of word type, $F(1, 181)=35.418$, $p=.000$, $\eta^2=.164$.

Specifically, reaction time for emotional words (*M*=812.19, *SD*=195.02) was significantly slower than neutral words (*M*=750.80, *SD*=177.02). This result indicates that the Emotional Stroop effect was replicated in the current study. The interaction between word type and condition was not significant, $F(2, 181)=.889$, $p=.413$.

State Mindfulness

Assumptions of ANCOVA including collinearity and linearity were met. Homogeneity of regression slopes was met for trait mindfulness, $F(3, 187)=1.099$, $p=.351$. Levene's test indicated homogeneity of variance, $F(2, 188)=.614$, $p=.542$. An ANCOVA investigating the effect of group on state mindfulness levels after the intervention while controlling for trait mindfulness was conducted. Results revealed a non-significant effect of condition on state mindfulness levels, $F(2, 187)=1.514$, $p=.223$. There was no effect of the covariate (FFMQ, $F(1, 187)=.007$, $p=.932$. Therefore, an ANOVA was conducted to investigate the effect of condition excluding the covariate. Results again revealed no effect of condition on state mindfulness, $F(2, 188)=1.518$, $p=.222$. Because of the bivariate correlation between attitudes toward mindfulness and state mindfulness, the analyses was conducted including attitudes toward mindfulness as a covariate. Homogeneity of regression slopes was violated, $F(3, 187)=.8.491$, $p=.000$; and therefore, the ANCOVA was not conducted.

Bivariate correlations also indicated significant correlations between state mindfulness and depressive symptoms, anxiety symptoms, perceived stress, and the Observe scale of the FFMQ. Therefore, another ANCOVA was conducted using these variables as covariates. Homogeneity of regression slopes was met for depressive symptoms, $F(3, 178)=1.625$, $p=.185$; anxiety symptoms, $F(3, 178)=.337$, $p=.799$; and perceived stress, $F(3, 178)=1.627$, $p=.185$. Homogeneity of regression slopes was not met for FFMQ Observe scale, $F(3, 178)=9.457$, $p=.000$; therefore it will not be included in the analyses. Levene's test was not significant, $F(2,188)=.190$, $p=.827$. None of the covariates significantly influenced state mindfulness, though anxiety symptoms was approaching significance, $F(1, 185)=2.852$, $p=.093$. There was no main effect of condition, $F(2, 185)=1.714$, $p=.183$. When depressive symptoms and perceived stress were removed as covariates, anxiety symptoms significantly influenced state mindfulness, $F(1, 187)=10.990$, $p=.001$. However, condition remained non-significant, $F(2,187)=1.669$, $p=.191$.

Distress

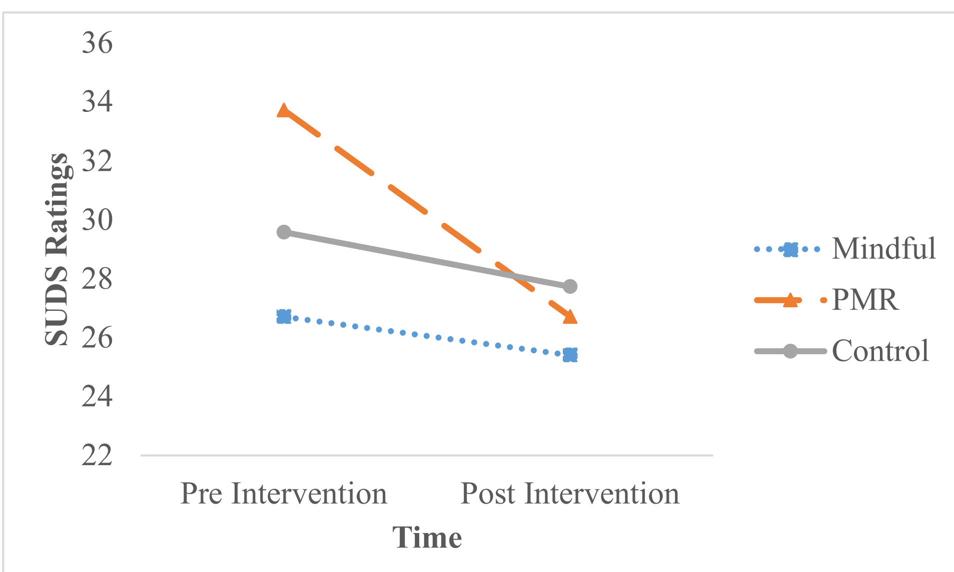
Data was inspected to ensure the assumptions of repeated measures ANCOVA were met. Linearity between covariates and SUDS ratings was confirmed with visual inspection of residual plots. Homogeneity of regression slopes was confirmed for perceived stress and depressive symptoms, as interactions were not significant, $F_{PSS}(3,166)=.321$, $p=.810$; $F_{CESD}(3,166)=.796$, $p=.498$; $F_{FASF}(3,166)=1.721$, $p=.165$. Levene's test of equality of variance was met for both pre-intervention ($F(2, 173)=.076$, $p=.931$) and post-intervention levels of distress ($F(2, 173)=.606$, $p=.546$. Additionally, Box's Test of Equality of Covariance Matrices was not significant, $F(6, 721918.101)=.288$, $p=.943$.

A repeated measures ANCOVA was conducted to compare pre-intervention and post-intervention levels of distress by condition while controlling for perceived stress and depressive symptoms. Results indicated a significant interaction of distress and condition, $F(2, 170)=3.731$, $p=.026$, $\eta^2=.042$. Two covariates were not significant, $F_{PSS}(1,$

170)=.008, *p*=.931.; F_{CESD}(1, 170)=2.591, *p*=.109. Anxiety symptoms as a covariate was approaching significance, F_{FASF}(1, 170)=3.820, *p*=.052. Therefore, a repeated measures ANOVA was conducted to examine the changes in distress by group including only anxiety symptoms as a covariate. Results revealed no significant interaction of distress and condition, *F*(2, 173)=2.225, *p*=.111.

Based on significant bivariate correlations between distress and caffeine and trait mindfulness, another ANCOVA was conducted including these as covariates. Homogeneity of regression slopes was met for caffeine, *F*(3,169)=.515, *p*=.652; and trait mindfulness, *F*(3,169)=1.147 *p*=.332. Levene's test was non-significant for both pre-intervention distress levels, *F*(2,173)=.234, *p*=.792; and post-intervention distress levels, *F*(2,173)=.225, *p*=.798. Box's test of equality of covariance matrices was also non-significant, *F*(6,721918.101)=.288, *p*=.943. Neither caffeine, *F*(1,171)=.745, *p*=.389; nor trait mindfulness, *F*(1,171)=.185, *p*=.667; significantly influenced distress ratings.

Figure 3. SUDS Ratings Pre- and Post-Intervention



However, there was a significant interaction between distress and condition, $F(2,171)=3.880$, $p=.023$, $\eta^2=.043$; indicating that the change in distress ratings differed by group. As shown in Figure 3, the PMR condition experienced a greater decrease in distress ratings compared to the mindful and control conditions.

Affect

Positive Affect. Inspection of the data revealed assumptions of linearity were met. Homogeneity of regression slopes was met for depressive symptoms, $F(3, 184)=.429$, $p=.733$; and anxiety symptoms, $F(3,184)=1.102$, $p=.350$. Levene's test indicated homogeneity of variance for both pre-intervention, $F(2, 188)=.339$, $p=.713$; and post-intervention positive emotions, $F(2, 188)=.155$, $p=.856$. Additionally, Box's test of equality of covariance matrices was not significant, $F(6, 871881.453)=.286$, $p=.944$.

A repeated measures ANCOVA was conducted to compare pre- and post-intervention levels of positive emotions by condition. The interaction between positive emotions and condition was non-significant, $F(2, 186)=.199$, $p=.820$. The covariates were not significant. Therefore, a repeated measures ANOVA was conducted in order to examine changes in positive emptions by group without covariates. The interaction between positive emotions and condition remained non-significant, $F(2, 188)=.224$, $p=.799$.

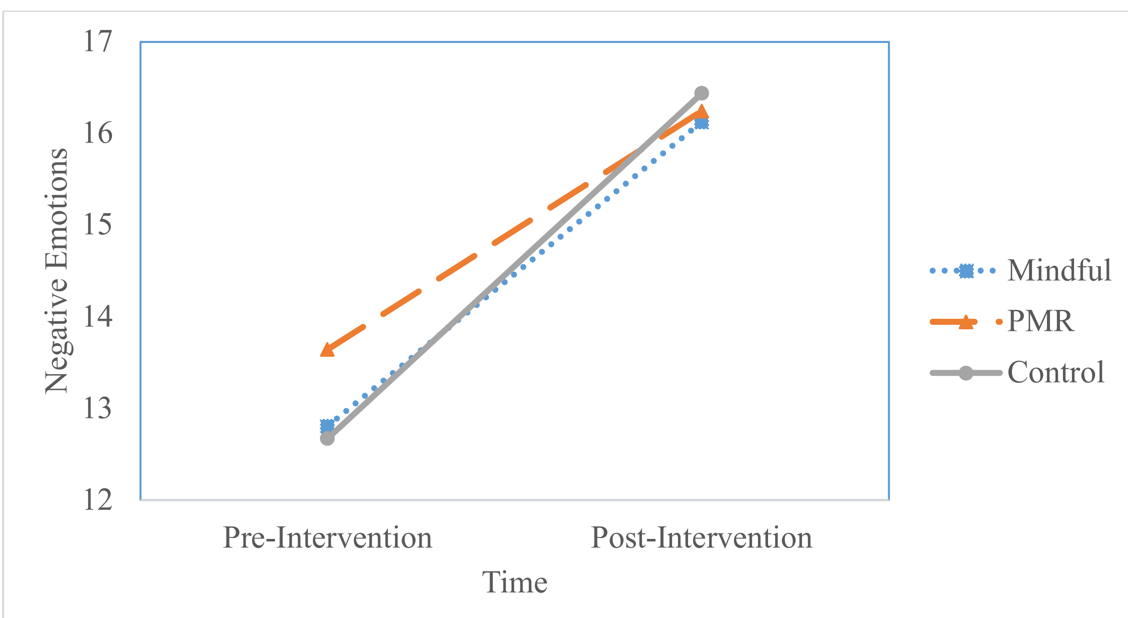
Based on the significant bivariate correlations between positive emotions and sex, perceived stress, and trait mindfulness, another ANCOVA was conducted including these variables as covariates. Homogeneity of regression slopes was met for all covariates: sex, $F(3, 181)=.322$, $p=.809$; perceived stress, $F(3, 181)=1.304$, $p=.275$; $F(3, 181)=.029$, $p=.993$. Levene's test indicated homogeneity of variance for both pre-intervention, F(2, 188)=.406, *p*=.667; and post-intervention positive emotions, *F*(2, 188)=.161, *p*=.852. Additionally, Box's test of equality of covariance matrices was not significant, *F*(6, 871881.453)=.286, *p*=.944. There was no interaction between positive emotions and condition, *F*(2, 185)=.151, *p*=.860. A significant interaction was found between positive emotions and perceived stress, *F*(2, 185)=4.125, *p*=.044. The other covariates did not demonstrate significant interactions with positive emotions.

Negative Affect. Assumptions of ANCOVA were evaluated. Examination of residual plots did not indicate curvilinearity. Homogeneity of regression slopes was met for anxiety symptoms, *F*(3, 184)=1.200, *p*=.311. Homogeneity of regression slopes was not met for depressive symptoms, *F*(3,194)=2.744, *p*=.045. Therefore, depressive symptoms will not be included in the model as a covariate. Equality of variance was not met for pre-intervention, *F*(2, 188)=5.140, *p*=.007; but was met for post-intervention levels of negative emotion, *F*(2, 188)=1.159, *p*=.316. However, examination of the standardized vs. predicted residuals indicates a linear trend. Box's test of equality of covariance matrices was met, *F*(6, 871881.453)=1.696, *p*=.117.

A repeated measures ANCOVA was conducted to compare pre- and post-intervention levels of negative emotions by condition. The interaction between negative emotions and condition was significant, *F*(2, 187)=3.208, *p*=.043, η^2=.033. Anxiety symptoms included as a covariate was not significant. Therefore, a repeated measures ANOVA was conducted to compare negative emotions by group without the covariate. The interaction between negative emotions and condition remained significant, *F*(2, 188)=3.253, *p*=.04, η^2=.033. Figure 4 shows that the control condition experienced the greatest increase in negative emotions, while the PMR group increased the least.

Examination of bivariate correlations indicated significant correlations between negative emotions and ethnicity, caffeine consumption, perceived stress, and trait mindfulness. Therefore, another ANCOVA will be conducted using these variables as covariates. Homogeneity of regression slopes was met for perceived stress, $F(3,178)=.888$, $p=.448$; trait mindfulness, $F(3,178)=1.153$, $p=.329$; and caffeine consumption, $F(3,178)=.333$, $p=.801$. Homogeneity of regression slopes was violated for ethnicity, $F(3,178)=3.043$, $p=.030$; therefore, it will not be included in the analysis. Levene's test was not significant for pre-intervention, $F(2, 188)=.2.633$, $p=.075$; or post-intervention negative emotions $F(2, 188)=1.015$, $p=.364$. Box's test of equality of covariances matrices was also not significant, $F(6, 871881.453)=1.696$, $p=.117$. None of the covariates demonstrated a significant interaction with negative emotion, $F_{FFMQ}(1, 185)=2.379$, $p=.125$; $F_{PSS}(1, 185)=.042$, $p=.837$; $F_{Caffeine}(1, 185)=.856$, $p=.356$.

Figure 4. Negative Emotions Endorsed Pre- and Post-Intervention



There was a significant interaction between condition and negative emotions, $F(2, 185)=3.171$, $p=.044$, . $\eta^2=.033$; indicating that the change in negative emotions differed based on condition, as shown in Figure 4. Simple main effects analysis reveals that at pre-intervention, PMR was significantly different than control, $p=.028$.

Heart Rate

Data was inspected to ensure the assumptions of repeated measures ANCOVA were met. Linearity between covariate and SUDS ratings was confirmed with visual inspection of residual plots. Homogeneity of regression slopes for caffeine consumption was confirmed, $F(6,374)=1.321$, $p=.247$. Levene's test of equality of variances was also confirmed for all three measurements of pulse: baseline $F(2, 188)=.701$, $p=.497$; post-intervention $F(2, 188)=.005$, $p=.995$; and post-Stroop $F(2, 188)=.445$, $p=.642$. Additionally, Box's test of equality of covariance matrices was not significant, $F(12,170682.276)=.570$, $p=.868$. Mauchly's test of sphericity was also not significant, $X^2(2) = 4.558$, $p=.102$.

A repeated measures ANCOVA was conducted to compare heart rate across the study, including baseline, post-intervention, and post-Stroop task; while controlling for caffeine consumption. Results revealed a non–significant interaction of heart rate and condition, $F(4, 374)=1.435$, $p=.222$. The effect of the covariate was also non-significant. Therefore, a repeated measures ANOVA was conducted to compare heart rate excluding the covariate. The interaction of heart rate and condition remained non-significant, $F(4, 376)=1.491$, $p=.204$.

Significant bivariate correlations were found between pulse and sex, sleep, and perceived stress. Therefore, an additional ANCOVA was conducted using these variables as covariates. Homogeneity of regression slopes was confirmed for sleep, *F*(6, 362)=1.504, *p*=.178. Homogeneity of regression slopes was violated for perceived stress, *F*(6, 362)=2.764, *p*=.013; and sex, *F*(6, 362)=2.851, *p*=.010. Therefore, these covariates will be excluded from the analysis. There was no significant interaction between pulse and condition, *F*(4,374)=1.484, *p*=.229; or pulse and sleep, *F*(2,374)=1.057, *p*=.349.

CHAPTER IV

DISCUSSION

The current study contributes to the study of mindfulness, as it addresses limitations of previous studies, including using a concentrative focus (Chiesa et al., 2011), decentering practice (Lee & Orsillo, 2014), active control (Allen et al., 2012; Bonamo et al., 2014), and evaluating whether the intervention truly produces changes in state mindfulness (Keng et al., 2011). It builds upon previous studies by including trait mindfulness, depressive symptoms, and anxiety symptoms as covariates and using alternative control conditions (Watier & Dubois, 2016).

The first hypothesis of this study was that the mindfulness intervention will improve performance on Stroop tasks compared to the relaxation and control conditions through an increase in state mindfulness. The results revealed that the mindfulness exercise failed to produce differences in state mindfulness by group, even when controlling for trait mindfulness, perceived stress, and depressive and anxiety symptoms. This is consistent with previous studies that have failed to find increases in state mindfulness (Lee & Orsillo, 2014). Additionally, Watier & Dubois (2016) found that both the mindfulness and attention conditions were effective at increasing state mindfulness, suggesting that other exercises that are not considered to be in the mindfulness realm may impact state mindfulness levels. The current results suggest that exposure to mindfulness through a 10-minute audio recorded mindfulness exercise may not be sufficient for producing mindfulness state, a state that might be a potentially important ingredient for mindfulness-based interventions aimed at enhancing cognitive performance. The cognitive benefits associated with brief mindfulness exercise have, in some studies, been accompanied by changes in state mindfulness (Bonamo et al. 2014; Watier & Dubois, 2016). Brief mindfulness exercise used in research studies can vey widely in terms of duration and approach (Bonamo et al., 2014; Lee & Orsillo, 2014; Watier & Dubois, 2016). Therefore, future research studies may benefit from a more targeted evaluation of variations in brief mindfulness exercises, with the specific aim of identifying the best practices for eliciting state mindfulness.

As would be expected given the failure of the recordings to produce changes in state mindfulness, there was no difference in groups with regard to accuracy on all color-word Stroop, neutral Stroop, and emotional Stroop tasks, even when controlling for trait mindfulness, sleep, caffeine consumption, anxiety and depressive symptoms, and attention problems. Additionally, there was no difference in reaction times across groups on incongruent color-word Stroop trials or neutral Stroop trials. However, significant differences were found between groups on both the congruent and control trials of the color-word Stroop. Specifically, the PMR condition had slower reaction times than both the mindfulness and control conditions on the congruent trials. On the control trials of the color-word Stroop, the PMR condition also had slower reaction times than the control condition. The mindfulness condition was also slower than the control condition, but this result was not significant, though it was approaching significance.

These results are in contrast to other studies that found differences in Stroop performance for experienced meditators (Teper & Inzlicht, 2012) or participants exposed to weeks long mindfulness training (Alfonso et al., 2011; Zylowska et al., 2007).

However, the current results provide support for other studies that did not find differences in Stroop performance for experienced meditators (Josefsson & Broberg, 2011; Lykins et al., 2012) or weeks long mindfulness training (Anderson et al., 2007; Moore et al., 2012; Semple, 2010). This also suggests that a brief intervention to enhance state mindfulness is insufficient to provide the benefits seen with trait mindfulness or longer periods of training. This study adds to the growing debate about the effectiveness of mindfulness interventions. Additionally, it suggests that changes in state mindfulness are necessary to produce enhanced performance.

The differences in reaction time by group provided an interesting finding. While the mindfulness condition did not improve reaction time compared to the other groups as expected, the relaxation group was found to have slower reaction times than the control group. This suggests that in some instances relaxation may be counter-productive to enhancing cognitive abilities, especially with reaction time tasks. These results could be explained by the Yerkes-Dodson theory which posits that under arousal is associated with sub-optimal performance (e.g., Cohen, 2011). PMR may result in under arousal in some circumstances that inhibits reaction time. Additionally, the mindfulness condition was also slower than the control condition, though this difference was only approaching significance.

A similarity between both the PMR and mindfulness interventions was that the recording specified to participants to close their eyes (alternatively, in the mindfulness recording, to lower their gaze). It is possible that this induced sleepiness, rather than relaxation or mindfulness, resulting in slower reactions. Additionally, PMR is used by some to facilitate sleep. On the other hand, listening to a potentially interesting interview may have promoted alertness. Future studies should consider alternative exercises that promote relaxation or mindfulness but maintain alertness, such as mindful walking. Future studies may also consider adding a self-report measure of alertness subsequent to the intervention in order to investigate effects of the intervention on levels of alertness.

The second hypothesis predicted that the mindfulness intervention would protect against the effects of negative emotionality elicited by the emotional Stroop task, resulting greater accuracy and reaction time. This hypothesis, which was based on assumptions related to the PDP model regarding emotion and attentional control, was not empirically supported. No differences were found between groups on accuracy or reaction time on the emotional Stroop tasks, even when controlling for trait mindfulness, sleep, caffeine consumption, attention problems, and anxiety and depressive symptoms. Thus it appears that the brief mindfulness exercise failed to have influenced baseline activation of emotionally-salient words and attentional control.

Previous studies investigating performance on the emotional Stroop have found mixed results for both longer-term mindfulness interventions, experienced meditators, and brief mindfulness interventions. The current study provides support for previous studies that did not find performance improvements (Lykins et al., 2012; Waters et al. 2009). Additionally, while another study found improvements in emotional Stroop performance, it is notable that the mindfulness condition did not differ from the relaxation conditions in the experiment (Lee & Orsillo, 2014), suggesting that mindfulness may be no more effective than relaxation. Previous research has looked at differences between mindfulness and relaxation interventions and often found no differences (e.g., Jain et al., 2007; Moritz et al., 2015). The current results may also suggest that a brief intervention to manipulate state mindfulness is insufficient to provide the type of benefits seen with trait mindfulness or longer periods of training.

Watier & Dubois (2016) found greater interference in emotional Stroop performance compared to neutral Stroop performance for only one of the control conditions. Interestingly, greater interference was found for the control condition that had experienced a similar increase in state mindfulness to the mindfulness condition. This suggests that factors other than increases in state mindfulness may be responsible for the effects. They also found that brief mindfulness interventions are more effective for participants who have low trait mindfulness. In the current study, trait mindfulness was used as a covariate and did not significantly affect performance.

Heart rate was used as a validity check for the mindfulness intervention. The third hypothesis predicted that increased heart rate after a stressful event (e.g., Stroop tasks), would be buffered by the mindfulness intervention. There were no differences between conditions despite controlling for caffeine consumption, sex, sleep, and perceived stress; therefore, this hypothesis was not supported by the current study.

The current study provides support for a previous study that also failed to find differences in physiological measures as a result of mindfulness interventions (Erisman & Roemer, 2010). The failure to find differences in heart rate by condition could also be due to the mindfulness intervention not specifically focusing on heart rate, as some other studies have done (Delizonna et al., 2009). Additionally, it may be expected that no differences would be found given that the mindfulness intervention did not increase state mindfulness compared to the other groups.

The fourth hypothesis predicted an increase in positive and decrease in negative emotions as a result of the mindfulness intervention. No differences were found between groups on positive emotions, despite controlling for anxiety and depressive symptoms, sex, perceived stress, and trait mindfulness. There was a significant interaction between group and negative emotions. While all groups showed increased negative emotions after the Stroop tasks, the PMR condition increased less than the mindfulness and control conditions.

The final hypothesis predicted that the mindfulness intervention would buffer against the effects of distress elicited by the Stroop tasks. The results showed a significant interaction between distress and condition. While all groups showed a decrease in distress following the Stroop tasks, the PMR group showed a greater decrease.

When the results of the final two hypothesis are combined, it suggests that a brief relaxation exercise may be more effective than a brief mindfulness exercise in protecting against negative emotions and distress. While previous research has found decreased stress as a result of mindfulness intervention, it is possible that the current brief, single-session mindfulness intervention is not sufficient to garner the benefits of trait mindfulness.

Previous studies that have found significant differences in Stroop performance as a result of mindfulness intervention or experience may be different in a number of ways. For example, in Watier & Dubois (2016) study, the nature of the comparison conditions may have inflated the effect of the mindfulness intervention due to the cognitive demands of the comparison conditions, thus decreasing the cognitive capacity remaining for performance on the Stroop.

In another study, an analog sample of GAD participants completed a 20-minute mindful breathing exercise (Lee & Orsillo, 2013). After completing two self-report measures, they completed a 3-minute re-induction exercise to minimize potential interference caused by filling out the measures. This longer exercise may have given participants more opportunity to learn and benefit from the mindfulness intervention. Additionally, participants in this study ranged from 18-60 years old and were recruited from both a college and community sample.

Both of these studies also excluded participants who had mindfulness experience. In this study, approximately 52% of participants rated their experience with mindfulness as “moderate” or greater. Additionally, less than 20% of participants had never engaged in one of the listed mindfulness activities. Therefore, a possibility for the difference in this study compared to other studies is participants’ greater experience with mindfulness.

Limitations of the current study include a primarily White, young adult, female sample recruited from a university setting, which limits generalizability of findings. Additional research with males and other ethnic groups should be conducted. As previously mentioned, the failure of the mindfulness intervention to produce greater state mindfulness is a limitation. The intervention used in the current study focused on awareness of breath and emotions. However, other approaches focusing on additional mindfulness skills could enhance the disengagement from emotions.

Future studies should investigate the optimal type and length of mindfulness exercises. Suggestions for future research include more active and engaging mindfulness exercises, such as mindful walking. Mindfulness interventions may focus on skills including accepting, compassion, and decentering that may be more likely to influence responses to emotional stimuli. Additionally, more research is needed in order to compare participants with varying levels of mindfulness experience. Many studies of mindfulness interventions have been conducted with majority female, White college students. Future studies should investigate a more diverse population. Given the mixed results found in research of brief interventions, detailed, systematic, multi-group comparisons are necessary in order to identify the mechanisms underlying these effects.

In conclusion, the results of the current study provide support to a growing body of literature that suggests that single session mindfulness interventions may not be as effective as once thought. Additionally, it suggests that the difference between mindfulness and relaxation exercises requires additional research to determine whether they are in fact two different constructs, and whether these differences can be seen in brief interventions.

REFERENCES

Alberts, H. J., & Thewissen, R. (2011). The effect of a brief mindfulness intervention on memory for positively and negatively valenced stimuli. *Mindfulness*, *2*(2), 73-77.

Alfonso, J. P., Caracuel, A., Delgado-Pastor, L. C., Verdejo-Garcia, A. (2011). Combined goal management training and mindfulness meditation improve executive functions and decision-making performance in abstinent polysubstance abusers. *Drug and Alcohol Dependence, 117,* 78-81. doi:10.1016/j.drugalcdep.2010.12.025

Allen, M., Dietz, M., Blair, K. S., van Beek, M., Rees, G., Vestergaard-Poulsen, P., … & Roepstorff, A. (2012). Cognitive- affective neural plasticity following active-controlled mindfulness intervention. *The Journal of Neuroscience, 32,* 115601-15610. doi:10.1523/JNEUROSCI.2957-12.2012

Anderson, N. D., Lau, M. A., Segal, Z. V., & Bishop, S. R. (2007). Mindfulness-based stress reduction and attentional control. *Clinical Psychology & Psychotherapy, 14*, 449-463. doi:10.1002/cpp.544

Arochova, O. (1971). The use of a modified Stroop Test in pre-school children. *Psychologia a Patopsychologia Dietata, 6,* 261-266.

Baer, R. A. (2003). Mindfulness training as a clinical intervention: a conceptual and empirical review. Clinical Psychology: Science and Practice, 10(2), 125–143. doi:10.1093/clipsy.bpg015.

Baer, R. A., Smith, G. T., Hopkins, J., Krietemeyer, J., & Toney, L. (2006). Using self-report assessment methods to explore facets of mindfulness. *Assessment*, *13*(1), 27-45.

Balota, D. A., Yap, M. J., Cortese, M. J., Hutchison, K. A., Kessler, B., Loftis, B., …Treiman, R. (2007). The English Lexicon Project. *Behavior Research Methods, 39*, 445-459.

Barkley, R. A., Murphy, K. R. (2006) *Attention-deficit hyperactivity disorder: A clinical workbook* (3rd ed.). New York: Guilford.

Beauchemin, J., Hutchins, T. L., & Patterson, F. (2008). Mindfulness meditation may lessen anxiety, promote social skills, and improve academic performance among adolescents with learning disabilities. *Complementary Health Practice Review*, *13*(1), 34-45.

Benson, H., Wilcher, M., Greenberg, B., Huggins, E., Ennis, M., Zuttermeister, P. C., … Friedman, R. (2000). Academic performance among middle school students after exposure to a relaxation response curriculum. Journal of Research and Development in Education, 33(3), 156–165.

Birch, J (2010). Identification of red-green colour deficiency: Sensitivity of the Ishihara and American Optical Company (Hard, Rand and Rittler) pseudo-isochromatic plates to identify slight anomalous trichromatism. *Ophthalmic & Physiological Optics, 30,* 667-671.

Birch, J. (1997). Efficiency of the Ishihara test for identifying red-green colour deficiency. *Ophthalmic & Physiological Optics, 17,* 403-408.

Bishop, S. R., Lau, M., Shapiro, S., Carlson, L., Anderson, N. D., Carmody, J., … Devins, G. (2004). Mindfulness: A proposed operational definition. *Clinical Psychology: Science and Practice, 11,* 230-241.

Bonamo, K. K., Legerski, J. P., & Thomas, K. B. (2014). The influence of a brief mindfulness exercise on encoding of novel words in female college students. *Mindfulness, 6, 535-544.*

Borkovec, T. D., Shadick, R., & Hopkins, M. (1991). The nature of normal and pathological worry. In R. Rapee & D. H. Barlow (Eds.), *Chronic anxiety: Generalized anxiety disorder and mixed anxiety-depression* (pp. 29-51). New York: Guilford.

Bremenr, J. D., Vermetten, E., Vythilingam, M., Afzal, N., Schmahl, C., Elzinga, B., & Charney, D. S. (2004). Neural correlates of the classic color and emotional Stroop in women with abuse-related posttraumatic stress disorder. *Biological Psychiatry, 55,* 612-620. doi:10.1016/j.biopsych.2003.10.001

Campbell-Sills, L., Barlow, D. H., Brown, T. A., & Hofmann, S. G. (2006). Effects of suppression and acceptance on emotional responses on individuals with anxiety and mood disorders. *Behavior Research and Therapy, 44*, 1251-1263.

Chan, D., & Woollacott, M. (2007). Effects of level of meditation experience on attentional focus: Is the efficiency of executive or orientation networks improved? *The Journal of Alternative and Complementary Medicine, 13*, 651-657. doi:10.1089/acm.2007.7022

Chiesa, A., Calati, R. & Serretti, A. (2011). Does mindfulness training improve cognitive abilities? A systematic review of neuropsychological findings. *Clinical Psychology Review, 31*, 449-464. doi:10.1016/j.cpr.2010.11.003

Cohen R.A. (2011) Yerkes–Dodson Law. In: Kreutzer J.S., DeLuca J., Caplan B. (Eds.) *Encyclopedia of Clinical Neuropsychology*. New York: Springer.

Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A global measure of perceived stress. *Journal of Health and Social Behavior, 24,* 285-296.

Davis, D. M., & Hayes, J. A. (2011). What are the benefits of mindfulness? A practice review of psychotherapy-related research. *Psychotherapy*, *48*, 198-208 doi: 10.1037/a0022062.

Dawkins, K., & Furnham, A. (1989). The color naming of emotional words. *British Journal of Psychology, 80,* 383-389.

de la Fuente, M., Franco, C., & Salvador, M. (2010). Reduction of blood pressure in a group of hypertensive teachers through a program of mindfulness meditation. *Behavioral Psychology-Psicologia Conductual*, *18*(3), 533-552.

De Raedt, R., Baert, S., Demeyer, I., Goeleven, E., Raes, A., Visser, A., … Speckens, A. (2012). Changes in attentional processing of emotional information following Mindfulness-Based Cognitive therapy in people with a history of depression: Towards an open attention for all emotional experiences. *Cognitive Therapy Research, 36,* 612-620. doi: 10.1007/s10608-011-9411-x

De Raedt, R., Schacht, R., Franck, E., & De Houwer, J. (2006). Self-esteem and depression revisited: Implicit positive self-esteem in depressed patients? *Behavior Research and Therapy, 44,* 1017-1028. doi:10.1016/j.brat.2005.08.003

Delizonna, L. L., Williams, R. P., & Langer, E. J. (2009). The effect of mindfulness on heart rate control. *Journal of Adult Development*, *16*(2), 61-65.

Didonna, F. (2009). Introduction: Where new and old paths to dealing with suffering meet. In F. Didonna (Ed.), *Clinical handbook of mindfulness* (1-14). New York, NY: Springer.

Ditto, B., Eclache, M., & Goldman, N. (2006). Short-term autonomic and cardiovascular effects of mindfulness body scan meditation. *Annals of Behavioral Medicine*, *32*(3), 227-234.

Eaton, W. W., Smith, C., Ybarra, M., Muntaner, C., & Tien, A. (2004). Center for Epidemiologic Studies Depression Scale: Review and Revision (CESD and CESD-R). In M. E. Maruish (Ed.), *The use of psychological testing for treatment planning and outcomes assessment: Instruments for adults* (pp. 363-377). Mahwah, NJ, US: Lawrence Erlbaum Associates Publishers.

Eilola, T. M. & Havelka, J. (2010). Behavioural and physiological responses to the emotional and taboo Stroop tasks in native and non-native speakers of English. *International Journal of Bilingualism, 15,* 353-369. doi: 10.1177/1367006910379263

Erisman, S. M., & Roemer, L. (2010). A preliminary investigation of the effects of experimentally induced mindfulness on emotional responding to film clips. *Emotion*, *10*(1), 72-82.

Feldman, G., Greeson, J., & Senville, J. (2010). Differential effects of mindful breathing, progressive muscle relaxation, and loving-kindness meditation on decentering and negative reactions to repetitive thoughts. *Behaviour Research and Therapy*, *48*(10), 1002-1011.

Galla, B. M., Sigi Hale, T., Shrestha, A., Loo, S. D., & Smalley, S. L., (2012). The disciplined mind: Associations between the Kentucky Inventory of Mindfulness Skills and attentional control. *Mindfulness, 3,* 95-103. doi: 10.1007/s12671-011-0083-0

Gershon, R. C., Wagster, M. V., Hendrie, H. C., Fox, N. A., Cook, K. F., & Nowinski, C. J. (2013). NIH toolbox for assessment of neurological and behavioral function. *Neurology*, *80*, S2-S6. doi: 10.1212/WNL.0b013e3182872e5f

Google (n.d.) Google Trends. Search Term: mindful. Retrieved from https://www.google.com/trends

Gosselin, K. P., Holland, B., Mulcahy, A., Williamson, S., & Widacki, A. (2016). Music for anxiety reduction and performance enhancement in nursing simulation. *Clinical Simulation in Nursing, 12,* 16-23.

Hackman, R. J., Holtzman, G. L., & Walter, P. E. (1992). Color vision testing for the U.S. Naval Academy. *Military Medicine, 157*, 651-657.

Hintzman, D. L., Carre, F. A., Eskridge, V. L., Owens, A. M., Shaff, S. S., & Sparks, M. E. (1972). "Stroop" effect: Input or output phenomenon? *Journal of Experimental Psychology, 95*, 458-459.

Hölzel, B. K., Carmody, J., Vangel, M., Congleton, C., Yerramsetti, S. M., Gard, T., & Lazar, S. W. (2011). Mindfulness practice leads to increases in regional brain gray matter density. *Psychiatry Research: Neuroimaging, 191*(1), 36-43.

Ishihara, S. (1995). *Ishihara instructions: A series of plates designed as a test for color deficiency, concise edition.* Tokyo: Kanehara & Co., Ltd.

Jain, S., Shapiro, S. L., Swanick, S., Roesch, S. C., Mills, P. J., Bell, I., & Schwartz, G. E. R. (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. doi:10.1207/s15324796abm3301_2

Jha, A. P., Krompinger, J., & Baime, M. J. (2007). Mindfulness training modifies subsystems of attention. *Cognitive, Affective & Behavioral Neuroscience, 7*, 109-119. doi:10.3758/CABN.7.2.109

Josefsson, T. & Broberg, A. (2011). Meditators and non-meditators on sustained and executive attentional performance. *Mental Health, Religion & Culture, 14,* 291-309. doi: 10.1080/13674670903578621

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

Kabat-Zinn, J. (2009). Foreward. In F. Didonna (Ed.), *Clinical handbook of mindfulness* (xxv-xxxiii). New York, NY: Springer.

Kang, Y., Gruber, J., & Gray, J. R. (2013). Mindfulness and de-automatization. *Emotion Review, 5,* 192-201. doi: 10.1177/1754073912451629

Keng, S. L., Smoski, M. J., & Robins, C. J. (2011). Effects of mindfulness on psychological health: A review of empirical studies. *Clinical Psychology Review*, *31*(6), 1041-1056.

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*(3), 297-300.

Lau, M. A., Bishop, S. R., Segal, Z. V., Buis, T., Anderson, N. D., Carlson, L., ... & Devins, G. (2006). The Toronto mindfulness scale: Development and validation. *Journal of Clinical Psychology*, *62*(12), 1445-1467.

Lee, J. K., & Orsillo, S. M. (2014). Investigating cognitive flexibility as a potential mechanism of mindfulness in generalized anxiety disorder. *Journal of Behavior Therapy and Experimental Psychiatry*, *45*(1), 208-216. doi: 10.1016/j.jbtep.2013.10.008

Levitt, J. T., Brown, T. A., Orsillo, S. M., & Barlow, D. H. (2004). The effects of acceptance versus suppression of emotion on subjective and psychophysiological response to carbon dioxide challenge in patients with panic disorder. *Behavior Therapy, 35,* 747-766.

Lykins, E. L. B., Baer, R. A., & Gottlob, L. R. (2012). Performance-based tests of attention and memory in long-term mindfulness meditations and demographically matched nonmeditators. *Cognitive Therapy Research, 36,* 103-114. doi: 10.1007/s10608-010-9318-y

MacLean, K. A., Ferrer, E., Aichele, S. R., Bridwell, D. A., Zanesco, A. P., Jacobs, T. L., ... Saron, C. D. (2010). Intensive meditation training improves perceptual discrimination and sustained attention. *Psychological Science, 21,* 829-839. doi: 10.1177/0956797610371339

Malinowski, P. (2013). Neural mechanisms of attentional control in mindfulness meditation. *Frontiers in Neuroscience, 7,* 1-11. doi: 10.3389/fnins.2013.00008

Moore, A. & Malinowski, P. (2009). Meditation, mindfulness and cognitive flexibility. *Consciousness and Cognition, 18*, 176-186. doi:10.1016/j.concog.2008.12.008

Moore, A., Gruber, T., Derose, J., & Malinowski, P. (2012). Regular, brief mindfulness meditation practice improves electrophysiological markers of attentional control. *Frontiers in Human Neuroscience, 6,* 1-15. doi: 10.3389/fnhum.2012.00018

Moritz, S., Cludius, B., Hottenrott, B., Schneider, B. C., Saathoff, K., Kuelz, A. K., Gallinat, J. (2015). Mindfulness and relaxation treatment reduce depressive symptoms in individuals with psychosis. *European Psychiatry, 30,* 709-714.

Mrazek, M. D., Franklin, M. S., Phillips, D. T., Baird, B., & Schooler, J. W. (2013). Mindfulness training improves working memory capacity and GRE performance while reducing mind wandering. *Psychological Science, 24*, 776-781. doi: 10.1177/0956797612459659

Nyklíček, I., Mommersteeg, P., Van Beugen, S., Ramakers, C., & Van Boxtel, G. J. (2013). Mindfulness-based stress reduction and physiological activity during acute stress: A randomized controlled trial. *Health Psychology*, *32*(10), 1110-1113.

Ostafin, B. D., & Kassman, K. T. (2012). Stepping out of history: mindfulness improves insight problem solving. *Consciousness and Cognition: An International Journal, 21,* 1031–1036. doi:10. 1016/j.concog.2012.02.014.

Paul, N. A., Stanton, S. J., Greeson, J. M., Smoski, M. J., & Wang, L. (2013). Psychological and neural mechanisms of trait mindfulness in reducing depression vulnerability. *Social Cognitive and Affective Neuroscience, 8,* 56-64.

Prinsloo, G. E., Laurie Rauch, H. G., Lambert, M. I., Muench, F., Noakes, T. D., & Derman, W. E. (2010). The effect of short duration heart rate variability (HRV) biofeedback on cognitive performance during laboratory induced cognitive stress. *Applied Cognitive Psychology, 25,* 792-801.

Pyszcynski, T., & Greenberg, J. (1987). Self-regulatory perseveration and the depressive self-focusing style: A self-awareness theory of reactive depression. *Psychological Bulletin, 102,* 122-138.

Renaud, P. & Blondin, J. P. (1997). The stress of Stroop performance: Physiological and emotional responses to color-word interference, task pacing, and pacing speed. *International Journal of Psychophysiology, 27,* 87-97.

Roberts-Wolfe, D., Sacchet, M., Hastings, E., Roth, H., & Britton, W. (2012). Mindfulness training alters emotional memory recall compared to active controls: support for an emotional information processing model of mindfulness. *Frontiers in Human Neuroscience*, *6*, 15. doi: 10.3389/fnhum.2012.00015

Rumelhart, D. E., Hinton, G. E., & McClelland, J. L. (1986). A general framework for parallel distributed processing. In D. E. Rumelhart, J. L. McClelland, & the PDP Research Group *Parallel distributed processing: Explorations in the microstructure of cognition, Volume 1: Foundations* (pp. 45-76). Cambridge, MA: Bradford Books/MIT Press.

Sarason, I. G., Pierce, G. R., & Sarason, B. R. (1996). Domains of cognitive interference. In I. B. Weiner (Personality and Clinical Psychology Series Ed.), Cognitive interference: Theories, methods, and findings (pp. 139–152). Hillsdale, NJ: Erlbaum.

Sauer, S., Walach, H., Schmidt, S., Hinterberger, T., Horan, M., & Kohls, N. (2011). Implicit and explicit emotional behavior and mindfulness. *Consciousness and Cognition, 20,* 1559-1569. doi:10.1016/j.concog.2011.08.002

Shao, R., & Skarlicki, D. P. (2009). The role of mindfulness in predicting individual performance. *Canadian Journal of Behavioral Science, 41,* 295-201. doi: 10.1037/a0015166

Shapiro S. L., Carlson, L. E., Astin, J. A., & Freedman, B. (2006). Mechanisms of mindfulness. *Journal of Clinical Psychology, 62*, 373-386. doi: 10.1002/jclp.20237

Silva, F. T. & Leite, J. R. (2000). Physiological modifications and increase in state anxiety in volunteers submitted to the Stroop color-word interference test: A preliminary study. *Phsyiology Behavior, 70,* 113-118.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18,* 643-662.

Tabachnick, B. G., & Fidell, L. S (2007). *Using multivariate statistics* (5 ed.). Boston, MA: Pearson Education, Inc.

Teasdale, J. D., & Bernard, P. J. (1993). *Affect, cognition and change: Re-modeling depressive thought.* Hillsdale, NJ: Lawrence Earlbaum.

Teper, R. & Inzlicht, M. (2012). Meditation, mindfulness and executive control: The importance of emotional acceptance and brain-based performance monitoring. *Social Cognitive and Affective Neuroscience, 8,* 85-92. doi: 10.1093/scan/nss045

van den Hurk, P. M., Giommi, F., Gielen, S. C., Speckens, A. M., & Barendregt, H. P. (2010). Greater efficiency in attentional processing related to mindfulness meditation. *The Quarterly Journal of Experimental Psychology, 63*, 1168-1180. doi:10.1080/17470210903249365

Vroom, V. H. (1964). *Work and Motivation*. New York: Wiley.

Waters, A. J., Reitzel, L. R., Cinciripini, P., Li, Y., Marcus, M. T., Vidrine, J. I., & Wetter, D. W. (2009). Associations between mindfulness and implicit cognition and self-reported affect. *Substance Abuse, 30,* 328-337.

Watier, N., & Dubois, M. (2016). The effects of a brief mindfulness exercise on executive attention and recognition memory. *Mindfulness*, *7*(3), 745-753. doi: 10.1007/s12671-016-0514-z

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,* 1063-1070.

Watts, F. N., McKenna, F. P., SHarrock, R., & Trezise, L. (1986). Colour naming of phobia-related words. *British Journal of Psychology, 77*, 97-108.

Wells, A. (1999) A cognitive model of generalized anxiety disorder. *Behavior Modification, 23,* 526-555.

Williams, J. M. G., Mathews, A., & MacLeod, C. (1996). The emotional Stroop task and psychopathology. *Psychological Bulletin, 120,* 3-24.

Zeidan, F., Johnson, S. K., Diamond, B. J., David, Z., & Goolkasian, P. (2010). Mindfulness meditation improves cognition: Evidence of brief mental training. *Consciousness and Cognition: An International Journal, 19*, 597-605. doi:10.1016/j.concog.2010.03.014

Zeidan, F., Johnson, S. K., Gordon, N. S., & Goolkasian, P. (2010). Effects of brief and sham mindfulness meditation on mood and cardiovascular variables. *The Journal of Alternative and Complementary Medicine*, *16*(8), 867-873.

Zylowska, L. (2008). Mindfulness meditation training in adults and adolescents with ADHD: A feasibility study. *Journal of Attention Disorders, 11*(6), 737-46.

APPENDICES

Appendix A

Negatively Valenced Words

1. Abuse
2. Afraid
3. Alone
4. Angry
5. Beaten
6. Blame
7. Burned
8. Cancer
9. Crash
10. Crisis
11. Cry
12. Danger
13. Dark
14. Defeat
15. Fatal
16. Guilt
17. Gun
18. Harsh
19. Hate
20. Hell
21. Horror
22. Hurt
23. Ill
24. Kill
25. Lonely
26. Murder
27. Pain
28. Panic
29. Poison
30. Poor
31. Sad
32. Shame
33. Shock
34. Stress
35. Suffer
36. Ugly
37. Useless
38. War
39. Worry
40. Wrong

Appendix B

Neutral Words

1. Agreed
2. Anchor
3. Autumn
4. Boat
5. Branch
6. Bread
7. Call
8. Coffee
9. Color
10. Core
11. Cover
12. Desk
13. Exceed
14. Field
15. Fish
16. Hill
17. Hot
18. Layer
19. League
20. Level
21. Link
22. Moon
23. Mouse
24. Note
25. Park
26. Pencil
27. Plate
28. Potato
29. Road
30. Rose
31. School
32. Send
33. Senior
34. Shop
35. Smooth
36. Solar
37. Tree
38. Truck
39. Wagon
40. Walk