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Evaluating the Effects of Mindfulness Practice on Attentional Control and Episodic Memory

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Evaluating the Effects of Mindfulness Practice on Attentional Control and Episodic Memory

by

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ABSTRACT

Mindfulness refers to a mental state of being that involves nonjudgmental acceptance of current cognitions and emotions with awareness of the present moment. Researchers and clinicians have shown the efficacy of mindfulness as a treatment for psychological disorders such as anxiety and depression and have found reductions in reported stress. Building on clinical benefits, mindfulness practice may also facilitate attentional processes as practitioners are required to inhibit distracting thoughts and re-direct their focus to the present moment. My thesis examined the relationship between mindfulness practice and attentional control and potential spillovers to episodic memory. Experiment 1 gauged the relationship between the frequency of practice and levels of mindfulness in day-to-day life to a battery of attentional control and episodic memory tasks. Experiment 2 evaluated the effects of a brief mindfulness intervention by having participants complete two 5 min sessions of mindfulness meditation followed by a battery of attention and memory tasks. This mindfulness group was then compared to a control group who completed a task that did not involve self-reflection and present awareness. No relationships were found between mindfulness and attentional control or episodic memory in Experiment 1. Relatedly, brief engagements in mindfulness mediation failed to benefit attentional control and episodic memory relative to the control group in Experiment 2, contradicting the prediction that brief mindfulness sessions would produce cognitive benefits.

Keywords: mindfulness, meditation, attentional control, episodic memory, working memory

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CHAPTER I – INTRODUCTION

Mindfulness meditation refers to the act of attending and being fully conscious of the present moment while maintaining a non-judgmental acceptance of any cognitions or emotions that occur (Marlatt & Kristeller, 1999). Though there are several types of meditation techniques, the practice typically involves deep breathing and self-reflection on one's present state which has been shown to produce physiological changes such as reductions in heart rate, blood pressure, and skin conductance (Goleman & Schwartz, 1976). Mindfulness practices are relatively new within Western society, but date back centuries, originating in East Asia from practitioners of Theravada and Mahayana Buddhism (Kabat-Zinn, 1982). Original practitioners emphasized rhythmic breathing to achieve a sense of inner peace, to contemplate life events, and self-reflect. While mindfulness originated as a religious practice, accumulating research over the past few decades has shown that secular mindfulness practice provides several psychological benefits. Many benefits impact mental health such as general stress reductions (Baer, Carmody, & Hunsinger, 2012; Ciesla, Reilly, Dickson, Emanuel, & Updegraff, 2012; Lagor, Williams, Lerner, & McClure, 2013), reductions in anxiety and depression, (Desrosiers, Vine, Klemanski, & Nolan-Hoeksema, 2013) pain (Zeidan, Grant, Brown, McHaffie, & Coghill, 2012), and treatment of eating disorders (Kristeller, Wolever, & Sheets, 2014). Although, the magnitude of some of the reported benefits of mindfulness interventions may be embellished due to publication bias and other pressures (see Schumer, 2018 meta-analysis, for review). Given the broad and successful therapeutic benefits of mindfulness meditation, a related question is whether mindfulness practice may also affect basic cognitive processes such as controlled attention and episodic memory, the latter of which requires a tuned attentional system to effectively encode and retrieve information. My thesis evaluates the relationship between mindfulness practice, attention, and memory by examining the frequency of mindfulness practice in a large sample and the potential benefits of a brief mindfulness-based intervention.

Like other forms of skill acquisition, mindfulness practitioners regularly engage in meditation with a goal of more efficiently and effectively achieving a mindful state in which the mind is stable and calm. To achieve this state, mindfulness practices are typically grouped into one of two approaches: The concentration-based and mindfulness-meditation approaches (Baer, 2003). Concentration-based approaches are categorized as the instruction of participants to direct their attention to a single stimulus throughout the session, such as a word, sound, or phrase, which is repeated until the session is concluded. When mind wandering occurs, the practitioner is redirected to the focal stimuli to contemplate it further, and no attention is paid to the nature of the thought that occurred during mind wandering (Delmonte, 1985). To exemplify, one may meditate to alleviate stress and silently repeat the phrase “this shall pass” throughout the session. When mind wandering occurs, attention is shifted back to the phrase and the process is repeated until the session is over.

Separately, mindfulness-meditation approaches are centralized on the experiences evoked within the individual when meditation begins, such as emotions and thoughts, and this meditation type emphasizes the nonjudgmental acceptance of cognitions as they occur rather than any specific goal-directed behavior (Baer, 2003). Additionally, mindfulness meditation emphasizes observations of stimuli that are constantly changing both internally and within the environment. It is paramount that one must be completely conscious of the present moment to achieve a mindful state. For example, a practitioner may be engaged in meditation with focus on the present moment, only to spontaneously recollect on an argument with a romantic partner from the previous week. Rather than labeling the event as positive or negative, the practitioner should merely acknowledge its presence and reengage with the present moment. Kabat-Zinn (1994) relates this state of mindfulness as sitting near a flowing stream in which one's thoughts represent the flowing water. Regardless of whether this stream is raging or slowly flowing, one should merely observe the thoughts moving by rather than being in the stream's current, as individuals often are in their thoughts in daily life.

The primary differences between the two approaches are the reactions to the stimuli that occur while meditating and the emphasis that is placed on the present moment. With concentration-based approaches, focus is restricted to a single stimulus and attention always returns to this stimulus when mind wandering occurs. Rather than emphasis being placed on consciousness of the present moment, emphasis is placed on the target stimuli which may emphasize selection-based attentional processes. Separately, mindfulness-meditation approaches operate to inhibit distracting thoughts that divert attention away from the present moment and the practitioner must inhibit these distractions and return attentional focus to the present moment if distractions cannot be overcome. Thus, mindfulness-based approaches might be more likely to use attentional control processes such as inhibition to avoid distracting thoughts and a selection process to focus on the practitioner's present state.

The research question of interest is therefore, how might mindfulness practice be linked to enhanced cognition? What features of mindfulness might lend themselves to improved attention? Components such as sustained attentional focus, inhibition of irrelevant distractions, and emotional regulation, are cognitive processes which are prioritized under mindfulness meditation. It is therefore possible that individuals who practice mindfulness meditation, particularly those who practice it regularly, may show enhancement for these attentional processes which may spillover to other tasks that require controlled processes, such as episodic memory (Wagner, 2002).

1.1 Attentional Control and Mindfulness

Attentional control systems involve the activation of relevant information and the control/inhibition of irrelevant information which can affect many aspects of cognition including memory and language (Balota & Duchek, 2015). Attentional control refers to an individual's unique ability to selectively process specific attributes (either internally or externally) for additional processing while simultaneously inhibiting competing attributes which may be more salient and includes working memory processes (Aschenbrenner & Balota, 2019; Jaeggi et al., 2003; Posner & Petersen, 1990). Given limits in the cognitive resources that are available to process environmental demands, the integrity of one's attentional control system is critical for ensuring task completion. This coordination of selection/maintenance and inhibition processes operates in tandem to ensure accurate and efficient behavioral functions. Thus, by design, mindfulness meditation engages attentional processes via controlled selection and inhibition.

Relatedly, working memory is a multi-component memory system which involves a capacity-limited memory store and an attentional process designed to prioritize information that is most relevant to the present (Baddeley & Hitch, 1974; Baddeley 1986, 1993; Engle, 2002). Individual differences in the capacity of this memory system are evident, as some individuals are more likely to hold a greater capacity of information over a delay. This ability to maintain information for use requestions the ability to inhibit off-task thoughts created endogenously and non-related events that occur in the external environment (Unsworth & Engle, 2007; Engle, 2018; Mashburn, Tsukahara, & Engle, 2020).

Several studies have shown that tasks that are generally thought to measure attentional control processes are often related to tasks though to measure working memory. For instance, the Stroop color naming task (Stroop, 1935), which utilizes processes such as inhibition and goal maintenance, has been shown to be sensitive to differences in working memory capacity (Kane & Engle, 2003). Participants with higher working memory capacity typically show faster latencies and higher accuracy for incongruent trials than those with lower working memory capacity. A converging pattern has been reported by Hutchison (2007) who found that Stroop performance loaded on the same factor as working memory capacity using a principal components analysis. Relatedly, studies on mind wandering have also shown sensitivities to differences in working memory capacity. Specifically, high (vs. low) working memory capacity participants were more likely to produce on-task thoughts when asked to report their cognitions at random over a one-week testing period (Kane, Brown, McVay, Silvia, Myin-Germeys, & Kwapil, 2007). Finally, Kane and Engle (2003; see too Kane et al., 2007), reported that participants with high working memory capacities, as assessed in the OSPAN task, showed an increase in cognitive processes such as attentional control, fluid reasoning, and short-term memory retention, including reductions in mind wandering.

Relevant to the present proposal, researchers have also reported some positive relationships between working memory capacity and mindfulness practice. Dubert, Schumacher, Locker, Gutierrez, and Barnes (2016) reported an increase in working memory capacity, as measured by the auto-OSPAN, in adolescents who completed eight 45-min sessions of mindfulness-based stress reduction (MBSR) over a 4-week period. The working memory increase was argued to occur due to MBSR increasing attentional maintenance on the present experience while inhibiting off-task thoughts. Additionally, other studies support this increased working memory capacity through regular mindfulness practice programs in both adolescent (Quach, Mano, and Alexander, 2016) and military populations (Jha, 2010). Similarly, Moore and Malinowski (2009), analyzed the relations between mindfulness, meditation, and cognitive flexibility and importantly, evaluated attentional control differences between individuals who frequently practiced mindfulness meditation (meditators) and individuals who did not (non-meditators). Results indicated that seasoned meditators performed better on both measures of attention (the Stroop task and the d2-concentration and endurance test) versus non-meditators. However, it is important to note that the meditator group consisted of Buddhist meditators who had minimally completed a 6-week meditation beginner course (and likely more meditation practice), whereas the non-meditators were individuals who worked at an office with no reports of meditation experience. Additionally, a meta-analysis by Fox et al. (2014) reported that neuroanatomical structures can be altered through long-term meditation practice, such as the orbitofrontal cortex, frontopolar cortex, and hippocampus, structures that are often related to attentional processes including encoding and retrieval of episodic long-term memory (Svoboda, McKinnon, &

Levine, 2006). Thus, meditation repetitions over time may produce attention-related benefits, and these benefits show promise to produce differences in functional connectivity in brain areas related to attentional and memory processes.

Similar benefits of mindfulness meditation have also been reported in a study that compared a group of mindfulness trainees who completed a 2-week mindfulness program, closely resembling MBSR therapy, relative to a control who completed a 2-week nutrition program (Mrazek, Franklin, Phillips, Baird, & Schooler, 2013). In the mindfulness group, participants were instructed about reaching a mindful state via meditation in sessions that occurred four times per week. Participants met four times per week during the mindfulness intervention and sessions consisted of 10 to 20 minutes of mindfulness practice which focused on physical posture and focused mindfulness meditation. Additionally, participants were instructed to partake in 10-minutes of mindfulness outside of class daily and were encouraged to incorporate mindfulness in their everyday activities. Consistent with attentional benefits reported above, mindfulness practice (vs. nutrition education) produced increases in GRE reading comprehension scores, working memory capacity (via the OSPAN task), and a reduction in reported mind wandering, suggesting that mindfulness benefits to cognitive processes extend beyond standard measures of working memory and occur after shorter mindfulness interventions.

Although engagement in mindfulness might produce some benefits, these patterns are not always consistent. For example, Lueke and Lueke (2019) compared a mindfulness and control group on tasks of verbal learning, memory, and attention. In the mindfulness group, participants were instructed to listen and follows along to a mindfulness meditation audiotape for 10-minutes which emphasized breathing and physical sensations in the present moment. For the control group, individuals listened to a 10-min audio clip describing an English countryside. The mindfulness group produced no improvements in measures of attention relative to the control group, indicating that brief mindfulness interventions may not benefit selective attention or attentional switching capabilities. However, the mindfulness group did show improvements in verbal learning and memory which was attributed to enhanced encoding. Similarly, Larson et al (2013) found no attentional benefits using a flanker task for individuals who completed 14 minutes of mindfulness meditation relative to a control group that listened to an instructional about ethics and relaxation. Overall, brief mindfulness interventions may be less likely to procure benefits to attention and memory despite some benefits found when long-term and repetitive interventions are used.

1.2 Episodic Memory and Mindfulness

In addition to working memory and attentional control processes, mindfulness meditation has also been examined in the context of long-term episodic memory which refers to a type of declarative memory which allows individuals to mentally “time travel” to past autobiographical events (Tulving 1983, 2002; Moscovitch, Cabeza, Winocur & Nadel, 2016). A key component of episodic memory is the recollection of contextual details that accompany the retrieved event. Recollections of contextual details from episodic memory are sensitive to individual differences in working memory and attentional control with source accuracy improving in high working memory individuals and in younger versus older adults (Wahlheim & Huff, 2015; Wahlheim, Alexander, & Kane, 2019). High-integrity attentional systems facilitate the encoding of contextual information at study by increasing the binding between context and event and aid retrieval by improving monitoring of episodic events for correct contextual information at test. Insufficient attention may increase the likelihood of context-related errors in episodic memory.

In a recent review, Levi and Rosenstreich (2019) described the effects of mindfulness on episodic memory in four domains: Attentional processes, contributions to sensitivity and bias via the signal-detection approach, contributions to dual memory processes, and the effects on memory accuracy by evaluating false memory errors. In terms of attentional processes, mindfulness may be associated with higher selective attention under conditions that require elevated levels of focus. For instance, Rosenstreich and Ruderman (2016) had participants completed a mindfulness questionnaire (FFMQ) to gauge trait-based mindfulness and then completed two recognition tests for sets of words. Full attention was used for the first set of words but divided for the second set at test encoding via a tone-classification task. When attention was divided, correct recognition scores decreased, however, a negative correlation between the nonjudgmental facet of mindfulness and false alarms was found in the main recognition test. This indicated that those with high nonjudgmental scores were less likely to falsely remember words that did not appear at encoding, improving memory accuracy. This nonjudgmental facet refers to an individual's ability to maintain a neutral mood regardless of the cognitions or stimuli they experience without attempting to suppress them. Thus, nonjudgement may be associated to attention as an individual's emotional valence connected to an idea or event may affect attention negatively, and the ability to maintain a neutral state would likely provide attentional benefits. Although overall mindfulness was not correlated to correct recognition, some facets of mindfulness may benefit episodic memory accuracy via error reduction.

Studies that evaluate mindfulness using the signal-detection approach evaluate memory processes on discriminability (i.e., sensitivity) and response bias. Discriminability is the ability to discern which items were studied (i.e., presented at encoding) versus unstudied (i.e., not presented at encoding), whereas bias is the favoring of one response type over another, regardless of the accuracy. There is no consensus on whether mindfulness consistently affects signal-detection parameters as results have been mixed. For instance, a brief mindfulness intervention has been shown to produce an increase in sensitivity (i.e., correct identification of studied items) after participants encountered a list of semantically associated words (Wilson, Mickes, Stolarz-Fantino, Evrard, & Fantino, 2015). However, other studies do not report the same sensitivity benefits with mindfulness when participants encountered word lists that are semantically unrelated (Rosenstreich, 2015; Rosenstreich & Ruderman, 2016). Thus, it is possible that the effect of mindfulness on recognition discriminability depends upon the semantic relationships between items at study. Separately, mindfulness appears to encourage a more liberal response bias as reflected in an increased propensity to classify memory candidates as studied than nonstudied (Rosenstreich 2015; Wilson et al. 2015). This bias may also reflect an increase in the propensity to make recognition responses using familiarity versus recollection-based processes (Yonelinas, 2002) as some evidence indicates that familiarity processes are strengthened via mindfulness interventions and recollection appears to be unaffected (Rosenstreich & Goshen-Gottstein, 2015;

Rosenstreich & Ruderman, 2017). Collectively, mindfulness may affect the type of memorial information processed by participants rather than affecting recognition broadly.

Finally, mindfulness may affect memory processes through the reduction in retrieval errors. In particular, proactive interference, which refers to a specific type of episodic memory error in which previously learned information interferes with the retrieval of more recently exposed information (Keppel and Underwood 1962), may particularly be affected by mindfulness. Research has shown that the hippocampus plays a role in successful resolution of proactive interference (Caplan, McIntosh, & De Rosa, 2007), which consistent with other evidence showing hippocampal/medial temporal lobe recruitment in episodic contexts, particularly when the memory task or stimuli are complex (see Ranganath, 2010, for review). Greenberg, Romero, Elkin-Frankston, Bezdek, Schumacher, and Lazar, (2019) examined whether proactive interference could be mitigated by mindfulness interventions and concurrently analyzed changes in hippocampal volume and activation. Participants either took part in a 4-week web-based mindfulness intervention or a creative writing control program. Interventions were visited 5 times a week by participants. As assessed by the Recent Probes proactive interference task (Jonides & Nee, 2006), a reduction in proactive interference errors was found in the mindfulness intervention group relative to the control. Further, an increase in grey matter density within the hippocampal region was observed following an 8-week mindfulness training program (Holzel, Lazar, Gard, Schuman-Olivier, Vago, & Ott, 2011). Thus, mindfulness interventions may benefit episodic memory accuracy by resolving proactive interference through enhanced activation and/or increased hippocampal volume.

In sum, mindfulness meditation may benefit both in the enhancement of attentional control/working memory and episodic memory via familiarity-based processes, promoting discriminability, and/or reducing interference. Despite these reported patterns, studies examining the effects of mindfulness on attentional control and episodic memory remain sparse with most studies using long-term interventions of mindfulness rather than examining potential short-term benefits of engaging in mindfulness. Additionally, most studies do not examine the effects of mindfulness on both attentional control and episodic memory concurrently. Given the well-documented relationship between attention and memory (Brown & Craik, 2000), one possibility is that mindfulness benefits on episodic memory may be mediated by improvements in attentional control. That is, to the extent that mindfulness facilitates attentional control, these benefits may spillover to episodic memory. The purpose of the present study was to therefore examine the benefits of mindfulness on attentional control and episodic memory concurrently by assessing attention and memory processes on a large sample of participants who may engage in mindfulness meditation spontaneously and by evaluating the effects of a mindfulness intervention (vs. a control) on participants who complete short sessions of meditation.

1.3 Present Study

The purpose of Experiment 1 was to examine the relationship between trait mindfulness and the frequency with which individuals practice mindfulness meditation spontaneously in their everyday lives and to assess the relationship between attentional control and episodic memory functions. Mindfulness was assessed through two questionnaires, the FFMQ (Baer et al., 2008) and the MAAS (Brown & Ryan, 2003), to measure self-reported qualitative aspects of mindfulness practice, and the tendency to be in a mindful state. Frequency of mindfulness practice are also assessed. To assess attentional control and working memory, participants completed the Stroop color-naming task (Spieler, Balota, & Faust, 1996) and the operation span task (OSPAN; Foster et al., 2015). Finally, participants completed the dual-list interference paradigm (Wahlheim & Huff, 2015), an episodic memory task that evaluates both proactive and retroactive interference. The dual-list paradigm has been sensitive to attention-related population differences such as younger versus older adults (Wahlheim, Richmond, Huff, & Dobbins, 2016) and is sensitive to working memory individual differences (Wahlheim et al., 2019). Given the reported relationship between mindfulness and proactive interference (Greenberg et al., 2019), the dual-list paradigm may be sensitive towards subject-level differences in engagement in mindfulness practice. Relationships between attentional control, episodic memory, and spontaneous mindfulness practice were assessed.

Experiment 2 evaluated the efficacy of a brief mindfulness intervention on attentional control/working memory and episodic memory by comparing participants who completed two short 5 min mindfulness-based breathing exercises relative to a control group who listened to an audio recording of Bob Ross painting split in two 5 min sessions. Participants then completed the attentional control battery used by Hutchison (2007) which included the Stroop task, the OSPAN, and the antisaccade visual search task (Kane, Bleckley, Conway, & Engle, 2001), in which participants must visually inhibit a distractor to search for a target. Additionally, participants completed the consonant/vowel-odd/even (CVOE) switch task (Minear & Shah, 2008) which evaluates the cost of deploying multiple task sets. The CVOE task presents participants with a bivalent stimulus (e.g., B-06) in which participants must classify the letter as a consonant or vowel or the number as odd or even in which the classification instructions switch across trials. Participants completed a block of trials that contained only a single task set (CV or OE) termed the pure block, and a block of trials in which the CV and OE trials switch randomly termed the switch block. Response latencies and errors typically increase when trials switch from one task set to another compared to repeated non-switch trials in the switch block, a difference termed the local switch cost. Separately, the difference in latencies and errors between nonswitch and pure trials is termed the global switch cost (Belleville, Bherer, Lepage, Chertkow, & Gauthier, 2008; Tse, Balota, Yap, Duchek, & McCabe, 2010). Local switch costs are typically accounted for as a task-set reconfiguration cost as individuals adjust to changing task sets, whereas the global switch cost reflects the additional processing due to maintaining two task sets even though the task set was repeated (Rogers & Monsell, 1995; Wylie & Allport, 2000). Although both local and global switch costs have been shown to be sensitive to attention-related population differences including older versus younger adults, older adults with dementia of the Alzheimer's type compared to age-matched healthy controls (Huff**,** Balota, Minear, Aschenbrenner, & Duchek, 2015), we home in on local switch costs, particularly errors, which are typically greater on the more challenging switch trials which are most sensitive to attention-related declines. Thus, if mindfulness meditation improves attentional control, a similar benefit would be expected on error rates on switch trials. Experiment 2 therefore experimentally evaluated whether brief exposures to mindfulness practice could produce immediate benefits to attention and memory processes.

CHAPTER II – EXPERIMENT 1: RELATIONSHIP BETWEEN MINDFULNESS PRACTICE AND COGNITION

The goal of Experiment 1 was to evaluate the relationship between frequency with which individuals practice mindfulness and achieve a mindful state and attentional control and episodic memory. In this experiment, participants were instructed to complete two questionnaires measuring trait mindfulness and mindfulness practice frequency followed by assessments of attentional control/working memory (Stroop and OSPAN) and the dual-list recall task to assess episodic memory. Given that the previous literature indicates relationships between mindfulness, attentional control, and episodic memory, Experiment 1 contained 3 hypotheses concerning the relationships between these variables.

H_1: Relationship between attentional control and episodic memory. I predict a positive relationship between attentional control/working memory, and performance on the dual-list interference task. This prediction was based on Wahlheim et al. (2019) who found a positive relationship between memory accuracy and working memory due in part to a reduction in interference for high working memory individuals.

H_2: Relationship between mindfulness, attentional control, and episodic memory. Additionally, I predict that individuals who practice mindfulness meditation more frequently and with higher quality (i.e., deeper meditation, longer meditation, etc., as indicated on the mindfulness questionnaires) will be more likely to produce higher rates of attention and episodic memory as assessed by the OSPAN, Stroop, and dual-list tasks.

H_3: Relationship between mindfulness and episodic memory meditation. Finally, I predicted that the relationship between mindfulness and episodic memory would be mediated by attentional control. Figure A.1 plots this predicted mediation model.

2.1 Method

Participants

One-hundred-fifty participants were recruited for the study. The sample consisted of undergraduate students from The University of Southern Mississippi (*n* = 100) and individuals recruited from Prolific (*n* = 50; Palan & Schitter, 2016) who were required to have a minimum high school education. Undergraduate student participants were recruited both online (*n* = 43) or in-person (*n* = 57) and were compensated with course credit[1]. Prolific participants only participated online were compensated with $6.00 each to complete the study. Due to a technical error, data was unavailable for a single participant in two tasks (the Stroop and Dual List Task) and thus was only included in analyses in which the tasks were available. A sensitivity analysis using G*Power (Faul et al., 2007) indicated that the sample size has adequate power (.80) to detect small relationships of *r* = .20 and higher (two-tailed).

[1] Testing location (online vs. in-person) was tested as a covariate in all results reported. Location was not found to be a reliable covariate and therefore all analyses collapse across testing location.

Materials

Mindfulness Questionnaires

Self-report questionnaires on mindfulness meditation practice were used to gauge the tendency of engaging in a mindful state in daily life and the frequency and duration that participants practice meditation. Specifically, participants completed the Mindfulness Attention Awareness Scale (MAAS; Brown & Ryan, 2003), a 15-item Likert-type assessment that measures levels of trait mindfulness by asking participants questions regarding how they respond to stimuli or experiences in their daily life (e.g., “I do jobs or tasks automatically, without being aware of what I'm doing.”). Responses are made using a 1-6 Likert scale. Participants further completed the 15-item Five Facets of Mindfulness Questionnaire (FFMQ-15; Baer et al., 2008), a short-form version of the FFMQ-39 designed to assess five distinct facets of dispositional mindfulness as follows: observing (ability to pay attention to one’s feelings and surroundings), describing (ability to communicate thoughts and/or feelings), acting with awareness (degree of aware of sensations and stimuli within oneself and environment), non-judging (acceptance of thoughts and cognitions as they are - neutrality), and non-reactivity (ability to inhibit thoughts, emotional expressions, and physical actions). Responses are made using a 1-5 Likert scale. Finally, a separate question asked participants to estimate the frequency of mindfulness-based mediation practice as well as duration in hours per week. The two scales and the frequency estimation question are listed in Appendix B.

OSPAN Task

The OSPAN task was taken directly from Foster et al. (2015). In this task, participants viewed and were instructed to read aloud mathematical strings (e.g., (5 × 4) –

6 = ?) and compute answers silently to themselves. Once a solution was computed, participants then clicked the mouse which directed them to another screen with a solution (e.g., 13) with instructions to select "yes" if the solution was correct, and "no" if the solution was incorrect. Once a response to a solution was made, a single letter was displayed for 1000 ms (e.g., K) followed by another mathematical string. This procedure was repeated for 2-7 mathematical strings/letters (i.e., spans) and followed by a serial recall test in which letters were recalled in the order in which they appeared by clicking on letter-labeled boxes on the screen. This procedure was repeated for two blocks containing 7 trials, with each span length tested once per block. Span lengths were presented randomly for each participant. Participants were instructed to place equal emphasis in mathematics/memorization portions of the task and required to maintain an 85% accuracy on the math portion. Accuracy feedback on math problems were provided at the end of each trial.

Stroop Color-Naming Task

Stroop stimuli was taken from Spieler et al. (1996) and included four color words (green, red, blue, and yellow) and four neutral words (bad, deep, legal, and poor) that were presented in one of the four colors. Participants were asked to identify the color that each word is presented in. Responses were made via key press in which four keys corresponded to each of the colors which are spaced evenly across the keyboard ("z", "v", "m", and "/"). Response latencies were assessed when the key was depressed (vs. released) and accuracy was computed based on the proportion of trials with a correct color classification. A total of 130 trials were presented which included 10 practice trials and 120 experimental trials. Practice trials consisted of 3 incongruent trials (word/color mismatch), 4 congruent colors (word/color match), and 3 neutral trials (words unrelated to color). Experimental trials consisted of 48 neutral trials (each neutral trial displayed 12 times in each color), 36 congruent trials (each color word presented 9 times in each color), and 36 incongruent trials (each color word presented 12 times in the other incongruent color). Practice and experimental trials were presented in a once randomized order that was fixed across participants. Additionally, to minimize participant fatigue, experimental trials were parsed into 30 blocks of 40 trials and spaced by a self-paced rest break.

Dual-List Recall Task

The dual-list recall task was based on Wahlheim and Huff (2015). In this task, participants studied 2 lists taken from the same semantic category with each list containing 8 words. Each word was displayed for 2 s. Participants were asked to remember each word for a later recall memory test. A screen labeled “List 1” preceded the first list and a screen labeled “List 2” immediately followed List 1 and preceded the second list. Both screens were presented for a 2 s duration. Following the presentation of the second list, participants were immediately presented with instructions to recall words from either List 1 (to assess retroactive interference) or List 2 (to assess proactive interference). Participants were given 1 min to recall as many words from the queried list as possible in any order. After completing the recall task, participants were instructed to repeat this procedure for an additional 7 sets of lists (8 total) in which 4 sets tested List 1, and 4 sets tested List 2. Lists were taken from the Battig and Montague (1969) categorical word norms and consisted of items from the four-footed animals, furniture, utensils, profession, sports, building, fruits, and birds, categories.

Procedure

The study was administered online using both E-Prime GO software (Psychology Software Tools, 2020) to collect response latencies and accuracy for the attentional control and episodic memory tasks, and Collector software (Garcia et al., 2015) to collect responses to the mindfulness questionnaires and demographics. Following informed consent, participants completed a brief demographics questionnaire (gender, age, years of education, and ethnicity) and the mindfulness measures (MAAS, FFMQ and estimated frequency of mindfulness practice). Then participants completed the OSPAN, Stroop, and the dual-list recall task. The order was the same across participants, and participants clicked a link in the Collector program which redirected them to E-Prime GO to begin each task. For the OSPAN task, participants were provided with task instructions, a brief training on how to complete the task, followed by the experimental trials. Following the OSPAN task, participants completed the Stroop task, which included a brief description of the task with instructions to classify the color for each of the words as quickly as possible without compromising accuracy by pressing one of 4 color-mapped keys. Participants then completed the dual-list task in which participants were instructed in advance that they would study two lists but would randomly be tested on one only after both lists were presented. Following completion of the cognitive tasks, participants were provided with a debriefing screen consisting of study information as well as the purpose of the study and then received compensation for their participation. The study lasted approximately 35 - 45 minutes.

2.2 Results

Mindfulness Measures

FFMQ scores were computed by averaging the total scores for the 15 questions. Questions were rated on a 5-point Likert scale (1 - never or very rarely true, 5 - very often or always true). Items 3, 4, 7, 8, 9, 13, and 14 were presented in reverse scales and were transformed before data analysis. The FFMQ had a mean score of 2.95 (*Range* = 2.39–3.53) and had acceptable reliability (α = .61). The MAAS score had a mean of 3.28 (*Range* = 2.74–3.64) and had acceptable reliability (α = .81; see Table A.1 for each of the mean scores across measures and tasks).

Attentional Control Tasks

OSPAN scores were computed as the total number of letters correctly recalled in serial order for each of the 2-7 span trials (i.e., partial span) across 2 blocks resulting in a possible maximum span score of 54 (*Range* = 1-50). Performance was not conditionalized based on math performance though few of the participants scored lower than the 85% correct that was requested in the instructions. Stroop analyses computed reaction times (RTs) and percent errors for the three trial types (congruent, neutral, and incongruent). Proportion of errors on incongruent trials were the primary dependent measure, as incongruent trials are more attentionally demanding and produce the highest error rates of the three trial types.

Dual-List Task

Dual-List Task analysis computed correct recall rates, interference rates (retroactive and proactive), and total intrusions rates from the two intrusion types (interference or non-presented items). For the analyses, the proportion of correct recall was the primary dependent measure to remain consistent with previous analyses using this paradigm (Huff & Walheim, 2015). No differences were found between proactive and retroactive lists (.58 vs. .57, for proactive and retroactive lists, respectively), $t < 1$, and no differences in intrusion rates were found between proactive and retroactive lists, (1.65 vs. 1.48) $t < 1$. Subsequent analyses therefore collapse across proactive and retroactive interference types.

Principal Component Analyses

The three mindfulness measures (FFMQ, MAAS, and frequency estimates) were initially submitted to a principal components analysis to examine factor loadings across variables. A single component was identified which accounted for 49.17% of variance across measures, frequency had a poor factor loading of .083. Given this poor loading, a second principal components analysis was conducted that only included the FFMQ and MAAS. Again, a single component was identified which accounted for 73.65% of variance across both measures which was attributed to daily states of mindfulness. From this analysis, a standardized component score was derived which was used in subsequent analyses to examine attention and memory relationships with mindfulness.

A component score was similarly extracted for attentional control using a principal components analysis. Both attentional control tasks were analyzed by including the mean error rate for incongruent trials in the Stroop task and the partial score from the OSPAN for each participant. A single component was extracted which accounted for 52.57% of variance across both task types (see Table 2 for factor loadings). Like the mindfulness questionnaires, a standardized component score was derived and used in subsequent analyses.

Correlations

Bivariate correlations were computed to examine the relationships between variables (Table A.3). Only one significant relationship was found. A relationship between the attentional control composite and episodic memory (r = .191 p = .019). However, no significant relationships were found between the mindfulness composite and attentional control composite (r = -.136 p = .098) or the mindfulness composite and dual-list recall performance (r = - .142 p = .083), in contrast to predictions $\mathbf{H_2}$ and $\mathbf{H_3}$. Given that the direct relationship between mindfulness and episodic memory was not in evidence, no mediation analysis was conducted.

Bivariate correlations were computed to examine the relationship between the five dispositional aspects of mindfulness (i.e., FFMQ) and attentional control and episodic memory. A few significant relationships were found between dispositional aspects of mindfulness and some attention/episodic memory measures. Specifically, negative relationships between describing and OSPAN performance (r = - .170 p = .04) and describing and dual-list recall performance (r = - .167 p = .04). However, no significant relationships were found between the other facets and measures of attention/episodic memory.

2.3 Discussion

The purpose of Experiment 1 was to evaluate potential relationships between everyday levels of mindfulness, the estimated frequency of mindfulness meditation practice, and attentional control and episodic memory functions. To ensure reliable measures of mindfulness and attentional control, principal components analyses were used to derive component scores for mindfulness and attentional control which combined mindfulness questionnaires and attentional control tasks. Following these analyses, bivariate correlations revealed that trait mindfulness measures were not correlated with either attentional control or episodic memory, contrary to hypotheses **H_2** and **H_3**. Although further analyses indicated that there may be a weak relationship between the ability to describe one's thoughts and/or feelings (i.e., aspect of describing in FFMQ) and attention through working memory, as assessed through the OSPAN, and episodic memory. A positive relationship was found however between attentional control and episodic memory as assessed by dual-list recall, which replicates prior work (Wahlheim et al., 2019) and is consistent with **H_1**. Overall, these findings suggest that an individual's tendency to be in a mindful state and the frequency of mindfulness practice were not associated with attentional control and episodic memory.

Although the unreliable relationship between reported mindfulness and episodic memory and attentional control were inconsistent with predictions, it is possible that these null patterns may be due to participants not achieving a mindful state while completing the cognitive tasks. As reviewed in the Introduction, regular mindfulness practice has been shown to improve performance on cognitively demanding tasks (Dubert et al., 2016; Moore and Malinowski, 2009; Mrazek et al., 2013), and therefore one may need to achieve a mindful state or achieve a mindful state regularly to procure cognitive benefits. In Experiment 1, no relationship was found between self-reported frequency of mindfulness practice and attentional control (r = -.02, p = .85) and frequency of practice and dual-list recall (r = .05, p = .51), however, reported frequency of practice was quite low (M = 0.98, *Range* = 0-14), which suggests that participants may not have sufficiently achieved a mindful state with any regularity that would have affected task performance.

This possibility is tested in Experiment 2 by implementing a mindfulness intervention in which individuals engaged in two bouts of mindfulness meditation while completing attentional control and episodic memory tasks. If a mindful state is a requisite for cognitive benefits, training individuals on mindfulness and having them engage in mediation should improve performance relative to a control group that does not engage in mindfulness.

CHAPTER III – EXPERIMENT 2: MINDFULNESS INTERVENTION ON ATTENTION AND MEMORY

The goal of Experiment 2 was to determine whether two brief 5 min mindfulness sessions would provide benefits on attention control and episodic memory across participants relative to a control condition which engaged in a restful activity that did not require achieving a mindful state. Participants in the mindfulness meditation sessions were calmly instructed to be present in the moment and to concentrate on their breathing and bodily sensations as they occurred throughout the session by an audio recording of Jon Kabat-Zinn. Unlike Mrazek et al. (2013), who used a nutritional log as a control task, the control task in Experiment 2 was carefully chosen to allow for a restful activity that did not provoke internal reflection but rather had participants focus on some sort of external process. Specifically, control participants were presented with an audio clip depicting Bob Ross painting a secluded bridge (Janson, 2016) and participants were tasked with mentally visualizing the painting that was described. To note, this control was chosen to match the active participation in a task and the audio modality of the guided meditation. Like Experiment 1, participants completed a battery of attentional control/working memory assessments consisting of the OSPAN and the Stroop color-naming task. However, as the testing setting changed to in lab due to the interventions, an additional two attentional control measures were included to provide a better assessment of attentional processes. Thus, Experiment 2 also assessed attentional processes using the antisaccade visual inhibition task (Kane et al., 2001), and the CVOE task-switching paradigm (Huff et al., 2015). Participants also completed the same dual-list interference task as an episodic memory measure (Wahlheim and Huff, 2015).

H_1: Interventions effects on attentional control. I predicted that the mindfulness intervention would improve performance in all measures of attentional control relative to the control group. This prediction was based on Mrazek et al., (2013) who found an increase in working memory and reduced mind-wandering after individuals completed a 2-week mindfulness training program when compared to a control program.

H_2: Interventions effects on episodic memory. I predicted that the mindfulness intervention would improve episodic memory performance as assessed in the dual-list recall task, relative to the control intervention. Thus, I expected to find that episodic memory can be improved through a brief mindfulness intervention. This prediction is based on Leuke and Leuke (2019) who found an increases in verbal learning and memory through enhancements of the encoding process, rather than storage and/or retrieval processes after individuals listened to a 10-minute audiotape of mindfulness meditation when compared to a control task.

3.1 Method

Participants

University of Southern Mississippi undergraduates participated in Experiment 2 and were compensated with partial course credit. Participants were randomly assigned to either the mindfulness intervention group (n = 46) or the control group (n = 45). Due to a technical error, mindfulness data were unavailable from three participants (FFMQ, MAAS, and frequency estimates) and thus were not included in correlational analyses with the mindfulness measures. A sensitivity analysis using G*Power (Faul et al., 2007) indicated that the sample yielded adequate power (.80) to detect medium sized group differences of Cohen's d = 0.53 or larger.

Materials

Participants similarly completed an attentional control battery to measure attentional control working memory. This battery consisted of the OSPAN (Foster et al., 2015) and Stroop tasks (Spieler et al., 1996) as used in Experiment 1, but also included computerized versions of the antisaccade (Kane et al., 2001; Hutchison, 2007) and CVOE switch task (Huff et al., 2015). These measures were conducted using a computer running E-Prime software. The dual-list recall task (Huff & Wahlheim, 2015) used in Experiment 1 was again used in Experiment 2. All demographics and mindfulness measures were

Antisaccade Task

The antisaccade task was based on a version used by Kane et al. (2001) and Hutchison (2007). Participants were instructed with looking at a fixation point on the center of the computer screen where they were informed that a large asterisk would be presented on the far left or far right side of the screen randomly and at the same horizontal level as the fixation point. Participants were instructed that once the asterisk was detected in their peripheral version, to quickly look away from the asterisk to the opposite side of the screen to detect a capital "O" or "Q" target letter that was presented. They were informed that the target would be presented briefly and covered up by a mask (##) and that their task was to report the correctly presented target letter by pressing the "O/Q" labeled keys on the keyboard, guessing if necessary. Trials were given with the presentation of a fixation point (+) which was centered on the screen for either 1000 or 2000 ms prior to the presentation of the asterisk. This timing difference varied randomly and was implemented to make the timing of the asterisk presentation unpredictable. After the 1000 or 2000 ms delay, a large asterisk presented in 20 pt. font appeared on the left or the right side of the screen for 300 ms. The target immediately followed the asterisk and was displayed for 100 ms followed by the mask which remained on the screen for 5000 ms or until the participant entered in their “O” or “Q” response. If no response was entered during this time, participants were presented with a feedback screen that stated “No Response Detected” to encourage correct responding on future trials. Participants were given a total of 64 trials which included 16 practice trials and 48 experimental trials. The experimental trials were divided into 3 blocks of 16 trials with a self-paced rest break presented between each block. Fixation durations and target letters were equally distributed across practice and experimental trials.

CVOE Task

The CVOE task was taken directly from Huff et al., (2015). In this task, participants were exposed to a bivalent letter/number stimulus pair (e.g., O 27) each trial, and two instructions sets were given, either participants were to classify the stimuli letter a consonant or vowel (C/V) or classify the number as either odd or even (O/E). The letters used in the bivalent stimuli that participants could be exposed to were split into 5 vowel and 5 consonants (e.g., A, D, E, H, I, J, O, P, S, U). Whereas the numbers were randomly shuffled from 1-99, again distributed evenly among odd and even numbers. Either the words consonant/vowel or odd/even were presented at the top left and right corners of the computer screen, which instructed participants to response to either the letter or the number dimension of the stimulus. Participants were instructed to press the “d” key on the keyboard when responding either consonant or odd, and the “k” key when responding either vowel or even. Each block consisted of correct responses that were distributed equally between the two keys. 24-point Courier New font was used for the bivalent stimuli. Trials were presented without an intertrial delay. Stimuli pairs were allowed to repeat throughout a block, but they could not repeat consecutively.

Participants were initially exposed to 10 test trials with feedback and then completed 3 blocks. The order of the blocks were always 2 pure blocks and then 1 switch block. A participant was either instructed to focus on classifying a single stimuli type (letter or number) throughout a block (Pure Block). Alternatively, participants may have been instructed to shift focus and classification from letter to number or number to letter, in the same block (switch block). The first pure block always consisted of C/V trials, followed by a block of O/E trials, and each consisted of 48 trials. Whereas the switch block contained 60 trials with a cue in every trial given above the stimuli pair indicating whether a number or letter was to be classified. Trials were run in an alternating run sequence in which cues for one trial were presented successively and then switched to the other trial type that was run successively (e.g., CV, CV, OE, OE, CV, CV, OE, OE …). This occurred continuously until completion of the block. Participants were asked to respond to each trial as soon as possible, without compromising accuracy.

Procedure

Experiment 2 was administered using E-Prime 3 software (Psychology Software Tools, 2016) to collect response latencies and accuracy for the attentional control and episodic memory tasks. All testing was conducted in-lab with an experimenter present. Participants were tested individually. Following informed consent, participants completed the same mindfulness measures from Experiment 1 (MAAS, FFMQ, and mindfulness frequency estimation), which was followed by the mindfulness/control intervention and attentional control and episodic memory tasks. Participants completed the same order of the following tasks: Intervention 1, OSPAN, Stroop, dual-list recall, Intervention 2, Antisaccade, and CVOE. A diagram depicting the tasks and their ordering is presented in Figure A.2. During Intervention 1, participants completed either the mindfulness-mediation practice or the control task depending upon their randomly assigned group. This intervention was completed for 5 min. A second intervention (Intervention 2) was completed at approximately the midpoint of the experiment and was designed to be a "booster" session for either the mindfulness intervention or the control task. Intervention 2 was identical to Intervention 1. The mindfulness intervention was an audio excerpt of a guided body-scan meditation led by Jon Kabat-Zinn, which closely followed meditations in MBSR programs (Sounds True, 2019). Prerecorded guided meditations were chosen to ensure the same quality of each mindfulness intervention session and eliminated confounds that may appear in experimenter led interventions. The 10-min audio excerpt was taken from an audiobook filled with a variety of guided meditations (Kabat-Zinn, 2002). The control intervention consisted of an audio clip of Bob Ross painting a secluded bridge with vivid detail given about the process (Bob Ross, 2016). Participants were instructed to visualize the act of painting the bridge during the presentation. The control task was designed to provide a non-active task (like mindfulness), but without the promotion of self-reflection and present focus that is characteristic of mindfulness meditation. Following each intervention, participants were asked to rate how engaged they were during the intervention and regardless of answer given this would not affect their compensation received. Following completion of the tasks, participants were provided with a debriefing screen consisting of study information as well as the purpose of the study and then received compensation for their participation.

3.2 Results

Mindfulness Measures

Both FFMQ and MAAS scores were computed the same as in Experiment 1. The overall FFMQ mean was 3.20 (*Range* = 2.87–3.64) and the MAAS mean was 3.55 (*Range* = 2.90-4.28) and both had acceptable reliabilities (α = .74 and α = .87 for the FFMQ and MAAS, respectively) Table A.1 displays the mean scores for each of the measures and tasks in Experiment 2.

Attentional Control and Dual-List Tasks

The OSPAN, Stroop, and dual-list tasks were analyzed as in Experiment 1. Again, analyses of the dual-list tasks indicated no differences between proactive and retroactive lists (.77 vs. .78, for proactive and retroactive lists, respectively) $t < 1$, and no differences in intrusion rates were found between proactive and retroactive lists (1.33 vs. 1.22) $t < 1$. Subsequent analyses therefore collapse across proactive and retroactive interference types. For the antisaccade task, the primary measure was accuracy which was computed by taking the total number of correct target classifications, divided by the total number of non-practice trials (48). Accuracy ranged from 38-98% across participants and chance performance was 50%. For the CVOE, the primary measure was the proportion of errors on switch trials in the switch block which were the most demanding due to participants switching tasks sets (i.e., task-set reconfiguration; Rogers & Monsell, 1995). Therefore, CVOE analyses were consistent with the Stroop task in that only the error rates for the most challenging trials were used in the analyses.

Principal Components Analysis

As in Experiment 1, the three mindfulness measures (FFMQ, MAAS, and frequency estimates) were submitted to a principal components analysis to examine factor loadings across variables. A single component was identified which accounted for 53.89% of variance across measures, but again frequency had a poor factor loading of -.072. Given this poor loading, a second principal components analysis was conducted that only included the FFMQ and MAAS (as in Experiment 1). Again, a single component was identified which accounted for 80.72% of variance across both measures which was attributed to daily states of mindfulness. From this analysis, a standardized component score was derived which was used in subsequent analyses to examine attention and memory relationships with mindfulness.

As in Experiment 1, a component score was similarly extracted for attentional control using a principal components analysis. A single component was extracted which accounted for 36.70% of variance across task types which was attributed to attentional control. Both the OSPAN and Antisaccade tasks loaded positively with higher scores indicating greater levels of AC (i.e., greater span scores and greater accuracy). Whereas Stroop incongruent trial errors and CVOE switch trial errors loaded negatively as greater error rates were indicative of lower attentional control. Like the mindfulness questionnaires, a standardized component score was derived and used in subsequent analyses (see Table A.2 for factor loadings).

Mindfulness vs. Control Group Comparisons on Attention and Memory

Mean composite scores for individual attentional control tasks and dual list task performance for the mindfulness group and control group are presented in Table A.5.

Regarding attentional control composites, there were no differences in the mindfulness group relative to the control group (.08 vs .09), $t < 1$, $p = .43$, which reflected no benefit from mindfulness practice on attentional control. Like attentional control, there was also no difference between the groups on dual list recall (.55 vs .55), $t < 1$, $p = .99$. Taken together, brief mindfulness interventions produced no attentional control or episodic memory boosts relative to the control interventions.

Correlations

Although not a primary goal of Experiment 2, bivariate correlations were computed (Table A.4). Consistent with Experiment 1 a relationship between the attentional control composite and episodic memory was found ($r = .519$ $p < .001$); however, no significant relationships were found between the mindfulness composite and attentional control composite ($r = .133$ $p = .209$) or the mindfulness composite and dual-list recall performance ($r = .054$ $p = .614$). Again, given that the direct relationship between mindfulness and episodic memory was not in evidence, mediation was not conducted.

Like Experiment 1, bivariate correlations were computed to examine the relationship between the five dispositional aspects of mindfulness (i.e., FFMQ) and attentional control and episodic memory. Experiment 2 indicated a few significant relationships found between dispositional aspects of mindfulness and attentional control. A positive relationship between describing and OSPAN performance ($r = .221$ $p = .04$) was found but was in the opposite direction as in Experiment 1. Additionally, a positive relationship was found between awareness and OSPAN performance ($r = .293$ $p = .006$), which was not found in Experiment 1. To note, the inverse relationship between describing and dual-list recall performance did not replicate from Experiment 1. No significant relationships were found between the other facets and measures of attention (*p*s >.05). Additionally, a significant positive relationship was found between observing and dual-list performance ($r = .273$ $p = .011$) which was not found in Experiment 1. To note, these correlations were conducted for individuals after completing interventions that may have affected the results.

Additionally, correlations were conducted measuring participant's perceived engagement to the mindfulness or control intervention and performance, and there were no significant relationships found (all *p*s > .30). This indicated that an individual's subjective report of engagement was not related to performance on attention/episodic memory measures.

3.3 Discussion

Experiment 2 examined whether two 5-minute mindfulness meditation sessions would produce benefits to attentional control and/or episodic memory relative to a task. Between-group comparisons revealed that individuals who completed mindfulness meditation before attention and episodic memory tasks did not receive a boost in performance. Similar null patterns were found regardless of participants reported engagement in mindfulness, suggesting effort given towards achieving a mindful state may not have been a contributing factor. Between-group comparisons are inconsistent with our initial hypotheses $\mathbf{H_1}$ and $\mathbf{H_2}$ but align with the results reported in Experiment 1. Although, results from the between-groups comparison are consistent with Leuke and Leuke (2019), who similarly reported no differences in attentional control using a selective attention measure (i.e., color-word interference test: CWIT) and an attention-switching measure (i.e., trail making test: TMT) following a brief mindfulness intervention.

Although not an initial goal of Experiment 2, bivariate correlations were conducted, and similar null relationships were found between trait mindfulness and both attentional control and episodic memory, providing additional evidence that trait mindfulness as assessed by the MAAS and FFMQ composite are not related to attentional control and episodic memory, as in Experiment 1. Additionally, another positive relationship was found between attentional control and episodic memory supporting prior work regarding the relationship between controlled processes and episodic memory (Wahlheim et al., 2019).

Also, an interesting note is the positive relationship found between the facet of describing and OSPAN performance indicating mindfulness and working memory are related to weakly through this dispositional facet of mindfulness. Although a relationship was found in Experiment 1 between these variables, the relationship was reversed in Experiment 2. However, unlike Experiment 1, a significant relationship was found between the mindfulness composite and OSPAN performance, indicating trait mindfulness is positively associated to working memory, a relationship that is supported by previous research (Jha, 2010; Mrazek et al., 2013; Quach & Alexander, 2016). Thus, Experiment 2 further suggests that trait mindfulness and the frequency of mindfulness practice are not associated with attentional control and episodic memory. Overall, Experiment 2’s findings suggest that when a mindfulness state is induced through brief meditation practice before cognitively demanding tasks, increases in performance are not observed, specifically in tasks associated with attention or episodic memory relative to a non-mindful control task.

CHAPTER IV – GENERAL DISCUSSION

The primary goal of my thesis project was to evaluate the effects of trait mindfulness and brief mindfulness practice on cognitive processes, specifically attentional control and episodic memory. In Experiment 1, I examined the relationship between everyday levels of mindfulness and the estimated frequency of mindfulness meditation practice on attentional control and episodic memory functions. As past research has not found consistent relationships between mindfulness practice and cognitive processes, my project further examined these variables using self-report frequency of mindfulness practice and a mindfulness intervention. In Experiment 1, trait mindfulness was found to have little-to-no relationship with attentional control when based on self-reported mindfulness practice. Additionally, the dispositional aspects of mindfulness (i.e., sub-facets of the FFMQ) were generally unrelated to either attentional control or episodic memory, with an exception to describing. Although the relationship found between describing and attentional control (through the OSPAN task) in both experiments was small and contradicting. Whereas the significant relationship between describing and episodic memory was only found in Experiment 1. Thus, the relationships were difficult to interpret. The unreliable relationship found between mindfulness and attentional control is somewhat inconsistent with past research that found individuals who practiced mindfulness daily over an extended duration showed some cognitive benefits in intervention studies (Moore and Malinowski, 2009; Mrazek et al., 2013; Dubert et al., 2016). Though it is important to note that individuals in the current study reported "estimated" frequency of mindfulness practice, whereas previous studies had individuals practice mindfulness on a regular basis in longer and more frequent training intervals (i.e., daily practice over 2 or more weeks). Thus, individuals may need to practice mindfulness frequently over a longer period before any relationship to attentional control is observed, with the minimum time of practice needed to report these benefits remaining unclear.

Additionally, these results are inconsistent with past research which showed support for a relationship between mindfulness and episodic memory (Wilson, et al., 2015; Levi & Rosenstreich, 2019). Although Wilson et. al., (2015) used a recognition test (vs. recall) which involves more familiarity-based processes. Whereas studies that have pulled on recollection-based processes of episodic memory using recall tasks have indicated similar results to the present study, indicating no relation found between mindfulness practice and episodic memory performance (Rosenstreich & Goshen-Gottstein, 2015; Rosenstreich & Ruderman, 2017). Thus, the relationship between mindfulness and episodic memory appears to be weak to non-existent when episodic memory is measured through a recollection-based task.

In Experiment 2, I compared whether attentional control and episodic memory could improve following two 5-minute mindfulness-based breathing exercises relative to a control group that listened to two 5-minute clips of Bob Ross painting a picture. I expected that those who performed the brief mindfulness practice would show a boost in performance on cognitive measures. However, results indicated that individuals who briefly practice mindfulness before attentionally demanding tasks do not noticeably improve in attentional control or episodic memory performance when compared to control tasks of similar modality that do not promote a mindful state. These findings are consistent with studies that found no attentional control benefits when a mindful state was induced following brief mindfulness practice. Specifically, Leuke and Leuke's (2019) findings which indicated no increase in attentional control performance when attention was measured by both tasks of selective attention and attention switching, and Larson et al., (2013) findings which found no behavioral differences in attentional control after a 14-minute mindfulness intervention versus a control group that did not promote mindfulness. However, when mindfulness practice length and frequency are increased over regular sessions (e.g., Dubert et al., 2016; Moore and Malinowski, 2009; Mrazek et al., 2013) cognitive benefits have been reported. Likewise, results indicated that individuals who briefly practice mindfulness before a recollection-based memory task (dual-list recall) do not noticeably improve in correct recall when compared to control tasks of similar modality that do not promote a mindful state. Due to the recollection processes that are prioritized in dual-list recall, results are consistent with past research which measured episodic memory through other recollection-based tasks (Rosenstreich & Goshen-Gottstein, 2015; Rosenstreich & Ruderman, 2017). Thus, it can be concluded that mindfulness practice does not act as an effective booster to either attention or episodic memory performance in such short practice intervals, nor does it support the notion that mindfulness meditation facilitates attentional control or episodic memory, at least for recollection-based tasks.

Although it is important to mention that these findings do not contradict the reported mental health benefits from mindfulness practice, as we did not measure stress, anxiety, depression, or any other factors from a mental health perspective. Though, the magnitude of some of the reported clinical benefits may be in question, especially those purporting benefits after brief mindfulness interventions, as some pressures including publication bias may have pushed researchers to embellish their results in the past (see Schumer, 2018 meta-analysis, for review). Our findings suggest that an individual may need to become more adept at mindfulness meditation through frequent and extended practice sessions before they are able to achieve a mindful state and receive any of the associated benefits. Which may not be achievable for most novice practitioners especially in such brief mindfulness practice sessions.

Some limitations of our study include the control task chosen and the population that partook in the interventions. Although, there is never a perfect control task, criticism may be directed to the control intervention in Experiment 2, as it seems likely the Bob Ross control provided individuals a similar state of relaxation as the guided mindfulness meditation. Though, this may have promoted mindfulness like benefits in such a brief intervention which could have confounded results, the control was chosen as it matched both the active process and audio modality of the guided mindfulness mediation, as well as did not promote nonjudgmental acceptance of cognitions or self-reflection which is exclusive to mindfulness practice. Thus, a pertinent question is would a less restful control be more likely to produce attentional control or episodic memory differences amongst groups? This may be possible, but findings from other experiments using brief control interventions would suggest not (Larson et al., 2013; Leuke & Leuke, 2019). However, future research could compare another control intervention that does not promote such a relaxed state while still matching the active process and modality of the guided mindfulness meditation.

Additionally, although we did not find mindfulness benefits in Experiment 2 from the brief mindfulness interventions, might benefits be found in other populations?

Specifically, in a group of older participants might a similar mindfulness intervention provide attentional control or episodic memory benefits compared to a control task that does not promote mindfulness. As, an abundance of past literature indicates older adults decline in cognitive capabilities might they find benefits from brief mindfulness interventions? Whereas the undergraduate participants in Experiment 2 are near their cognitive peaks, older adults have worsened attentional control and episodic memory capabilities. Thus, a possibility of Experiment 2's findings may be that no cognitive benefits were shown as participants are already at ceiling cognitive levels. Future research could provide insight as to whether older adults find cognitive benefits from brief mindfulness interventions where undergraduates did not.

CHAPTER V – CONCLUSION

Findings from Experiment 1 indicate that the trait-like tendency to be mindful and estimated frequency of practice is not significantly related to the cognitive processes of attentional control or episodic memory. These patterns are echoed in Experiment 2 which found brief mindfulness meditation does not boost attention or episodic memory recall or reduce intrusions, when completed immediately before the completion of those tasks. Although a short intervention would have been a cost-effective opportunity to facilitate attentional control and/or episodic memory if effective, the data do not support the predicted pattern. However, the resulting data has provided valuable insight to the limitation of mindfulness interventions, in their relation to cognition, as time of practice may be critical to any attentional control/working memory increases that may be found (Dubert et al., 2016; Jha 2010; Moore and Malinowski, 2009; Mrazek et al., 2013;). Further studies are needed to indicate how more long-term practice may facilitate improvements to cognitive performance, as my frequency measure was self-reported and highly skewed and past literature seems to support the possibility of cognitive benefit through more long-term consistent mindfulness practice. Future experiments may be able to parse through the duration/frequency of practice needed before any noticeable cognitive benefits are displayed, if possible. Overall, trait mindfulness is weakly related to individuals' levels of attention control or correct recall in episodic memory, and brief mindfulness interventions appear to produce no improvement in cognitive processes, at least when compared with to a control task that does not promote mindfulness.

APPENDIX A – Tables and Figures

Table A.1 *Descriptives Between Measures/Tasks: Experiments 1 & 2.*

Experiment	**Measure Type**	**Measure/Task**	***M***	***SD***
Experiment 1	Mindfulness	FFMQ	2.98	.48
		MAAS	3.28	.72
		Est. Frequency	.98	2.17
	AC	OSPAN	35.70	10.75
		Stroop Errors	.06	.07
	EM	Dual-List Recall	.58	.17
Experiment 2	Mindfulness	FFMQ	3.2	.54
		MAAS	3.55	.86
		Est. Frequency	.99	1.57
		Engagement	6.63	1.65
	AC	OSPAN	32.93	10.30
		Stroop Errors	.07	.12
		Antisaccade	.80	.13
		CVOE Errors	.04	.04
	EM	Dual-List Recall	.55	.12

Notes. AC refers to attentional control, EM refers to episodic memory, FFMQ refers to mean Likert scores, MAAS refers to average Likert scores, Est. frequency refers to the estimated hours individuals practice mindfulness weekly, Engagement refers to individuals perceived engagement levels to the interventions on a 1-10 Likert scale, OSPAN refers to average partial score across blocks, Stroop errors refer to incongruent errors, CVOE errors refers to switch-task error rates, and dual list recall rates are collapsed across proactive and retroactive interference conditions.

Table A.2 *Loadings of Attentional Tasks on the Attentional Control Composite: Experiment 2.*

Task	**Attentional Control Loading**
OSPAN Score (Partial)	.703
Stroop Incongruent Errors	-.419
Antisaccade Accuracy	.704
CVOE Errors	-.549

Table A.3 *Descriptives and Bivariate Correlations Between Observed Variables: Experiment 1.*

	OSPAN	**Stroop**	**Dual-List**	**AC Comp.**	**Mindfulness Comp.**	**Observing**	**Describing**	**Awareness**	**Non-judging**	**Non-reactivity**
OSPAN	—	.051	.369**	.725**	-.144	-.029	-.170*	-.063	-.024	-.037
Stroop		—	-.092	.725**	-.053	.085	.088	-.132	-.044	-.013
Dual-List			—	.191*	-.142	-.046	-.167*	.210	-.117	-.068
AC Comp.				—	-.136	.039	-.057	-.134	-.047	-.034
Mindfulness Comp.					—	.255**	.664**	.437**	.412**	.255**
Observing						—	.181*	-.303**	-.356**	.356**
Describing							—	.137	.163*	.335**
Awareness								—	.642**	-.265**
Non-judging									—	-.291**
Non-reactivity										—
M	35.7	.06	.58	—	—	3.34	2.82	2.81	3.03	2.89
SD	10.75	.07	.17	—	—	.89	.91	.91	1.10	.94

Notes. * = *p* < .05; ** = *p* < .01. *M* and *SD* were 0.00 and 1.00 for the Attentional Control and Mindfulness composites as these scores were standardized.

Table A.4 *Descriptives and Bivariate Correlations Between Observed Variables: Experiment 2.*

	OSPAN	**Stroop**	**Antisaccade**	**CVOE**	**Dual-List**	**AC Comp.**	**Mindfulness Comp.**	**Observing**	**Describing**	**Awareness**	**Non-judging**	**Non-reactivity**
OSPAN	—	-.111	.281**	-.152	.403	.703**	.288**	.002	.221*	.293**	.123	.103
Stroop		—	-.101	.085	-.203	-.419**	-.043	-.029	-.112	.077	.022	-.166
Antisaccade			—	-.161	.326**	.704**	-.037	.090	-.063	-.040	.046	.055
CVOE				—	-.298**	-.549**	-.001	-.080	-.081	-.001	.032	.019
Dual-List					—	.519**	.054	.273*	.081	-.007	-.049	.132
AC Comp.						—	.133	.082	.144	.103	.063	.117
Mindfulness Comp.							—	.221*	.678**	.700**	.589**	.441**
Observing								—	.244*	-.126	-.102	.400**
Describing									—	.283**	.236*	.334**
Awareness										—	.451**	.101
Non-judging											—	.006
Non-reactivity												—
M	32.93	.07	.80	.04	.55	—	—	3.24	3.14	3.06	3.48	3.1
SD	10.3	.12	.13	.04	.12	—	—	.82	.98	.81	1.01	.93

Notes. * = p < .05; ** = p < .01. M and SD were 0.00 and 1.00 for the Attentional Control and Mindfulness composites as these scores were standardized

Table A.5 *Summary statistics for attentional control and episodic memory tasks/composites as a function of intervention type: Experiment 2.*

Intervention Type	**Measure/Task**	***M***	***SD***
Mindfulness	AC Comp	.08	.98
	OSPAN	33.30	10.60
	Stroop Errors	.05	.08
	Antisaccade	.80	.12
	CVOE Errors	.04	.05
	Dual List Recall	.55	.13
Control	AC Comp	-.08	1.02
	OSPAN	32.56	10.10
	Stroop Errors	.08	.14
	Antisaccade	.80	.14
	CVOE Errors	.05	.04
	Dual List Recall	.55	.09

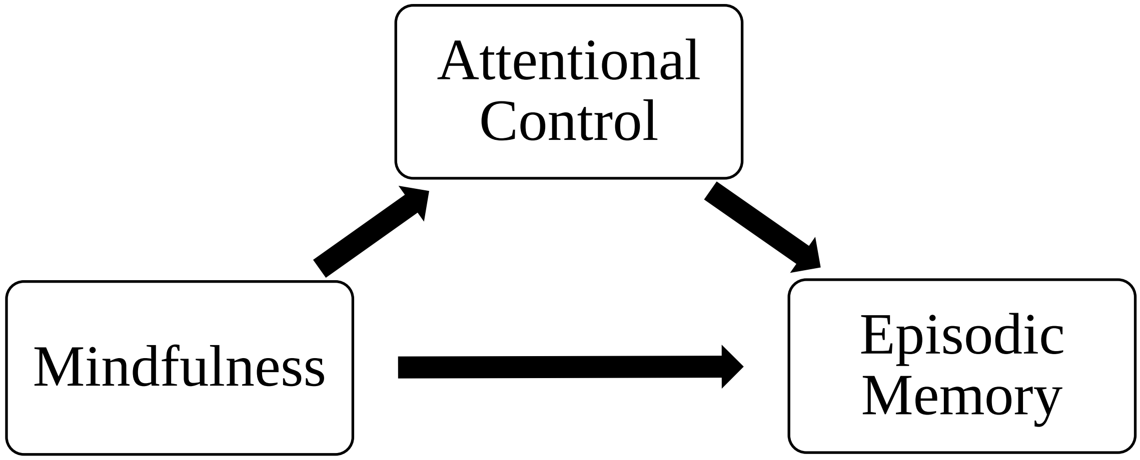

Figure A.1 *Expected mediation of attentional control between mindfulness and episodic memory in Experiment 1.*

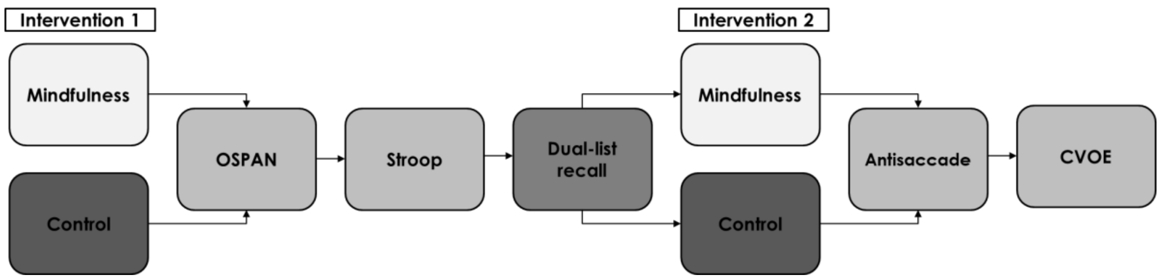

Figure A.2 *Expected mediation of attentional control between mindfulness and episodic memory in Experiment 1.*

APPENDIX B – Questionnaires

MAAS Questionnaire (Brown & Ryan, 2003)

Day-to-Day Experiences

Instructions: Below is a collection of statements about your everyday experience. Using the 1-6 scale below, please indicate how frequently or infrequently you currently have each experience. Please answer according to what really reflects your experience rather than what you think your experience should be. Please treat each item separately from every other item.

1	2	3	4	5	6
Almost Always	Very Frequently	Somewhat Frequently	Somewhat Infrequently	Very Infrequently	Almost Never

I could be experiencing some emotion and not be conscious of it until sometime later.	1 2 3 4 5 6
I break or spill things because of carelessness, not paying attention, or thinking of something else.	1 2 3 4 5 6
I find it difficult to stay focused on what's happening in the present.	1 2 3 4 5 6
I tend to walk quickly to get where I'm going without paying attention to what I experience along the way.	1 2 3 4 5 6
I tend not to notice feelings of physical tension or discomfort until they really grab my attention.	1 2 3 4 5 6

MAAS Questionnaire Continued

I forget a person's name almost as soon as I've been told it for the first time.	1 2 3 4 5 6
It seems I am "running on automatic," without much awareness of what I'm doing.	1 2 3 4 5 6
I rush through activities without being really attentive to them.	1 2 3 4 5 6
I get so focused on the goal I want to achieve that I lose touch with what I'm doing right now to get there.	1 2 3 4 5 6
I do jobs or tasks automatically, without being aware of what I'm doing.	1 2 3 4 5 6
I find myself listening to someone with one ear, doing something else at the same time.	1 2 3 4 5 6
I drive places on 'automatic pilot' and then wonder why I went there.	1 2 3 4 5 6
I find myself preoccupied with the future or the past.	1 2 3 4 5 6
I find myself doing things without paying attention.	1 2 3 4 5 6
I snack without being aware that I'm eating.	1 2 3 4 5 6

MAAS Scoring

To score the scale, simply compute a mean of the 15 items. Higher scores reflect higher levels of dispositional mindfulness.

FFMQ Questionnaire (Baer, Smith, Lykins, Button, Krietemeyer, Sauer, Walsh, Duggan, & Williams, 2008)

Instructions

Please use the 1 (never or very rarely true) to 5 (very often or always true) scale provided to indicate how true the below statements are of you. Circle the number in the box to the right of each statement which represents your own opinion of what is generally true for you. For example, if you think that a statement is often true of you, circle '4' and if you think a statement is sometimes true of you, circle '3'.

1	2	3	4	5
Never or very rarely true	Rarely true	Sometimes true	Often true	Very Often or Always True

1. When I take a shower or a bath, I stay alert to the sensations of water on my body.	1 2 3 4 5
2. I'm good at finding words to describe my feelings.	1 2 3 4 5
3. I don't pay attention to what I'm doing because I'm daydreaming, worrying, or otherwise distracted.	1 2 3 4 5
4. I believe some of my thoughts are abnormal or bad and I shouldn't think that way.	1 2 3 4 5
5. When I have distressing thoughts or images, I "step back" and am aware of the thought or image without getting taken over by it.	1 2 3 4 5

FFMQ Questionnaire Continued

6. I notice how foods and drinks affect my thoughts, bodily sensations, and emotions.	1 2 3 4 5
7. I have trouble thinking of the right words to express how I feel about things.	1 2 3 4 5
8. I do jobs or tasks automatically without being aware of what I'm doing.	1 2 3 4 5
9. I think some of my emotions are bad or inappropriate and I shouldn't feel them.	1 2 3 4 5
10. When I have distressing thoughts or images I am able just to notice them without reacting.	1 2 3 4 5
11. I pay attention to sensations, such as the wind in my hair or sun on my face.	1 2 3 4 5
12. Even when I'm feeling terribly upset I can find a way to put it into words.	1 2 3 4 5
13. I find myself doing things without paying attention.	1 2 3 4 5
14. I tell myself I shouldn't be feeling the way I'm feeling.	1 2 3 4 5
15. When I have distressing thoughts or images I just notice them and let them go.	1 2 3 4 5

Mindfulness Frequency Estimation Question

Please estimate the average amount of time you engage in mindfulness practice hourly per week. For example, if you practice for only 30 minutes a week type .5, or if you practice for an hour a week type 1. If you do not practice mindfulness regularly, please type 0 below.

APPENDIX C – IRB Approval Letter

Office *of*
Research Integrity

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NOTICE OF INSTITUTIONAL REVIEW BOARD ACTION

The project below has been reviewed by The University of Southern Mississippi Institutional Review Board in accordance with Federal Drug Administration regulations (21 CFR 26, 111), Department of Health and Human Services regulations (45 CFR Part 46), and University Policy to ensure:

- The risks to subjects are minimized and reasonable in relation to the anticipated benefits.
- The selection of subjects is equitable.
- Informed consent is adequate and appropriately documented.
- Where appropriate, the research plan makes adequate provisions for monitoring the data collected to ensure the safety of the subjects.
- Where appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of all data.
- Appropriate additional safeguards have been included to protect vulnerable subjects.
- Any unanticipated, serious, or continuing problems encountered involving risks to subjects must be reported immediately. Problems should be reported to ORI via the Incident template on Cayuse IRB.
- The period of approval is twelve months. An application for renewal must be submitted for projects exceeding twelve months.

PROTOCOL NUMBER: IRB-21-328
PROJECT TITLE: Evaluating the Effects of Mindfulness Practice on Attentional Control and Episodic Memory
SCHOOL/PROGRAM: Psychology
RESEARCHER(S): Jacob Namias, Mark Huff

IRB COMMITTEE ACTION: Approved
CATEGORY: Expedited

7. Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

PERIOD OF APPROVAL: August 23, 2021

Donald Sacco Jr.

Donald Sacco, Ph.D.
Institutional Review Board Chairperson

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