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The Impact of a Single Session of Mindfulness Meditation on the Attentional Blink in Non-Meditators

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THE IMPACT OF A SINGLE SESSION OF MINDFULNESS MEDITATION ON THE ATTENTIONAL BLINK IN NON-MEDITATORS

By

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ABSTRACT

The Impact of a Single Session of Mindfulness Meditation on the Attentional Blink in Non-Meditators

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Attentional resources are limited therefore a stimulus can go undetected if it closely follows another target by 200-500ms. This phenomenon is known as the attentional blink. Mindfulness meditation has been shown to be beneficial in target detection and in decreasing the attentional blink. Since there is no standard for the type of meditation or duration of practice that leads to attention benefits, this study compares the two most popular types of meditation in a group of non-meditators: focused attention and open monitoring meditation. This study utilized an attentional blink paradigm to measure if a single session of mindfulness meditation can improve target detection capabilities. The focused attention group decreased their attentional blink, shown in improved T2 detection whereas the open monitoring group did not however this change was not significant. These findings suggest that non-meditators may need longer or more formal training to see significant behavioral changes.

TABLE OF CONTENTS

Chapter 1: Introduction

Attention, like many other cognitive functions, has a limit. It has been structurally and functionally defined and redefined over time and is still being examined on many levels. The organization of attention as a network and what its capacity is has been widely studied both in healthy controls and individuals with attentional deficits. Manipulating attention, awareness, and arousal aid in understanding the intricacies of top-down attentional control. In theory, attention can be trained to increase capacity and sustainability. One of these manipulations of attention is the practice of Mindfulness-Based Stress Reduction. Mindfulness is defined as paying attention, on purpose, to the present moment (Kabat-Zinn, 1990). Mindfulness practices can regulate attention as observed through behavioral and ERP measures (Slagter et al., 2007; Davidson & Lutz, 2008; Moore et al., 2012). The current research aims to understand if this type of focused attention will result in an increase in attentional capacity observed through target detection accuracy.

Attentional Blink

The paradigm chosen for this experiment is a rapid serial visual presentation (RSVP) with targets presented at varying time points. The duration of the delay between target 1 (T1) and target 2 (T2) can create an attentional blink if T2 follows T1 by 200-500ms. The attentional blink occurs because conscious identification of a visual stimulus takes time and occupies the attentional resources available therefore another target presented will be difficult to detect. This type of visual search task is time-dependent. The objects are spaced 100 milliseconds apart so that the presentation is rapid, and the individual must remain alert and focused throughout the presentation. Woodman and Luck (1999) discussed that the time course of attention shifts is 100 milliseconds. This would allow the individual to switch attention to the next object presented in the sequence. The second target is presented at different intervals following T1 to expose the attentional blink with the blink being most visible between 200 and 500ms post T1 presentation (Armstrong & Munoz, 2003).

The attentional blink is visible in multiple target RSVP tasks. These tasks help to determine what individuals can consciously report seeing within a series of objects presented at different times. This presentation consists of numbers, letters, words, or images that are shown in a continuous stream at the same location on a screen. The string of objects will contain one or multiple targets that the participant reports following the completion of the presentation (Raymond et al., 1992).

Single-target identification created a better understanding of different theories of attentional and perceptual mechanisms associated with visual searches (McLean et al.,1983). Multiple-target identification has shown an attentional blink between the first and second target. The attentional load of multiple stimuli inhibits individuals from proper identification of the target when it is presented shortly after the first target (Broadbent & Broadbent, 1987; Kanwisher, 1987; Kanwisher & Potter, 1989). Raymond et al. (1992) refer to this as a “post target processing deficit”. The attentional load of attending and attempting to remember the first target is too great therefore if the second target appears shortly after the first it will not be attended. Broadbent and Broadbent (1987) theorized that target identification includes an early selection filtering technique in which the simple defining features of the target are detected followed by a late selection stage of identification of information that will be reported. Alternatively, Keele et al. (1978) proposed a late-selection model with two separate components. They suggest that the defining characteristics and the reported features are processed simultaneously but at slightly different rates. Both of these theories attempt to account for the individual's inability to report stimuli at certain positions following a target.

Rapid serial visual presentations require the target features to be identified as well as the to-be-reported details about the target. The combination of those two processes takes about 100 milliseconds and the entire procedure requires attention. However, this does not suggest that the attentional resources are once again available for processing stimuli after the 100-millisecond window. In studying multiple targets, Armstrong and Munoz (2003) suggest that there is still an identification deficit for about 200 - 500 milliseconds after the first target. Second-target-identification is not possible in that time-span because attention is still being allocated to the processing of the original target. Researchers believe that this attentional allocation is the cause of a noticeable gap in attentional abilities rather than a problem with perception, memory or response. This theory was supported by giving the participants instructions to forget the first target (Shapiro et al., 1997; Taylor, 2018). By removing attentional resources from the first target, the second target was more easily detected showing a reduced attentional blink.

More than just attending to the targets, attentional blink requires conscious awareness of the objects presented to allow for individuals to report the targets presented. This is not just simply orienting attention but involves a deeper awareness of the object and ability to report that object correctly. For many of the attentional blink intervals, it is clear that reporting the targets was simple and the participants were attending to and consciously aware of what was being presented. For some of the intervals testing the attentional blink, the participants report lower confidence and often just guess (Raymond et al., 1992; Taylor, 2018). Using scalp-recordings, researchers can understand whether the individual attended to the target or did not attend to it and as such did not recognize it as novel or different from the other objects presented. Targets often make it to sensory awareness even if the individual is unable to report it. In that case it is important to investigate event-related potentials from scalp recordings regarding novelty or other early perceptual processing to distinguish if the target was noticed by the participant. These components will be discussed further in relation to attention and meditation. This paradigm was chosen because the attentional blink is easily influenced. The attentional blink has been manipulated by external factors both in increasing the size of the blink and decreasing the size of the blink.

What Affects the Attentional Blink

The attentional blink can be positively and negatively affected in relation to the type of stimuli presented, age, and attention disorders. In individuals with attention deficits such as Attention Deficit Hyperactivity Disorder (ADHD), there is a strong lack of concentration and the ability to report the target correctly decreases. In this population the attentional blink is often longer in adults and individuals report fewer correct targets than matched controls (Armstrong & Munoz, 2003). In children, however, the recovery of attention from the initial target was about the same as their peers although overall, they did make more errors in identification of targets (Mason et al., 2005). When comparing individuals of different ages with no attention deficits, the attentional blink gets larger and more pronounced proportional with age (van Leeuwen et al., 2009). Issues with correct target identification with increased age and ADHD are due to the inability to sustain attention for the amount of time necessary to detect the stimulus presented.

The attentional blink is observed in most multiple target RSVP experiments. However, there are some conditions in which participants report the target correctly at a higher frequency than chance. Shapiro et al. (1997) discuss that there can be unconscious priming that will aid in correctly reporting a target if it is related to a first target even if the first target was presented too briefly to allow for recognition. This technique is often used with masking in attentional research. Researchers investigated if, after being presented with a target that was semantically related to the target in question, the participant would be more likely to report the target correctly (Maki et al., 1997; Grossi, 2006). The targets were masked to prevent overt identification of it which helps to keep conscious perception of the targets out of the equation (Grossi, 2006). This associative priming survived the attentional blink and was able to be reported (Maki et al., 1997).

Along with priming, objects with emotional connections are often easier to identify than neutral objects. Emotionally salient stimuli can also improve reporting abilities. The use of words with more pleasant or unpleasant tones is more effective in reducing the effect of the attentional blink compared to neutral words. Words that were associated with higher arousal were more easily remembered and reported correctly than neutral words as the second target (Keil & Ihssen, 2004). This research suggests that the information carrying emotion is more quickly and easily consolidated and processed into working memory. Attentional processing also favors emotional stimuli such as a threat. Maratos et al. (2008) discussed that negative emotions decrease the attentional blink more than positive or neutral ones when comparing angry or threatening faces to positive or neutral ones. This was also seen in relation to individuals with arachnophobes who were presented with neutral photos and photos of spiders. Individuals detected correctly the second target more often when it was related to their phobia (Trippe et al., 2007). This emotional connection to threats, fear, or anger, is an innate protective quality. The attentional resource capacity normally experienced during an RSVP task, is essentially overridden by a potential threat which takes priority in recognition and attentional processing. Emotional stimuli can also influence the presence of the attentional blink in the opposite way. Whereas priming and emotionally salient stimuli diminishes the attentional blink, distractors can increase the blink because there is more attentional load. In many studies, emotion can be used as a distraction or an aid in recognition. The emotional attentional blink is an impairment in target identification because the distractor is emotionally salient. Investigations into this emotional attentional blink showed that when presented with emotional stimuli, the individuals were unable to report the target correctly as well as were unable to ignore neutral distractors while performing a secondary task (Keefe et al., 2019). This study showed that the distractors, if emotionally salient, can overload attention in a way that is different from the typical attentional blink. If it is possible to train attention to disengage from distractors, then it's plausible that the attentional blink would be less prominent.

Attention as a System

Since the attentional blink is present because of limited attentional resources, it is important to understand the subsystems of attention and what subsystems are affected. To monitor these systems, it is essential to know where to locate them in the brain. Attention is a complex cognitive process and involves a wide range of brain areas. There are likely two distributed neural networks that work together in the attentional process. These systems are the ventral and dorsal attentional networks (Corbetta & Shulman, 2011).The dorsal system of attention corresponds to voluntary shifts of attention. This system is associated with dorsal frontal and parietal areas. These areas are recruited in visually and memory-guided eye movements indicating attention and eye movement coordination (Corbetta & Shulman, 1998). The ventral attention network is involved with reorienting to stimuli outside of the focus of attention (Corbetta & Shulman, 2011). The ventral attention network is strongly associated with the temporoparietal junction. Both attentional networks work to detect behaviorally relevant stimuli. In the current study, visual attention will be examined through the dorsal system.

Posner and Petersen (1990) discussed that, although the attention systems are separate, there is a level of interconnectedness within the orienting, detecting, and alerting systems. The hierarchy of attention systems aids in attending and processing information: when one system is at capacity it can defer to the other system. The process of attending to a stimulus occurs in a variety of locations. Each of the areas have different functions in relation to attention such as orienting, alerting, and detecting (Posner & Petersen 1990). Areas identified in orienting attention are the posterior parietal lobe, lateral pulvinar nucleus, posterolateral thalamus, and the superior colliculus (Mountcastle 1978; Wurtz et al., 1980; Petersen et al., 1987; Petersen et al., 1988). Developing and sustaining a state of alertness involves the right cerebral hemisphere (Heilman et al., 1984). Lastly, areas related to target detection involve strong connections between the posterior parietal lobe and the later and medial frontal cortex (Goldman-Rakic, 1988). These connections are important for conscious attention. This target detection network is important in studying the attentional blink since target detection capabilities are impaired due to an inability to evenly distribute attentional resources.

Attention, Arousal, and Conscious Awareness

Even with attention focused on a particular point during a RSVP task, objects presented often do not make it to conscious reportable awareness. Since there are dissociations between attention and conscious awareness, it is essential to distinguish attention from arousal and conscious awareness. Although they share many basic commonalities, there is a distinction between attention and arousal. Arousal relates to the salience and the nature of the stimulus that attracts the attention of the individual externally. Arousal is related to a general state of wakefulness whereas attention likely requires a greater level of awareness, often termed consciousness (Filley, 2002). Attention involves the guidance of focus in accordance with the intention to attend (Filley, 2002). The intention to attend involves higher-order processing that allows for objects to reach conscious reportable awareness.

Posner (2012) argues that, although there are dissociations between attention and consciousness there are aspects of attention that are directly connected and necessary for conscious perception There is evidence that certain stimuli can be processed by the visual system even when there is a lack of reportable awareness (Halligan & Marshall, 1990; Boyer et al., 2005; Naccache et al., 2002). An individual can be attending to something and not be able to bring it to conscious reportable awareness just as they may have their attention misdirected and still have conscious awareness of a stimuli. Olivers & Nieuwenhuis (2005) found that when providing some distractions, participants were able to improve their target detection capabilities in a rapid serial visual presentation task.

Top down attention and conscious awareness may in fact be two separate processes wherein individuals may attend to something and not be able to consciously report it. Attention has different subsystems and, although certain attentional networks may be required for conscious perception, others might not be constantly necessary. Posner and Petersen (1990) suggest that the signal detection system is necessary for conscious processing whereas the orienting system might not be which is supported by the findings of Olivers & Nieuwenhuis (2005).

In masked priming experiments, the prime is unreportable by the participant but still creates unconscious priming to a target (Naccache et al., 2002). Naccache et al. (2002) found that unconscious priming took place if, and only if, attention is focused during the window when the prime-target pair is presented. In this case, attention modulated unconscious processing. Understanding attention's role in conscious perception aids in understanding attentional control and modulation. Since some stimuli are only processed at the sensory level and do not move to conscious perception, more extensive measures are taken to observe what individuals are attending to and what remains undetected in attentional blink studies.

Event-Related Potential Components of Attention

As previously laid out with regards to the attentional blink, researchers can investigate if individuals are attending to certain targets even if they are not consciously aware of its presence by using electroencephalography (EEG). These scalp recordings provide a noninvasive way to measure brain activity and provide high temporal resolution. They can be time-locked to an event of interest. These event-related potentials (ERPs) can be analyzed to see if individuals are registering a stimulus presentation at the sensory level even if there is no evidence of conscious awareness.

ERPs can be used to show cognitive operations in response to a stimulus. An average ERP waveform can be time-locked to an externally observable event with the primary reference events being the presentation of a stimulus or the execution of a behavioral response (Jung et al., 1999). In the current study, the focus will be on the P3b and the N2 components associated with updating working memory and object detection and categorization respectively. In attentional blink paradigms the presence of the P3b and N2 components are widely studied and supported.

In object detection and attention, the P300 and the N200 components are important components. The N200 component is a negative waveform that is often observed between 235 and 335 milliseconds after the stimulus presentation and it is indicative of object recognition and categorization (Woodman, 2010). However, this waveform can also be observed slightly earlier peaking between 160 and 240ms post-stimulus (Moore et al., 2012). This component is commonly observed in an oddball task used for target detection such as in attentional blink studies and is often referred to as the N2b.

The P300 component is a positive waveform observable roughly between 250 and 500 milliseconds after the stimulus presentation and it is indicative of target discrimination (Polich, 2007). There are two varieties of the P300 component, the P3a and the P3b. The P3a component is involved in stimulus-driven attentional tasks indicating orientation to a irregular or novel target while the P3b component is more widely studied for directed attention and its involvement in memory processing. The P3a component involves stimulus evaluation while P3b is associated with resource allocation and memory consolidation of infrequent objects. The P3a component is observed in frontal regions whereas P3b is found in more parietal regions (Polich, 2007). The P3b component is also associated with updating working memory, stimulus evaluation, and response selection. Verleger (2020) also discusses that, although P3b components get larger for unexpected stimuli, there is an increase in P3b amplitude with increased time intervals between stimuli. This is important for the attentional blink paradigm wherein temporal changes affect the behavioral output. It indicates that the P3b component will likely be small for the targets that are closer together.

In attentional blink studies where a target was not correctly identified, there were still visible N1 and P1 components thought to be related to early perceptual activity and sensory processing (Vogel et al., 1998). These components reflect encoding of some visual information. They are present when individuals attend to visual stimuli. Even though the individuals were incorrect in identifying the target, the ERP components showed that these targets were encoded in the visual cortex. This indicates that although the individuals cannot bring the target to conscious perception, the stimulus has been encoded at the sensory level.

Vogel et al. (1998) showed that the P300 waveform associated with updating working memory is not present during the attentional blink. Updating working memory however is a key factor in reporting multiple targets during an RSVP test. This effect likely shows that the attentional blink interferes with postperceptual processing (Vogel et al., 1998). This postperceptual processing occurs after encoding at the sensory level and before individuals have thoughts about what is happening. Overall, some theories of consciousness indicate that although participants have no conscious perception of a stimulus they are able to sense it. This is supported by the ERP research that the stimulus was encoded in sensory cortex, observed in distinct N1 and P1 components but was not updated in working memory demonstrated in the lack of visible P3b components.

Along with averaged ERPs, power in particular frequency bands such as alpha and gamma waves can be regulated by attention. Alpha waves are measured between 8-12Hz while gamma waves are generally observed 30Hz and above. Landau et al. (2007) investigated voluntary and involuntary spatial attention in a spatial-cueing paradigm using targets to examine modulation of gamma waves. Gamma waves are often associated with learning, attention, and focus (Lutz et al., 2004). Modulation of gamma-bands has been related to voluntary attention, but not involuntary attention shifts. This modulation could be indicative of perceptual binding and attentional selection (Landau et al., 2007). Perceptual binding is an important component of conscious awareness and in turning sensations into a reportable information.

Modulation of alpha waves has also been studied with attention tasks. Alpha activity is highly related to cognitive load and attentional control (Sauseng et al., 2005; Marrufo et al., 2001). In a cued visual spatial attention task, Sauseng et al. (2005) found that the modulation of alpha activity is controlled by prefrontal regions in shifting of attention. The alpha band differentiated between attended and unattended stimuli: showing a stronger amplitude suppression during attended stimuli. Alpha bands decrease in amplitude during cognitive activity. Suppression occurred before the presentation of the target and was affected by shifting attention (Marrufo et al., 2001).

Ways to Improve Attention: Mindfulness Meditation

Mindfulness meditation involves two main components, attentional control and a non-judgmental attitude (Kabat Zinn, 1990). Practitioners learn to not only control attention, but to remain in a neutral non-reactive state to intrusive thoughts or stimuli. This attentional stability as well as flexibility, aids in maintaining a balance of attentional control and non-judgmental perspective. Mental training in the form of meditation created lasting changes in the attentional system involving self-regulation of attention (van Leeuwen et al., 2009; Bishop et al, 2004). It is theorized that this training decreases the attentional blink because it creates a more distributed attentional state. To understand how mindfulness meditation can improve results on a multiple-target RSVP task and reduce the presence of attentional blink, it is important to understand the basis of how mindfulness can improve attention as a whole.

Attentional subsystems that can be altered by meditation include orienting, alerting, and conflict monitoring. Jha et al. (2007) investigated a control group compared to non-meditators who took an 8-week mindfulness-based stress reduction (MBSR) class and meditators who had participated in a one-month intensive retreat. Before the class, the one-month meditators performed the best, however, after the 8-week class, the MBSR participants performed better than the controls on stimulus detection tests. Valentine and Sweet (1999) reported that, when comparing concentrative and mindfulness meditators, the mindfulness meditators, who maintained a more open awareness, performed better on one of the attention tasks involving expectancy and faster stimulus presentation. However, both types of meditators performed better than the controls on the task (Valentine & Sweet, 1999). Concentrative meditation parallels a focused attention meditation and mindfulness meditation parallels an open monitoring meditation. Ainsworth et al. (2013) compared both focused attention and open monitoring meditation in non-meditators. Individuals performed an attention network test and improved in executive control of attention indicating a successful selection of task-relevant stimuli. Lutz et al (2008) reviews the ideas that mindfulness meditation allows the individual to not only monitor and sustain attention, but also teaches individuals how to disengage from distractions to refocus attention on the current task in order to select for relevant stimuli. Tibetan Buddhist monks were able to sustain attention on a particular object for extended amounts of time following focused attention meditation training (Carter et al., 2005). The behavioral results obtained from Carter et al. (2005) with Tibetan Buddhist monks were also observed in fMRI studies of sustained attention (Brefczynski-Lewis , 2007). Compared to novices, experienced meditators showed a stronger activation pattern in brain regions related to monitoring, engaging attention, and attentional orienting such as the dorsolateral prefrontal cortex, visual cortex, and superior frontal sulcus (Lutz et al 2008). It was even suggested that meditators with the most hours of experience have a decrease in activity of attentional networks during attention tasks because they do not require the same level of effort to sustain attention (Brefczynski-Lewis, 2007). This U-shape curve follows closely with other learned skills giving rise to the idea that meditation training has similar long-term effects to training a muscle or learning a language.

Types of Mindfulness Meditation

There are two main types of mindfulness meditation. Although they receive different names when variations are made, the core practice remains the same. The two kinds of meditation this study will focus on are focused attention and open monitoring meditation. Shamatha–Vipashyana meditation practice is the formal Buddhist term for the focused attention meditation (FA) which uses voluntary attention on an object. This object is usually the breath but can also be related to sensations in the body or sounds outside of the body (Lutz et al., 2007). This type of meditation involves a more concentrative position because the focus is usually on the breath, one's surroundings such as sounds, or any other sensation. Often this meditation is used in the form of a body scan where the focus is on monitoring the body and engaging and disengaging with different areas.

Vipashyana meditation is the formal name for open monitoring meditation (OM) and contains no explicit focus. The goal of the meditation is to monitor the mind and surroundings as a whole (Lutz et al., 2007). The open awareness of one's entire experience is the central focus of this meditation. The non-reactive monitoring allows the individual to free themselves of the tendencies to cling onto a specific idea or object. Open monitoring turns the focus from a specific event such as breathing or sound awareness, to the entire sensory experience.

Of the two types of meditation, open monitoring takes more practice and requires more formal training (Jha et al., 2007). Within the practice of mindfulness, one of the key points is that when attention wanders, practitioners should disengage from the distraction and reengage with the present moment. In focused attention meditation, the mind does not have the same opportunity to wander because the focus is on a specific object of attention. In open monitoring meditation ,however, the focus, being so broad and attending to the entire experience of being present, allows for more distractions (Kapleau, 1965). Without formal training, novice meditators might not have the ability to notice their distractions as quickly and to disengage and return focus to the meditation. For this reason, Kapleau (1965) suggests that, to effectively practice open monitoring meditation, practitioners should master the focused attention meditation.

Event-Related Potential Components Post Mindfulness

Meditation can change neural activity when observed through EEG recordings. Components N2 and P300 are commonly studied in relation to attention and stimulus discrimination within meditation studies especially with unexpected targets (Atchley et al., 2016). Moore et al. (2012) found that when monitoring ERP components during the Stroop Test, the P300 and the N2 components were most prominently different between the group of meditators and the controls. Meditation led to an increase N2 amplitude over both hemispheres (Moore et al., 2012). The N2 component is a negative component was measured between 160 and 240 milliseconds after the stimulus is presented. The N2 and P300 components were recorded over lateral and medial posterior regions respectively. Source localization was used to estimate neural sources. This led Moore et al. (2012) to believe that there was an increase in activity in the left medial and lateral occipitotemporal areas for the meditation group. These regions are involved with the ventral processing stream for lexical tasks (Cohen et al., 2002; Cohen and Dehaene, 2004). The presence of a large N2 component is consistent with the idea that there is a steady increase in attention. This is due to the fact that the time course of enhanced stimulus processing when attending to non-spatial features is between 100 and 150 milliseconds after stimulus onset (Hillyard & Anllo-Vento, 1998).

Another component that was different between meditators and controls was the P300 component. This component reflects early processing and resource allocation and was different between groups for stimuli that were incongruent (Moore et al, 2012). This component decreased in amplitude for the meditation group and increased for the control group. The source localization was likely the lateral occipitotemporal and inferior temporal regions of the right hemisphere, which have been connected to object recognition processing (Schendan & Kutas, 2002). The temporal and parietal P3 component is linked to attentional resource activation during discrimination of stimuli as well as inhibition when discerning conflicting information (Polich, 2007). Moore et al (2012) suggest that meditation can aid in processing because there is less demand for attentional resources. Slagter et al. (2007) also found a significant decrease in the P3b component following target one presentation in meditators. This indicates a decrease in attentional load and allocation of attentional resources for target one. The P3b component also corresponded with an increase in target detection. Atchley et al. (2016) however observed increases in the P300 and N2 components in the novice and experienced meditators in relation to discriminating stimuli and detecting a target. These results indicate that meditators display an increase in target detection abilities even for unexpected stimuli. In the attentional blink studies investigating the P300 and N2 components, it is possible to see overlapping ERP components since the targets are presented in quick succession. The neural response to T1 might be present in T2 analysis. For example, it is often difficult to distinguish an N1 from an N2 since the targets are within 100ms or 200ms of each other in many cases.

Mindfulness Meditation and the Attentional Blink

Attentional blink studies that have used open monitoring (OM) meditation have increased attention of each moment and decreased elaborative stimulus processing (Valentine & Sweet, 1999; Davidson& Lutz, 2008). This decrease has helped participants to attend to each stimulus more easily and not miss the second target stimuli. Participants were trained in OM meditation and then performed attentional blink tasks and had scalp-recorded brain waves monitored. Researchers were very interested in looking at the ERP component P3b, which is associated with resource allocation. After practicing meditation and performing an attentional blink task, there was a noticeably smaller P3b component for the first word being attended to (T1) (Slagter et al., 2007; Davidson& Lutz, 2008). This would display that the participants were not allocating as much of their attentional resources to the first word, which gave them the ability to detect and identify the second target.

The duration of meditation and the length of practice over one's lifetime have an effect on the benefits of mindfulness. After a three-month meditation retreat to learn and practice open monitoring meditation, individuals performed better on an attentional blink test, showing higher correct responses to the target and a decreased blink after the first target was presented (Slagter, 2007). This longitudinal study indicates that the meditation training increased target detection abilities and decreased attentional blink. This suggests that the meditation training improved sustained attention and attentional engagement for a continuous time frame. In comparing individuals before the three-month retreat, the meditators did not perform better than the controls which is indicative of the different durations and styles of practice that meditators participate in. To understand the interconnectedness of different styles of meditation, one study aimed to investigate the effects of open monitoring and focused attention meditation on scores for an attentional blink task. In using focused attention and open monitoring meditation, van Leeuwen et al (2009) found that in age-matched groups of meditators and controls, the magnitude of the blink and the duration of the blink were greater for controls compared to the meditators. This study aimed to consider the problem that age increases attentional blink. Compared to younger controls, the older meditators performed better on the RSVP task and showed a decrease in attentional blink after meditation (van Leeuwen et al, 2009). This indicates that mindfulness can decrease the attentional blink and improve attentional control even for individuals who begin with a large blink. Attentional blink studies involve sustained attention and attentional control which are two key points of meditation training. These studies together suggest that meditation can improve one's ability to disengage from stimuli and evenly allocate attentional resources.

A general state of awareness is distinctly different from attention orientation. In a state of constant alertness without any true focus, almost any target can be detected according to Davidson and Lutz (2008). Orienting to a target interferes with other cognitive operations whereas maintaining an open monitoring of space does not produce the same amount of interference (Duncan, 1980). This supports the idea that open monitoring meditation training is more effective for improvement in attentional resource allocation and decreasing the size of the attentional blink.

Open monitoring meditation has been able to give participants the skill set to engage and disengage from different stimuli without losing information in the process. This type of open awareness requires a formal training to master. There have been a lot of theories regarding the focus of attention as a spotlight that can be shifted. Posner's theory of the attentional spotlight discusses the loss of important information when shifting attention from one stimulus to another. When people shift attention from one stimulus to another they have to shift attention, engage with the new stimulus, and disengage in the previous stimulus (Posner & Petersen, 1990). During this process information can get lost. If OM meditation can show a decrease in resource allocation to each stimulus that is presented, it could change the way the that attentional control is understood.

How Much Meditation is Necessary to See Benefits?

Currently, much of the research on mindfulness meditation involves individuals who are either long-term practitioners or have participated in an intensive course or retreat. In much of the attention research, the participants are either meditators before the study begins or are trained extensively and are being compared to non-meditators. Studies comparing Buddhist monks to non-meditators found that, with more hours of practice, less attentional resources were used (Davidson & Lutz, 2008). Other studies immersed their participants in a 10-day meditation retreat, while others went further to study the effects of a one-month mindfulness meditation retreat (Chambers et al 2008; Jha et al., 2007; van Vugt & Jha, 2011). The most extensive studies place participants in a three-month meditation retreat, finding that they performed better on sustained attention tasks following the meditation (Slagter et al., 2007; Lutz et al., 2008).

Throughout all of these, the important factor is disconnecting from real life during these periods. These immersions are free from daily life distractions. Researchers wanted to see if benefits could be observed when meditation is incorporated into daily life. This led to shorter studies such as 20 minutes of daily mind-body training over five days or 30 minutes daily for five days a week over a one-month span which found improved executive attention (Tang et al., 2007; Tang et al., 2010). In the study by Ainsworth et al. (2013), participants received formal training from a consultant psychologist in three sessions a day of one hour each. This lasted for eight days. This study found a significant improvement in executive attention measured on the Attentional Network Task for both the focused attention and open monitoring meditation groups. Both meditation groups experienced a similar increase in performance. The briefest studies conducted consisted of only two 15-minute meditation or three 20-minute meditations (Polak 2009; Wenk-Sormaz, 2005).

Other researchers investigated if brief sessions of meditation, only repeated two or three times, can create long-lasting effects (Polak, 2009; Wenk-Sormaz, 2005). The difficulty in studying long-term effects of meditation is that evidence suggest that non-meditators need formal training or more prolonged meditation exposure to show significant changes. In Polak's (2009) research, individuals performed a Stroop test, which, as Moore confirmed, does not accurately display varying levels of attentional control between groups. Participants results on the Stroop test did not indicate any meditative effects in terms of improvement on the task. For this reason, a test including more attentional control and sustainability is likely necessary to observe behavioral changes. Polak's (2009) research investigated if there are any long-term effects after only two bouts of meditation; hypothesizing that the first meditation would have some lasting effect and would enhance the effects of the second meditation leading to better performance. Polak (2009) did not find any significant improvement on the attention, orienting, or alerting for the meditation group when using a Stroop test for measuring attention and executive control. Wenk-Sormaz (2005) also used the Stroop test; however, the research was more interested in investigating habituation pre and post meditation. The meditation was called transcendental meditation which focuses on the word 'om', falling under the category of focused attention meditation. This study did find a reduction in interference during the Stroop test but not on a word production task. This suggests that the ability to selectively attend to the color is enhanced by the meditation, however, the word production of what color is there is not aided by the meditation practice. Improved attentional capabilities after brief mindfulness gives rise to the idea that the benefits of meditation may be immediate but not long lasting in regard to attentional control.

To investigate the question of how long to practice mindfulness practice for it to be effective in increasing attention, Moore et al. (2012), began a longitudinal study to understand the benefits of continuous meditation practice incorporated into daily life in a group of non-meditators compared to controls. Moore et al. (2012) said that the minimum time frame for individuals to settle into the meditation practice and develop attentional stability is between 10 and 15 minutes. The aim of their study was to investigate the lower boundaries of meditative practice. Individuals in their study participated in meditation over a 16-week period and were monitored at the beginning, middle, and end. Implementing a focused attention meditation, focusing on aspects of breathing, participants were tested using Stroop Word-Color Task to understand the potential changes in cognitive control. The behavioral data did not show improvement after the meditation; however, the neuronal activity related to executive control was altered after continuous practice. Thus, their findings display the benefits of the meditation through other measures besides behavioral responses. The potential limitations of the Moore et al. (2012) study were the lack of formalized training in how to practice as well as the consistency of practice.

Current Study

The current study aims to understand whether a single session of meditation can affect the limit in attentional resource allocation observed in a multiple-target RSVP task, as measured by behavioral performance on an attentional-blink task. Neurophysiological data were also collected to observe ERP components related to target detection and attention. The current thesis will only present the behavioral findings. The literature is not conclusive on the length of practice, the specific type of meditation, or the frequency at which to practice in order to observe results. Currently, the guidelines for mindfulness practice are very vague and leave much of it up to the practitioner to decide. Given the claims that there are benefits, it would be useful to identify which forms of training are most beneficial. In terms of long and short-term effects, this study will investigate the short-term effects of two-types of meditation. The aim is to see if the benefits of meditation on resource allocation and attentional capacity are immediate. For this reason, this study aims to investigate if individuals who do not have formal mindfulness training can benefit from meditation.

To train attention, an 11-minute guided meditation is used: either focused attention or open monitoring. It was previously found that between 10 and 15 minutes of meditation allow practitioners to settle into the practice and obtain a type of attentional control (Moore et al., 2012). It is hypothesized that a single bout of focused attention meditation will decrease the effects of the attentional blink, seen as increased T2 detection accuracy. Open monitoring meditation showed more beneficial in decreasing the effects of the attentional blink in the study conducted by Davidson and Lutz (2008) and Slagter et al. (2007). However, based on the level of training needed to master open monitoring, non-meditators in the current study are theorized to perform significantly better after the focus attention meditation. Although neither meditation group will receive any formal training on how to disengage from distractions, the focused attention group will learn how to engage and disengage with stimuli as a whole. This tool lends itself to the practice of engaging and disengaging with the targets during the RSVP. This study is intended for individuals who have not participated in any formal mindfulness meditation trainings.

This focused attention meditation will provide the participants tools for better attentional resource allocation and likely improve the ability for accurate target detection. A focused attention task such as the attentional blink paradigm will measure the efficacy of this type of meditation by measuring the change in the size of the blink in target detection accuracy. The first hypothesis of this study is that there will be an observable attentional blink at the lag 2 condition. Next, it is expected that there will be an improvement in target detection for the focused attention group in the lag 2 condition following the meditation.

Chapter 2: Methods

Participants

Participants consisted of 21 conveniently sampled individuals ranging from ages 19 to 57 (mean age: 24.76, standard deviation 32.59) in the New York City or greater metropolitan area. Individuals were questioned about meditation experience prior to testing. Formal meditation experience was an exclusion criterion. Although some individuals had their own informal meditation practice none had received any training in meditation prior to the experiment. The three participants that reported meditation experience had used some form of focused attention meditation, which mostly focused on the breath or body sensations. It was important to recruit individuals who had no formal meditation experience because any formal training could alter their performance on the task due to the skills they learned and recruited for the task. Older individuals and those with attention disorders such as ADHD were originally going to be excluded from the study however, since meditation studies have shown attentional improvements in older individuals as well as those with ADHD, they were included in the study (van Leeuwen et al., 2009). Since this was a convenience sample and the research supported opportunity for improvement in individuals with ADHD they were included in the sample.

There were 7 males and 14 females participating in this study. Participants were obtained through word of mouth and were compensated at a rate of $15 per hour. The study totaled two hours and 19 participants received $30 for participation: one refused compensation and one participant was receiving course credit. Nineteen individuals had a bachelor's degree or greater and two were in the process of earning a Bachelor's. Participants had normal to corrected normal vision. Two participants reported ADHD diagnoses but were not currently medicated.

Materials

A PC computer was selected to ensure the speed of presentation was consistent and the letters were clearly visible to the participants. Viewing distance was 57 cm. A chin rest was provided for participants.

Stimuli and Design

Stimuli were all uppercase letters. Twenty-six letters of the alphabet in black font were shown in RSVP on each trial. Stimulus onset asynchrony was 100ms and the interstimulus interval was 50ms: each stimulus was presented for 50ms followed by a 50ms blank screen. T1 and T2 had a possibility of being at five different positions in the sequence. In Figure 1, an example of a possible sequence is presented followed by the questions that the participants were tasked with answering. One of the stimuli was circled as the T1 either at position 6, 7, 8, 9, or 10 and T2 was presented circled at either 1, 2, 5, 8, or 10 frames after the T1. Each position of T1 and T2 were presented an equal number of times: 100 presentations for each condition. Since attentional blink is normally observable between 200 and 500ms, the lag 1 and lag 5 were intended to show the attention preservation at 100ms and 500ms following T1 presentation (Armstrong & Munoz, 2003). All letters were black and presented on a gray background. There was a cross presented for 500ms before each sequence for fixation. Following the full 26 letter sequence, participants are asked to report T1 and T2 consecutively shown in Figure 1. The responses were time dependent and were not triggered by responses being keyed in so participants that did not answer were recorded as blank and marked as incorrect.

Meditation Group Selection: Participants were assigned one of two meditation groups prior to volunteering. This was accomplished by assigning each participant a number from a random number generator. Odd numbers were assigned to the focus attention group while even numbers were assigned to the open monitoring meditation group. The focused attention group contained 11 participants and the open monitoring contained 10 participants. Both meditations were pre-recorded by the investigator to ensure consistency in length, delivery, and voice. The guidelines for the meditation followed the structure of guided meditations from Mindfulness-Based Stress Reduction courses and similar scripts can be found on YouTube under focused attention and open monitoring guided meditation. During the meditation individuals were instructed to close their eyes to ensure that there were no distractions.

Focused Attention group: In this group, individuals listened to an 11-minute body scan meditation. The focused attention meditation is a very common and simple meditation that is easy to follow and usually keeps the participants engaged. In this meditation, they were instructed to focus on their breathing. They were guided through a meditation describing how to relax and guide the breath throughout their bodies. A body scan was selected over a breath or sensory meditation because the body scan guides the participants to engage and disengage with different body parts and teaches how to let go of something once in focus to move onto the next object of focus.Instructions to disengage from distracting thoughts were given multiple times throughout the meditation and participants were instructed to bring their focus back to their breathing. This was intended to be an anchor for participants to return to. They were instructed to follow along and keep attention on different parts of the body as well as the entire process of breathing and breath as it travels through the body.

Open monitoring group: In this group, participants listened to an 11-minute open monitoring meditation. This type of meditation uses the practice of keeping an open mind. The concept is to keep an open awareness of the entire sensory experience. Individuals were instructed to not hold onto anything specific but just to be aware of everything happening. This meditation was more centered around acceptance of all of the things within sensory awareness. They were guided to be aware of their different senses as well as the entire experience of sitting. Just as the focused attention meditation did, they were instructed to disengage from intrusive and distracting thoughts and bring attention back to the present moment and their entire sensory awareness. This open monitoring left slightly more time for silent reflection and open awareness.

Task

The experimental procedure used four blocks of 125 trials: 2 before the meditation as a control and 2 after the meditation as the experimental condition. The entire session lasted about an hour. In between blocks two and three, there was an 11-minute guided meditation. The lights were kept on for the meditation, but individuals were instructed to close their eyes or keep them open gazing down. Specific instructions given to participants throughout the experiment are included in the Appendix.

Individuals were urged to keep their focus on the cross in the center of the screen and not look down at the keyboard if possible. Participants were also reassured that the timing was intended to be very fast and their lack of confidence in their guesses was standard for this type of experiment. Each session began with a practice run of 26 trials followed by four blocks of 125 trials. The first two blocks would serve as a control set. Then the participants performed the mindfulness meditation. The following two blocks were observed for meditation effects. Having participants serve as their own controls was useful in that everyone has varying levels of experience with relaxation and meditation. It was also beneficial because there are many different confounds that can affect attention such as age, education level, socioeconomic level, or attentional disorders. The ability for participants to serve as their own controls eliminated the need to match participant groups.

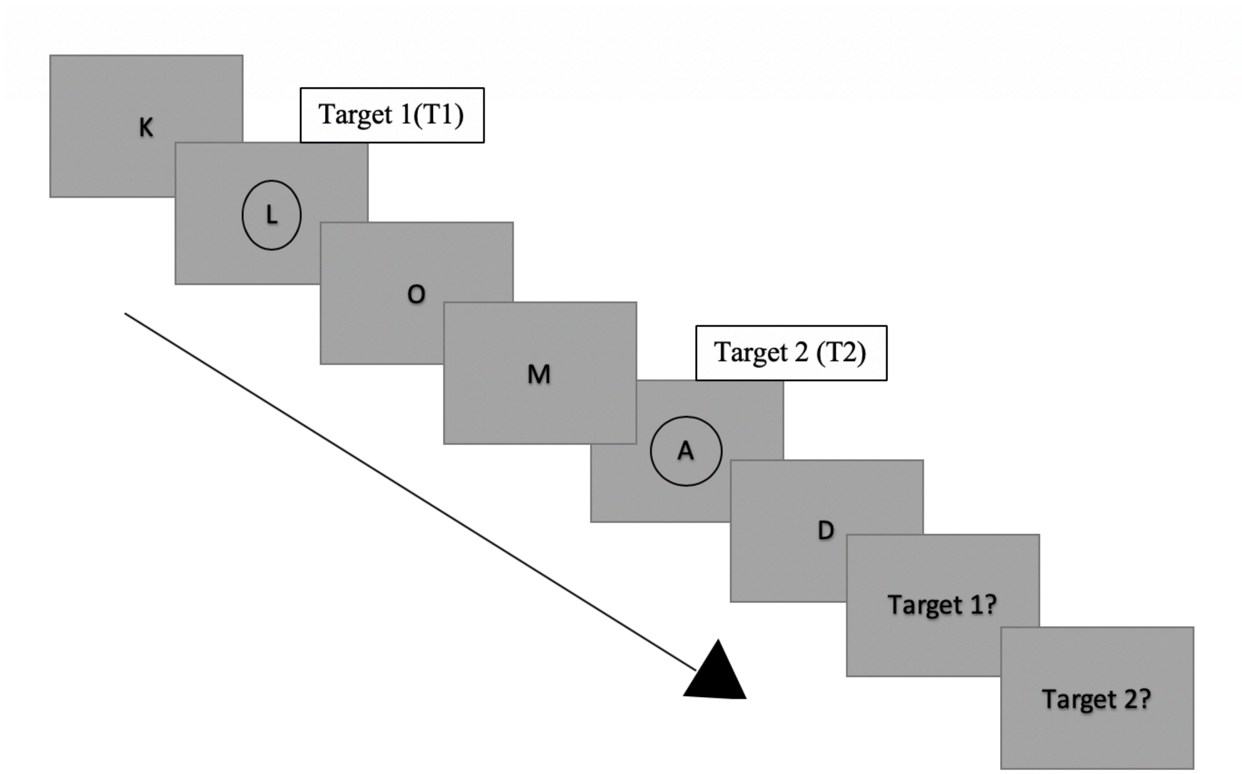

Figure 1
Stimulus presentation of letters and targets with subsequent questions.

Analyses

Analyses behavioral data were performed using R and were tested with a $p < .05$ level of significance. Although there was neurophysiological data collected, this investigation will only consider the behavioral results.

The condition of interest to compare in the pre and post meditation conditions between the two meditation groups was Lag 2 since that is where the attentional blink is thought to be visible. Comparing the groups in overall performance over all five positions of T1 or T2 is not the intention of this study. The condition in which there is hypothesized to be a change after meditation is the attentional blink condition (Lag 2).

To analyze the results, trials in which no response was recorded were removed for each participant. These were recorded as incorrect responses even though the participant did not respond. Data analysis began with separating each response time and target response into meditation groups. The analysis consisted of measuring T2 accuracy in the context of the T1 position or the T2 position. These groups were then compared between the types of meditation. Then the percentage of T2 correct responses were calculated for pre and post meditation conditions for each position of T1 and T2.

First T1 position effect on T2 was investigated to rule that out as a confound. Average percentages of T2 response accuracy were calculated for each T1 position (6,7,8,9,10) for both the focused attention (FA) and open monitoring (OM) groups shown in Table 1. The same was done for T2 position (Lag 1,2,5,8,10) shown in Table 2. ANOVAS were performed to investigate interactions and main effects of meditation group, meditation overall, and position of T1 [shown in results].

Analysis of T2 position effect used an ANOVA and subsequent post-hoc tests. A Kruskal-Wallis test with subsequent pairwise Wilcox tests were used to investigate significant interactions that were discovered. Since each participant did two blocks of trials before the meditation and two blocks after, a pairwise comparison was employed. These post-hoc tests were used to compare the pre and post meditation conditions for T2 positions in both meditation groups in relation to T2 detection accuracy.

Chapter 3: Results

The first prediction was that both meditation groups would show an attentional blink at lag 2 observed in a decrease of target detection accuracy. The attentional blink was visible for both meditation groups which is displayed in Table 2 and Figure 3. The second prediction was that after performing meditation, there would be a decrease in size of the attentional blink. This would be expected for only the focused attention meditators. This decrease in attentional blink was measured by an increase in accuracy of T2 detection for the Lag 2 condition. T1 position effect was analyzed to rule it out as a confound since T1 was presented at various positions. The literature suggests that if one group of subjects begins with a significantly lower target detection accuracy in the pre-test then they will have greater room for improvement in the post-test condition. To rule this out, the hypothesized attentional blink condition was compared for both meditation groups in the pre-meditation condition. There was no significant difference between the groups before meditation suggesting that both groups had an equal chance of improving their accuracy of T2 detection for the attentional blink condition.

T1 Position Effect: It was important to rule out a T1 position effect on T2 accuracy. Table 1 displays the T1 position along with the percentage correct of T2 detection in the pre and post conditions for both meditation groups. Table 1 shows that even though the focused attention meditators had a generally higher average percentage correct of T2 detection than the open monitoring meditators, there was no real improvement in detection accuracy after either meditation. Based on the averages presented in Table 1 it did not appear that T1 affected T2 accuracy however ANOVAs were run to confirm this. There was no main effect of type of meditation $F(1,19) = 3.948$ $p = 0.0615$. There was no main effect of lag $F(4,76) = 0.431$ $p = 0.785$. There was no main effect of pre and post meditation conditions $F(1,19) = 0.856$ $p = 0.366$. There was no interaction between the type of meditation, the lag, and the pre and post meditation conditions $F(4,76) = 1.065$ $p= 0.380$. The position of T1 does not affect T2 accuracy in either meditation group before or after the meditation. This removes T1 position as a confounding variable. This is consistent with the hypothesis that T1 position does not impact T2 detection accuracy no matter where it is presented in relation to T2. Since there was no interaction between the T1 position and the T2 detection accuracy and the type of meditation or the meditation condition it was ruled out as a confound.

Table 1: T1 Position Effect on T2 Accuracy by Meditation Group

T1 Lag	Type	%T2 Correct Pre	% T2 Correct Post
6	FA	59	62.7
7	FA	60.3	62.5
8	FA	63.6	60.5
9	FA	62.4	61.3
10	FA	61.9	65.2
6	OM	52.2	54.5
7	OM	53.5	55.3
8	OM	52.8	53.9
9	OM	54.9	55.5
10	OM	53.8	52.7

Note: Lag indicates the position at which T1 is presented in the sequence. Type of meditation is either Focused Attention (FA) or open monitoring (OM).

In Figure 2, T1 position effect is plotted to show the stability in score over the different lag conditions. The focused attention group began with slightly higher accuracy in reporting T2 than the open monitoring group however there was no main effect of type of meditation on accuracy.

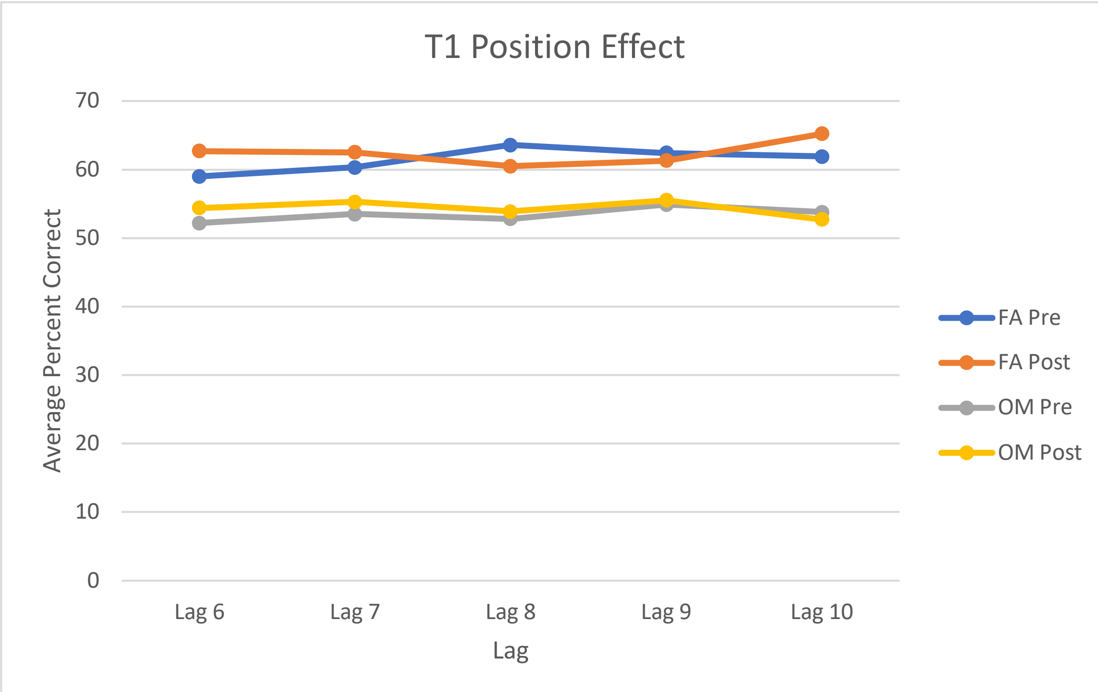

Figure 2
T1 position is presented for both meditation conditions (FA and OM). The lag is the frame at which the T2 is presented. These were then separated into pre and post for each lag condition. The average percent correct is the T2 responses.

T2 Position Effect: The prediction was that for the Lag 2 position, both groups of meditators would show an attentional blink however, post-meditation, the FA group was predicted to show a decreased attentional blink compared to the OM group. Table 2 shows the type of meditation and the pre and post meditation average percentage of T2 detection based on T2 position. Table 2 shows a visible attentional blink indicated by a significant decrease in percentage of T2 correctly identified for the Lag 2 condition. Table 2 also confirms that the attentional blink is only visible between 200 and 500ms because the accuracy of T2 detection at Lag 1 (100ms post T1) and Lag 5 (500ms post T1) do not have the same attentional deficits that Lag 2 displays.

Table 2: T2 Position Effect on T2 Accuracy by Meditation Group

T2 Lag	Type	% T2 Correct Pre	% T2 Correct Post
1	FA	39.2	46.4
2	FA	12.6	19.9
5	FA	73.8	69.8
8	FA	90.4	85.8
10	FA	86.5	89.5
1	OM	36.3	37.8
2	OM	11.4	12
5	OM	61.8	61.2
8	OM	77.7	79.4
10	OM	79	80.6

Note: Lag indicates the position at which T2 is presented following T1. Type of meditation is either Focused Attention (FA) or open monitoring (OM).

Figure 3 shows a visible attentional blink for both groups at Lag 2. For the post-meditation condition the focused attention group has an increase in accuracy of T2 detection for Lag 2 whereas the open monitoring does not. Figure 3 shows that the open monitoring and the focused attention had similar pre-meditation T2 response accuracy for the Lag 2 condition. Scores for the open monitoring group remained virtually the same for all lag conditions. The focused attention group showed an increase in T2 detection accuracy for the Lag 1, 2, and 10 conditions but decreased accuracy for the Lag 5 and 8 conditions.

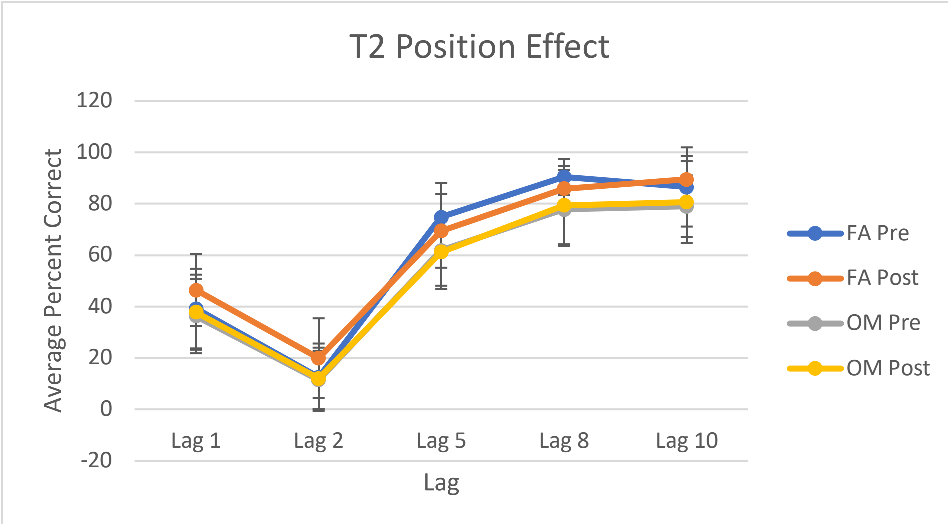

Figure 3
T2 position is presented for both meditation groups (FA and OM). The lag is the number of frames in between T1 and T2. They are separated for pre and post meditation conditions. The average percent correct is the T2 response. Error bars show the standard deviation of each lag condition for the different meditation types during the pre and post meditation conditions.

There was no main effect of type of meditation on T2 detection accuracy $F(1,19) = 3.493$ $p = 0.0771$. There was no main effect of pre and post meditation conditions $F(1,19)= 1.638$ $p = 0.216$. There was a main effect of lag $F(4,76) = 260.656$ $p< 2e\text{-}16$. This effect is shown in Figure 3. There was a significant interaction between lag and pre/post meditation conditions $F(4,76)= 2.624$ $p=0.0405$. This indicates there is a significant difference between the pre and post conditions for different T2 positions. There was no significant interaction between type of meditation, lag, and pre/post meditation $F(4,76)= 1.963$ $p=0.1087$. This indicates that the T2 accuracy on the pre and post tests for different lag conditions does not depend on the type of meditation performed.

The interaction between the lag and the pre/post meditation conditions warranted further testing to determine what the individual differences were. Kruskall-Wallis and pairwise Wilcox tests were performed to investigate the differences. Since there was a main effect of Lag a pairwise Wilcox test was performed to determine what the differences were for the lag conditions. Since there was no effect of type of meditation, the groups were compared together to investigate lag condition differences. The different lag conditions are significantly different for all conditions except lag 8 and lag 10. The lag 2 condition showed significantly lower accuracy than all other conditions. Lag 5 showed lower accuracy than lag 8 and lag 10 but lag 8 and 10 were not significantly different from one another. The results of this test are shown in Table 3.

To understand if the type of meditation had an effect on target detection accuracy, all lag conditions were collapsed, and a Kruskal-Wallis test was used. There is a significant difference between the meditation groups (Chi-squared = 4.3837, p=0.03628, df=1). This overall difference is visible in Figure 3 wherein the focused attention meditation group had differing scores than the open monitoring group both in the pre and post meditation conditions for different lag conditions.

A Wilcox test was used to compare the pre and post target detection accuracy in the Lag 2 condition for both types of meditation. There was no significant difference between the pre and post meditation conditions. The open monitoring group did not have significantly different accuracy between the pre and post-test (Chi-squared = 0.11811, p = 0.7311, df = 1). There was also no significant difference in the focused attention group for the lag 2 condition (Chi-square = 0.9127, p= 0.3394, df= 1). In Figure 3 there is a visible increase in accuracy for the Lag 2 condition in the focused attention group. When looking at the average correct responses in Table 2, the focused attention group increase in detection accuracy from 13% to 20% correct while the open monitoring condition increase from 11% to 12%. The variances among the groups for the

T2 position effect is shown in Figure 3 with standard deviation error bars. Although the focused attention group did increase in accuracy after the meditation, the difference was not significant.

Table 3 Pairwise Wilcox Test of T2 Accuracy by Lag

	1	2	5	8
2	2.0e-10			
5	3.1e-10	1.8e-14		
8	6.5e-14	1.7e-14	5.7e-07	
10	7.6e-14	1.7e-14	1.1e-06	0.43

Note: All 5 lag conditions are compared to determine if they are significantly different from one another. P values are listed in each box. P<.05 is considered significant.

Chapter 4: Discussion

The study aimed to investigate if a single bout of mindfulness meditation can improve attentional resource allocation and target detection capabilities in the short term. Attentional resources are limited. This limitation of attentional processing capacity is observed when two stimuli are temporally close; termed an attentional blink. A target presented between 200 and 500ms following the first stimulus shows this attentional blink. Specifically, resources are still being utilized to process T1 which interferes with detection of T2. To test whether attention can be improved, participants performed either focused attention or open monitoring meditation followed by a post-meditation RSVP task.

Confirming the first hypothesis, there was a visible attentional blink at the lag 2 condition. This was observed as a decrease in target detection accuracy for that condition. Both meditation groups showed this decrease in target detection accuracy in the lag 2 condition. There was a type of attentional preservation that occurred with targets presented at 100ms. The accuracy, although was not the same as the later lag conditions, was still higher than the lag 2 condition. The lag 5 condition also showed higher accuracy than the lag 2 condition confirming that the attention blink only lasts between 200 to 500ms.

Inconsistent with the second hypothesis, there was not a significant change in the size of the attentional blink for either meditation group after meditation. There was a visible decrease in the size of the attentional blink for the focused attention group observed as an increase in target detection accuracy however it was not a significant difference. This is potentially an issue of power. Although each participant performed a sufficient amount of trials for analysis of the lag conditions, the number of participants was not sufficient to show statistical differences among the two groups of meditators. It is also possible that the meditation was not long enough or formal enough for the changes to be drastic enough to detect significance between the meditation groups.

This is inconsistent with the research done by Slagter et al. (2007) who found that a mental-training meditation task is effective for improving T2 detection accuracy. The focused attention meditation is a form of mental-training because it teaches the participant how to engage and disengage with stimuli. It is hypothesized to allow for an increase in attentional allocation and distribution abilities. The significant difference between the type of meditation indicates that overall, the type of meditation affected the accuracy although it was not singularly observed in the lag 2 condition.

Based on the research conducted by Polak (2009) and Moore et al. (2012) it was possible that participants in the current study would not display significant behavioral differences after just one bout of meditation. It is hypothesized that even if there were no behavioral changes, there would be neural activity differences observed in relation to increased detection of T2 even if the identify was not reported correctly. If there were no behavioral changes observed, investigating N2 and P3b in relation to T2 could show if the participants were unconsciously aware of the stimulus being a target even if they were unable to report it. Observing neural activity changes without behavioral changes could still confirm the theories that meditation affects attention even in the short-term. Differences in the P3b and N2 components observed following T2 presentation, in conjunction with behavioral differences, would indicate the meditation could create both neural activity changes as well as behavioral changes in the short-term.

Although there weren't significant behavioral results, neural activity changes are still expected since Moore et al. (2012) found that neuronal activity changes can occur without matching behavioral changes. The hypothesis is that this increase of attentional allocation would be observed in the form of an increase in the N2 component and P3b component over parietal areas. This increase would reflect improved object recognition and categorization as well as stimulus evaluation and working memory updating.

To strictly compare the two meditation groups against each other though is not a true test as to whether the meditation aided in improving attention abilities. The literature suggests that, in a group of nonmeditators, the focused attention meditation group should perform better on the task following the meditation and the open monitoring meditators will not perform significantly better on the task based on level of training required for each type of meditation (Kleanu, 1965). However, this is not to say that focused attention meditators will perform significantly better than the open monitoring group, just that there will be an increase in score for one group and not the other. Since the two groups were not significantly different in the attentional blink condition before the meditation, we can assume that each group had a fair chance of improvement.

The focused attention meditation appears to improve attention shown in an improvement in accuracy of T2 detection on the behavioral task. The open monitoring group did not show any quantifiable changes after performing the meditation. This decrease in attentional blink is consistent with the Slagter et al., (2007) findings that in the mental-training attention meditation group there was an improved T2 accuracy selective to the time window of the attentional blink. Focused attention meditation gives participants tools to allocate attentional resources more efficiently and decrease the size of their attentional blink. However, in the current study there was no significant interaction between the type of meditation, the pre and post conditions, and the lag which is inconsistent with the results of Slagter et al. (2007). This could be due to the small number of participants in each meditation group. It also could be due to the styles of meditation since there was no main effect of meditation type. The way that the meditations were administered might not have been drastically different enough since the open monitoring was still guided and didn't leave extensive time for self-reflective meditation. In the study by Slagter et al. (2007) the meditation was more consistent with a continuous open monitoring meditation with components of focused attention meditation. The overlap in meditation techniques doesn't give a clear indication of what part of the medication practices are beneficial for mental-training.

The observation that there was a slight decreased in the attentional blink for the focused attention meditators do not corroborate previous studies with long term meditators who perform better after open monitoring meditation than focused attention meditation (Davidson & Lutz, 2008). They do however support the theory suggested by Kapleau (1965) that focused attention meditation is the base level of meditation and open monitoring requires more practice to observe benefits. Open monitoring meditation allows for a full awareness of space and likely decreases the amount of attention given to any specific target since there is a guidance towards complete attention to the surroundings. Focused attention meditation aids in present moment engagement and allows for disengagement from distracting thoughts because this type of meditation provides an object to anchor the thoughts. The ability to fully disengage with competing thoughts comes with practice (Lutz et al., 2004). The decreased attentional blink suggests that the focused attention meditators were able to learn and utilize these skills. The open monitoring group were not taught the same skills in their meditation since they were practicing not engaging with anything specific and not how to engage and disengage specifically. These findings suggest that for inexperienced meditators, a focused attention meditation is more favorable than open monitoring meditation when looking to improve attention.

The focused attention meditation aims to introduce a more centered focus and should help with sustained attention (Slagter et al., 2007). This isn't necessarily the case in this study since accuracy on T2 detection decreased in the two lag groups following the condition at which the attentional blink is present. The results indicate that the focused attention meditation group was able to improve resource allocation abilities, decreasing the attentional blink but was unable to increase sustained attention to improve accuracy of target detection for all of the lag conditions. The decrease in score for the lag 5 and lag 8 condition indicates an inability to sustain attentional control. This is likely due to the lack of formal training and practice that the participants had.

The decrease in target detection accuracy for the two lag conditions following the attentional blink condition suggests that individuals were able to use the focused attention meditation to increase attentional allocation when targets were closer together but when they had to wait longer for T2 to appear they could not sustain attention after the meditation practice. The type of focused attention meditation they performed, taught them to engage and disengage. When targets were presented quickly they were able to engage and disengage however when they were further apart they could not maintain the same level of continuous attention and awareness. They were unable to sit with open awareness and wait for a target to be presented as the open monitoring group could since they were taught to keep the awareness open entirely. The open monitoring group remained consistent in the pre and post meditation conditions likely because they kept their awareness open to any and all targets but could not actively direct focus on the targets any differently than before the meditation. This is supported by Davidson and Lutz (2008) who postulate that in maintaining an open awareness, any target can be detected. Leaving awareness open benefitted the open monitoring group because they were consistently able to report the target. They were not trained extensively enough to improve but their scores remained stable. The focused attention meditators were actively engaging and disengaging but didn't have the skills to maintain that for long periods of time since it likely requires more mental energy. The open monitoring meditators were not given the appropriate tools to allocate attentional resources to targets more evenly therefore their detection accuracy remained virtually the same in the pre and post-meditation conditions. This is consistent with the hypothesis that open monitoring meditation requires more extensive training to master.

Accuracy on T2 detection was dependent on the lag and the participation in meditation overall. Consistent with previous research, T1 position does not have an effect on T2 detection accuracy (Slagter et al., 2007). The study supports that brief mindfulness meditation is able to improve attentional resource allocation in non-meditators but not sustained attention. It also shows that focused attention meditation has the ability to decrease the attentional blink in nonmeditators after just one session of meditation although not significantly. More formal training is necessary for focused attention meditation to successfully improve sustained attention and for open monitoring meditators to see attentional benefits. These findings demonstrate that through focused attention meditation, increased control over the distribution of limited brain resources may be possible.

Most studies regarding mindfulness meditation performed either focused attention or open monitoring mediation with some utilizing a combination of both. Slagter et al. (2007) observed a T2 detection accuracy increase for the meditators while Moore et al. (2012) did not observe any behavioral changes following meditation training. The Slagter et al. (2007) study provided the participants with formal training in person but the Moore et al. (2012) study had participants schedule and conduct their own training leaving more room for individual differences in practice. This might have affected what skills the practitioners gained from the meditation. The current study was able to show some amount of behavioral changes without formal training however the in-person nature of the training increased adherence and minimized distractions. This study compared the two most common meditation practices to show the benefits for non-meditators in relation to attention.

According to Moore et al. (2012) a meditation should last between 10 and 15 minutes to allow the practitioner to settle into the meditation. For the current study, an 11-minute meditation was used. However, the conclusions Moore et al. (2012) made about the time it takes to settle into a meditation may be dependent on type of meditation training. The participants in that study were meditation naïve when beginning the study just as the participants in this study were. However, Moore et al. (2012) had participants use a 10-minute meditation for a 16-week period. The repeated exposure to meditation might have increased the ease at which participants could settle into the meditation. It was not reported in that study whether the participants found it difficult to settle into the meditation during the first sessions before they were comfortable with the meditation practices. Even if the meditators in that study were able to settle into the practice in a 10-15-minute meditation, the meditation was led by a trained mindfulness educator. The current study had the practices lead by a mindfulness practitioner but not a trained educator. It is possible that in the current study the meditation was not long enough for either of the meditation groups to truly benefit from it.

This study aimed to investigate the short-term benefits of both of the common types of mindfulness meditation. For non-meditators, focused attention meditation shows improvements for allocating and controlling attention displayed in behavioral change. The changes in target detection accuracy indicate that for non-meditators, focused attention meditation is a more beneficial type of meditation to improve attention. Currently many studies are investigating mindfulness as a practical tool to be used within the workplace, schools, and clinical practice. Hertz (2018) found that mindfulness can be beneficial in the workplace to decrease mind wandering and increase attention. Tarrasch (2018) found that in elementary school children, mindfulness lessons increase attentional control and selective attention and decreased impulsivity. The conclusions of the current study indicate that even brief exposure to mindfulness creates change. Consistent with long-term meditation studies, mindfulness can improve attentional control and aid in focusing attention. More extensive meditation practice is needed for mastery of focused attention and open monitoring meditation overall and improving sustained attention as a whole. The practical implications of this study are that non-meditators can likely implement mindfulness meditation in small quantities to improve attentional control for the short-term.

Future Directions:

The next step in analyzing the effects of mindfulness meditation in non-meditators is to analyze the EEG data collected during this task. As previously mentioned, the two components of interest would be the P3b and the N2 components. Based on previous findings, when investigated in relation to T2, these components should increase in amplitude: P3b becoming more positive and N2 becoming more negative. These findings are still expected even though there wasn't a significant change in the behavior.

For future research studies including ERP investigations, incorporating confidence ratings for the responses would be informative. Analyzing ERP components and responses in which there were greater or lesser levels of confidence would be able to tell if components differed when individuals were more or less confident in their answers. Overall, individuals reported finding the task very difficult following the practice trials but seemed to feel more comfortable with it as the study progressed. By including a confidence rating, it would be informative to see if the participants felt more comfortable with the task even if their behavioral results didn't change. Although there is potential for practice effects, some individuals did improve while others did not which indicates that the task does not get significantly easier with practice. The percentage correct also stayed fairly consistent for each individual in most conditions.

Limitations:

One of the limitations of mindfulness meditation studies is that there is no one consistent way to administer either type of meditation. This creates potential overlap in the styles of meditation. The duration and style of meditation may have not have been enough to observe true changes.

Participants who expressed concern about keeping their hands on the home row and were not confident in letter placement on the keyboard were instructed to keep their eyes on the screen at least until the second target was presented. There was no way to monitor when participants looked down at the keyboard. When the second target was presented, individuals might have looked down to put their fingers on target 1 and target 2 waiting for the questions to be asked. If this was the case then these individuals were not holding the targets in working memory. Other participants might have not needed to look down at the keyboard to place their hands meaning they likely watched the entire stream of letters and had to hold both targets in their working memory while watching other stimuli be presented. This potentially creates an inequality in difficulty of the task between the participants who were keeping the targets within working memory and those who immediately put their fingers on the correct keys once the second target was presented.

Some participants also reported feeling very sleepy during or right after the meditation. This could have affected how they performed on the block of trials immediately following the meditation. Their fatigue during the meditation also could have altered the information they obtained from the guided meditation. This makes it difficult to know which participants were engaged, which were distracted, and which were fatigued and maybe in a semi-conscious state. Since the paradigm is very repetitive, there is potential for fatigue during the trials especially for individuals that chose to continue straight through in between blocks. The individuals with ADHD reported difficulty sitting still the entire time and reported that at times focusing on the task became challenging. Since age and ADHD both increased the size of the blink, it might have been beneficial to keep a specific age range of interest as well as exclude individuals with ADHD since their blink is normally larger. Although older individuals and those with ADHD are able to decrease the size of their attentional blink after meditation, it is not explicitly mentioned if there is a threshold of the amount of meditation necessary to do so. Shortening the age range and excluding individuals with attention deficits would have given a clearer picture of meditation benefits for non-meditators as a whole. For a group of non-meditators in a short-term meditation study the exclusion criteria could've been more specific to ensure that the sample had a fair chance of improvement after just one session of meditation.

Conclusion:

This study presented the question of whether one session of mindfulness meditation was enough to aid non-meditators in improving attentional allocation to decrease the size of the attentional blink. An attentional blink was observed from 200 to 500ms. There was some evidence that the group of focused attention meditators improved their target detection capabilities during the condition in which the attentional blink was present. Their accuracy in detecting the second target during the attentional blink condition improved by 7 % and, although it was not a significant difference, the open monitoring group only improved in accuracy by 1 %. This finding suggests that focused attention meditation can improve participants' ability to distribute attentional resources effectively to multiple targets, but a longer session and/or more participants will be necessary to have confidence in this conclusion. The open monitoring group did not benefit from the meditation in the same way in accordance with the hypothesis. These findings indicate that focused attention meditation may be beneficial for improving subsystems of attention in non-meditators.

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Appendix

Individuals were then given these instructions prior to beginning the study.

- You will see a sequence of letters that flash quickly in the middle of the screen
- Two of these letters will have circles around them
- The first letter that has a circle around it is Target 1
- The second letter that has a circle is Target 2
- Both targets will appear at different times on a given trial, for example target 1 might occur 5 seconds in and then in the next trial occur 8 seconds in
- The 2nd target will appear at different times after target 1 as well - sometimes it will appear just after and other times it will be many seconds later.
- Make sure you keep your eye focused on the center of the screen for the entire duration of the sequence so that you do not miss a target
- Quickly after the sequence of letters it will ask you to report the first and then the second target letter
- It is helpful to keep your hands on the home row as the question for target 2 appears just seconds after the question for target 1
- The responses are timed and after responding the prompt may remain on the screen even after your responses are recorded. You do not need to press the letters again.
- While you are watching the sequence, remember target 1 and target 2 so that you can quickly key in the letters when the sequence is completed
- When keying in answers, even if you miss typing in the first target, make sure that you still answer the question for the 2nd target
- If you aren’t confident of what the target is, it is better to guess than leave it blank

- Do not stress about getting the questions correct, just try your best
- Each sequence and response take about 12.5 seconds and there are 125 sequence trials in each block
- After you have completed a block, you will see a screen that reads “please wait for instructions”, you may continue right away to the next block by pressing any key or you may take a moment in between.
- After 2 blocks we will do a brief meditation and continue onto the next two blocks - when you see “please wait for instructions” press enter and continue to the next one
- Following the meditation, you will repeat the same procedure for 2 more blocks
- *before the meditation*
    - Now I’m going to play you a guided meditation, there is no expectation here just to try to relax.