

Does Mindfulness Affect Subsystems of Attention?

by

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Dissertation submitted in partial fulfillment of
the requirements for the degree of Doctor of Philosophy in the Department of
Psychology & Neuroscience in the Graduate School
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ABSTRACT

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Abstract

Attention is considered a fundamental component of mindfulness, and current theory suggests that it is a primary mechanism of change that contributes to the substantive improvements in physical and psychological functioning attributed to mindfulness-based interventions including Mindfulness Based Stress Reduction (MBSR) and Mindfulness Based Cognitive Therapy (MBCT). Using the Attention Network Test (ANT) and an Inattentive Blindness (IB) task, the current study assessed differences in subsystems of attention in a group of experienced MBSR practitioners and a group of meditation naïve controls. MBSR practitioners demonstrated superior conflict monitoring performance relative to the control participants; however, groups did not differ with regards to their performance on the alerting and orienting components of the ANT. Additionally, although the MBSR practitioners were nearly half as likely as their control counterparts to evidence IB, this difference was not significant. Finally, self-reported mindfulness was higher in meditators relative to meditation naïve control participants, though scores did not correlate with performance on the attention tasks. The implications of these findings and directions for future research are discussed.

Dedication

To my mother who has always been the light at the end of my tunnels and my father who truly believed that I could be anything I wanted to be (and secretly held out hope that one day I'd want to be an army general). To my brother Jef who taught me the meaning of "viva la vie boheme" and my brother Jason who has been my compass in more ways than one. To Andreas Penna who has proven to be my lifelong confidant and place of refuge. To Betsy Holmberg and Katrina Poetzl who laughed, cried, and then laughed some more with me. To Amy Huguelet, Ryan Anolick, Abra Berens, and Ben Wang who are at the foundation of who I am and who I aspire to be. To the Flecks, in gratitude for everything they've taught me about love, acceptance, family, and sewing. To Jordana Segal and Jackie Gollan who were the impetus for all of this and to Tom Lynch for taking a chance on me. To all of the volunteers at Independent Animal Rescue (IAR) and to Jennifer Naylor for making a difference. To Elmo, Colin, and Mindee, who have provided me with boundless comfort and comic relief. Finally, to Mat Fleck – no words can express what your love has meant to me. This, Mat, is for you.

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1. Introduction

1.1 Mindfulness and mindfulness based stress reduction

The relationship between mindfulness and psychology that underscores over 2500 years of Buddhist tradition has only recently become a topic of serious inquiry in Western psychology. Indeed, only in the last 20 years, with the advent of positive mental health and stress reduction initiatives, have Western scientists seriously begun to explore the construct of mindfulness and its relationship to psychology (Bishop et al., 2004; Shapiro, Carlson, Astin, & Freeman, 2006; Wallace & Shapiro, 2006). Although mindfulness is considered an ancient practice, the term itself is relatively modern. Mindfulness is the English translation of the amalgamation of two Pali terms – Sati and Sampajana – which, in combination, can be interpreted as awareness, circumspection, discernment, and/or retention. In an attempt to integrate these various definitions, Bhikku Bodhi, a renowned Theravadan scholar and monk, suggested that mindfulness means remembering to pay attention to that which one is experiencing in the present moment with care and discernment (Shapiro, 2009; Wallace & Bodhi, 2006).

In the context of clinical psychology, mindfulness became a particularly meaningful construct following the introduction of Mindfulness-Based Stress Reduction (MBSR, Kabat-Zinn, 1982) – a program aimed at facilitating mental and physical health via mindfulness meditation. With over 250 medical centers offering MBSR programs across the United States (Jha, Stanley, Kiyonaga, Wong, & Gelfand, 2010), MBSR has

been, and continues to be, the most commonly cited method of mindfulness training in clinical psychology (Baer, 2003; Shapiro, Oman, Thoresen, Plante, & Flinders, 2008).

MBSR was developed in a behavioral medical setting as a treatment for people suffering from chronic pain and stress related disorders. The program is typically provided as an 8-week course in which as many as 30 participants meet as a group on a weekly basis for 2.5 hours to receive instruction on mindfulness meditation in conjunction with discussions regarding stress and coping. Participants are instructed to practice the meditations they learn in the weekly course for up to 45 minutes a day, 6 days a week, over the duration of the program. Participants are also provided with audio tapes or CDs to facilitate their practice but are encouraged to practice without the assistance of tapes after the first few weeks of the course. In addition to the weekly courses and daily practice, an all-day (7-8 hour) intensive meditation retreat is offered around the 6th week of the program.

Although MBSR is a relatively new intervention, a review of the research literature suggests that it is uniquely successful in treating a range of physical and psychological disorders (Greeson, 2008; Grossman, Niemann, Schmidt, & Walach, 2004). MBSR has been associated with decreased symptoms and symptom severity in patients suffering from generalized anxiety (Kabat-Zinn et al., 1992), binge eating (Kristeller & Hallett, 1999), social anxiety (Goldin & Gross, 2010) and attention deficit (Zylowska et al., 2008) disorders. In terms of the medical research, participation in MBSR has been

associated with significant improvements on physiological indices of disease amongst patients suffering from cancer (Carlson, Speca, Faris, & Patel, 2007; Witek-Janusek et al., 2008), psoriasis (Kabat-Zinn et al., 1998), and HIV (Robinson, Mathews, & Witek-Janusek, 2003). In addition, patients with heart disease (Tacon, McComb, Caldera, & Randolph, 2003), chronic pain (Kabat-Zinn et al., Lipworth, & Burney, 1985), fibromyalgia (Grossman, Tiefenthaler-Gilmer, Raysz, & Kesper, 2007), and rheumatoid arthritis (Pradhan et al., 2007) evidenced significant improvements on self-report measures of psychological and physiological functioning following completion of an MBSR course. Finally, Mindfulness-Based Cognitive Therapy (MBCT; Teasdale, Segal, Williams, & Mark, 1995) – a hybrid of the MBSR program that integrates components of cognitive behavioral therapy (CBT) for depression (Beck et al., 1979) – is proving to be particularly effective at reducing the rate of episode relapse in patients with recurrent major depression (Teasdale et al., 2000). More recent research suggests that, in suicidally depressed patients, MBCT is associated with significant improvements in meta-awareness and memory specificity, which have been targeted as processes that are critical to relapse prevention (Hargus, Crane, Barnhofer, & Williams, 2010). Although these outcome studies attest to the applicability of MBSR and MBCT, they provide little in terms of furthering our understanding of how these interventions produce the changes attributed to them (Bishop, 2002; Hayes & Shenk, 2004; Hayes & Wilson, 2003; Shapiro, 2009; Shapiro et al., 2006).

1.2 Mindfulness models

Although the bulk of the empirical research on MBSR has focused on whether or not it can produce substantive changes in physical and mental health, recent years have seen an increase in theoretical articles proposing potential mechanisms of change (see Bishop et al., 2004; Dimidjian & Linehan, 2003; Hayes & Shenk, 2004; Hayes & Wilson, 2003; Shapiro et al., 2006; Teasdale, Segal, & Williams, 1994). Although the models and hypotheses that have been proposed are diverse, the majority emphasize at least one common factor – attention. The significance of attention with regards to mindfulness is perhaps no more obvious than in the definition proposed by Kabat-Zinn (2003) in which he defines mindfulness as “paying attention; on purpose, in the present moment, and non-judgmentally. Although many researchers debate the role and function of intention and attitude (Bishop, 2002; Dimidjian & Linehan, 2003; Hayes & Wilson, 2003), the majority agree that *attention* is a fundamental component of mindfulness.

The two most widely recognized models of mindfulness in the MBSR literature both identify attention as a central mechanism. The first, proposed by Shapiro et al. (2006), is based on Kabat-Zinn’s 2003 definition of mindfulness that conceptualizes the construct in terms of three components – intention, attitude, and attention. According to Shapiro et al.’s model, these facets of mindfulness contribute directly and indirectly to the significant positive transformations attributed to mindfulness meditation. Exactly how the aforementioned components contribute to positive changes is less clear. The

authors noted that attention, for instance, as it is studied in cognitive psychology, is a multifaceted construct that pertains to a plethora of cognitive skills. Rather than exhausting all of the ways in which attention may be implicated in mindfulness, the authors focused on three specific skills that they suggested are employed and enhanced through mindfulness meditation. Specifically, the authors maintained that vigilance or *sustained attention* – defined as the ability to allocate attention to one object over a period of time (Parasuraman, 1998; Posner & Rothbart, 1992), *switching* – the capacity to deliberately switch attention from one object to other objects or mental sets (Posner, 1980), and *cognitive inhibition* – the capacity to willingly restrict secondary elaborative processing of thoughts, sensations, and feelings (Williams, Mathews, & Macleod, 1996), would all be significantly improved by mindfulness practice.

Although Shapiro et al.'s model was not the first to consider attention as a mechanism inherent in mindfulness; theirs was the first tri-axiomatic model of mindfulness. Bishop et al.'s (2004) earlier model of mindfulness identified only two primary components – the self-regulation of attention and an attitude characterized by curiosity, openness, and acceptance. With regards to attention, the authors made the same predictions regarding changes in *sustained attention*, *switching*, and *cognitive inhibition* that Shapiro et al. (2006) made; moreover, Bishop et al. also suggested that the these changes in attention result in increased cognitive resources necessary for information processing. Specifically, the authors suggested that when the mind

disengages from elaborative thinking, more resources are made available to process information pertaining to one's current experience. As such, Bishop et al. hypothesized that mindfulness results in a wider perspective on experience thereby enhancing *non-directed attention*.

Another important model to consider in the context of mindfulness research is the Interacting Cognitive Subsystems (ICS) model. The ICS was originally conceptualized as a model for understanding the maintenance, vulnerability, relapse, and treatment of depression (Teasdale & Barnard, 1993). It was later applied as a framework for describing the cognitive mechanisms targeted by MBCT in the treatment of recurrent depression (Teasdale, Segal, & Williams, 1994).

According to the ICS, negative interpretations foster negative automatic thoughts that ultimately contribute to the formulation of negative schemas (i.e., negative predictions about the future, negative evaluations of the self, attributions of failures to personal inadequacy, etc.) via what is termed a "cognitive loop." The negative schemas resulting from this cognitive loop may produce emotional reactions that manifest physically and include bodily effects such as bowed and stooped posture, sad expressions, and so on. As with the cognitive information, this sensory data regarding the body's behavior feeds back via a "sensory loop" that increases and sustains these effects. Ultimately, the interaction between the sensory information pertaining to one's negative state in the sensory loop and the negative schemas produced in the cognitive

loop result in depressogenic schemas. A depressed state is thus maintained by the ongoing production of these depressogenic schemas, which are ultimately self-perpetuating.

The ICS model of depression suggests that, following recovery, mild states of depression can reactivate depressogenic schemas that were formed during previous episodes of depression, thus triggering, in some instances, a depressive relapse. Rather than seeking to avoid mild states of depression that might reactivate depressogenic schemas, treatments based on the ICS aim to interfere with the feedback loops that sustain and perpetuate these schemas. In the context of MBCT, this is achieved by increasing one's skills in attentional control. Specifically, Teasdale et al. (1994) suggested that the information and interactions between cognitive and sensory loops that result in depression are processed relatively mindlessly. Mindfulness in this context refers to the integrated processing of information pertaining to the same topic across various subsystems, including the cognitive subsystems employed in the articulation of meaning. Conversely, "multi-tasking" or "mindlessness" occurs when several unrelated streams of data are processed simultaneously throughout the total system. Mindlessness is therefore considered akin to the experience of driving on autopilot, whereas mindfulness is associated with the subjective experience of being engaged.

Mindfulness in this model requires the continuity and coherence of information content across the total system; in MBCT, individuals practice being mindful of the

content of moment to moment experiences. By deliberately re-deploying attention in this way, they engage all cognitive subsystems in the processing of moment to moment experiences, thereby inhibiting the mindless engagement of depressogenic schemas that enhance and sustain a depressed state.

The hypothesis that mindfulness requires the employment of cognitive resources otherwise engaged in elaborative thinking (such as those required to activate and perpetuate depressogenic schemas) is consistent with Bishop et al.'s (2004) hypothesis that mindfulness enhances non-directed attention and Shapiro et al.'s (2006) theory that mindfulness improves skills pertaining to cognitive inhibition. Thus, in addition to agreeing generally about the fundamental role of attention in mindfulness, the predominant models share similar theories with regards to which specific subsystems of attention are employed and honed via mindfulness meditation.

1.3 Models of attention

Given that attention is an enigmatic construct in its own right (Balota & Marsh, 2004), a review of contemporary theories on attention would facilitate our efforts to understand how it applies to mindfulness research. Research from cognitive psychology suggests that there are two partially distinct systems of attention – an endogenous system associated with voluntary, goal-directed (top-down) processing and an exogenous system associated with involuntary or stimulus-driven (bottom-up) processing (Posner, 1980). Whereas the endogenous system is considered a voluntary

system in which activation depends on cues indicating perceptual and response characteristics of stimuli to which individuals should attend, the exogenous system is considered an alerting system that is engaged when there are sudden changes in sensory stimuli, particularly when the stimuli are unexpected, have a low probability of occurrence, or are outside of the region upon which one is focusing (Corbetta & Shulman, 2002). Researchers have speculated that the endogenous system is similar to the system that is employed in concentrative meditations in which people's focus is intentionally and deliberately focused on one's experience, whereas the exogenous system may be analogous to the type of receptive attention that is activated in mindfulness meditations (Jha, Krompinger, & Baime, 2007).

This exogenous/endogenous model is an extension of the tripartite model of attention (Posner & Peterson, 1990) in which attention is defined in terms of three functionally distinct cognitive subsystems – alerting, orienting, and conflict monitoring. As per the tripartite model of attention, alerting refers to the ability to remain in an alert or vigilant state of readiness; orienting reflects one's ability to direct and limit attention to only a subset of stimuli; and conflict monitoring is the ability to prioritize among competing tasks and responses. Thus in terms of exogenous/endogenous processing, alerting represents an exogenous process, whereas orienting and conflict monitoring are generally considered endogenous systems of attention (Corbetta & Shulman, 2002).

1.4 MBSR: Concentration vs. mindfulness-based meditations

Before turning to a review of the research upon which the current study is predicated, let us consider where the MBSR literature fits in the broader domain of meditation research. Unlike concentration-based approaches, such as Transcendental Meditation, in which participants are trained to narrow their focus to a single object or experience (e.g., a sound, syllable, breath), mindfulness-based meditations teach participants to expand their field of awareness to account for all stimuli, including thoughts, emotions, and sensations in the present moment. Whereas the aim in concentration-based meditation approaches is to redirect one's attention back to the object of focus when the mind wanders without attending to the nature of the distraction, mindfulness-based meditations consider mind-wandering and the process of distraction to be other events to observe in the context of the meditation. In a sense, mind-wandering is considered an object of attention in mindfulness-based approaches rather than a distraction from a focal point (Baer, 2005). Not surprisingly, preliminary research suggests that meditation differentially affects attention as a function of whether meditation is concentration-based vs. mindfulness-based (Brefczynski-Lewis, Lutz, Schaefer, Levinson, & Davidson, 2007; Lutz et al., 2009; Valentine & Harrlett, 1999). Although the research literature has identified improvements in attention as a function of meditation type, both types – concentrative and mindfulness – have been found to positively affect attention. Specifically, concentration-based meditations have been

associated with increased activity in brain regions associated with attention (Goldin & Gross, 2010) and improvements in sustained attention tasks and executive functioning (Brefczynski-Lewis, Lutz, Schaefer, Levinson, & Davidson, 2007; Lutz et al., 2009), and mindfulness-based meditations have been uniquely associated with an increased ability to detect unexpected stimuli (Cahn & Polich, 2009; Valentine & Sweet, 1999) and the enhanced capacity to represent non-linguistic-based awareness in working memory (Farb et al., 2007). Thus, although the specific subsystems engaged in meditation may depend, to some degree, on meditation type, evidence suggests that both mindfulness and concentrative meditations hone attention.

1.5 Focused attention: An arguably concentrative component of MBSR

Although the majority of the meditations taught in MBSR, including sitting and walking meditation, encourage practitioners to monitor all experiences perceived in the present moment, some, such as the body scan exercises, emphasize an object of focus (in the case of body scan exercises, the objects of focus include various regions of the body). Thus although MBSR has been compared antithetically to concentration-based meditation approaches (Anderson, Lau, Segal, & Bishop, 2007), aspects of the program are consistent with concentration-based approaches.

Research initiatives have aimed to address this discrepancy by examining the specific effects of the various meditation exercises employed in MBSR on subsystems of attention. In so doing, researchers have suggested that MBSR engages two unique forms

of nonlaborative, nonconceptual attention-focusing meditations: (1) *focused-attention* (FA), which involves maintaining selective attention on a chosen object in a way that is similar to the traditional concentration-based meditations, and (2) *open-monitoring* (OM), which refers to the attentive, non-judgmental awareness of all experiences occurring in the present moment and is consistent with traditional mindfulness-based meditations (Goldin & Gross, 2010; Perlman, Davidson, & Lutz, 2010). Although the clinical significance of this distinction for MBSR practitioners remains to be determined, the theoretical implications of this discourse are immediately apparent. Specifically, if MBSR trains students in both FA and OM practices, and thus essentially employs both concentration and mindfulness-based meditations, then its practitioners would theoretically improve the subsystems of attention that are uniquely targeted by these distinct approaches. Thus, although the majority of the meditations taught in MBSR (e.g., sitting meditation, walking meditation, hatha yoga) and the emphasis on “choiceless awareness” that is the hallmark of this training are consistent with traditional mindfulness-based approaches, students are also introduced to, and receive instruction in, several concentrative-based meditations (e.g., body scans and loving-kindness). This nuance is particularly important to consider in reviewing the extensive research literature on attention and meditation: those studies that directly examine how attention is affected by MBSR are most relevant to the current research as they share a common training protocol and therefore minimize error variance. Additionally, as

MBSR incorporates training in focused-awareness meditation *and* open-monitoring the recent research pertaining to how this combined training affects subsystems of attention is important to consider. Finally, as the aforementioned studies are few and far between, research on how other mindfulness-based meditations affect attention will also be considered.

1.6 Preliminary research

1.6.1 MBSR research

Jha et al. (2007) assessed changes in attention using the tripartite model of attention (Posner & Peterson, 1990) as a framework for their analysis. In evaluating changes in these cognitive networks related to mindfulness meditation, the authors assessed three groups of participants with varying degrees of meditation experience using the Attention Network Test (ANT; Fan, McCandliss, Sommer, Raz, & Posner, 2002). The first group included participants unfamiliar with mindfulness techniques who took part in an 8-week MBSR course; the second group consisted of participants experienced in mindfulness meditation, with an average of 60 months of prior meditation experience, who partook in a 1-month intensive mindfulness retreat; the third group functioned as a no-treatment control condition in which participants had no previous meditation experience.

At Time 1 (baseline), experienced meditators in the retreat condition showed significantly better performance on the conflict monitoring component of the ANT

compared to the other two groups. The authors reported significant improvements in orienting for participants in the MBSR condition at Time 2 (immediately after the MBSR training concluded) relative to the other conditions. Additionally, the experienced meditators in the retreat group evidenced significant improvements in alerting compared to the control and MBSR participants at Time 2. Notably, groups did not differ significantly on conflict monitoring performance at Time 2 despite the significant differences observed at Time 1. The authors concluded that meditation improves subsystems of attention associated with voluntary, endogenous attention, as evidenced by improvements in orienting and conflict monitoring scores in participants newly trained in MBSR. In addition, the authors deduced that meditation experience develops exogenous, bottom-up processing as is reflected by improvements in alerting scores amongst the experienced meditators following the completion of their retreat.

Rather than using the ANT to assess changes in the constructs of alerting, orienting, and conflict monitoring specific to the tripartite model of attention, Anderson et al. (2007) used standard switch and sustained attention tasks to measure switching and sustained attention respectively; in addition, the researchers administered the emotion Stroop task to assess changes in cognitive inhibition and an object detection task to measure changes in non-directed attention. Notably, all of the tasks employed by Anderson et al. assessed subsystems of attention primarily associated with endogenous processing.

Although they reported significant improvements in self-reported mindfulness and emotional well-being, Anderson et al. (2007) found no significant differences between participants who completed the MBSR course and those in a wait-list control condition on any of the attentional control tasks. Thus, unlike Jha et al. (2007), Anderson et al. failed to find significant group differences on measures of attentional subsystems associated with endogenous attentional control among MBSR completers relative to controls.

Finally, in their study on emotion regulation following MBSR training, Goldin and Gross (2010) observed significant changes in brain activity among participants with Social Anxiety Disorder following the completion of an 8-week MBSR course. Prior to commencing the course and then again following its conclusion, participants performed a computer task in which they were shown 18 experimenter-selected social anxiety-related self-belief statements pertaining to self-focused, self-critical personal beliefs (e.g., "I am ashamed of my shyness"). For each trial, participants viewed the statement and were then instructed to either "Shift attention to the breath" (breath focused attention) or "Count backward from 168" (distraction-focused attention) for 12 seconds. Participants completed this task in an fMRI machine, which provided anatomical and functional images for analyses.

Results showed that post-MBSR participants evidenced reduced amygdala activity and increased activity in brain regions implicated in visual attention-related

parietal and occipital brain regions associated with alerting, or exogenous, processing (Fan, McCandliss, Fossella, Flombaum, & Posner, 2005) during the breath-focused (but not distraction-focused) task. In addition, participants reported significant reductions in negative emotion experience post-MBSR. These results are among the first to demonstrate significant changes in brain activity in regions of the brain associated with attentional deployment in participants following their completion of an MBSR program.

1.6.2 FA and OM research

While the aforementioned studies were the first to consider changes in attention following MBSR training specifically, recent research has looked generally at how meditators with extensive training in FA and OM meditations perform on measures of attention. Although few studies of this type have been conducted, , their results support the hypothesis that training in both FA and OM meditations – such as that provided in MBSR – uniquely affects subsystems of attention. Specifically, relative to meditation-naïve, matched controls, experienced meditators with this combined training evidenced significant reductions in attentional blink – a phenomenon in which people are less likely to identify a second rare target after correctly identifying the first if the second one occurs between 200 and 300 ms after the first target (Leeuwen, Muller, & Melloni, 2009). The attentional blink has been associated with reductions in sustained attention and the decreased efficiency of inhibitory mechanisms associated with aging (Chao & Knight,

1997). As such, Leeuwen et al. suggested that combined training in FA and OM meditations may help overcome age-related deficits associated with attentional blink.

Additionally, using the dichotic listening task to assess sustained attention, Lutz et al. (2009) reported significant improvements in task performance following three months of intensive training in both FA and OM meditations. Changes in task performance correlated with increased stability of cortical signal processing as measured by an EEG. Although the two studies reviewed in this section do not evaluate the effects of MBSR specifically, they represent a promising new direction of meditation research. Specifically, these studies argue for more specificity with regards to the multifaceted training components inherent in any meditation tradition in order to facilitate the development and testing of nuanced theories regarding the mechanisms of change that underlie the success of these approaches.

1.6.3 Mindfulness-based meditation research

Although MBSR incorporates training in FA, the majority of the meditations taught in the program emphasize OM, and the philosophy of the course extends from an appreciation for, and emphasis on, the significance of the present moment. As such, research pertaining to how mindfulness training specifically shapes attention will be important to consider in the context of the current research. Among the most recent findings are those of Chambers, Lo, and Allen (2008) who reported significant improvements among participants who completed a 10-day intensive mindfulness

retreat relative to controls on tasks assessing working memory, sustained attention, and attention switching. Thus, as in Anderson et al. (2007), the authors focused specifically on sub-systems of attention associated with endogenous processing. Interestingly, the findings from Chambers et al. contradicted those reported by Anderson et al. and provide further evidence that training in mindfulness-based meditation improves endogenous systems of attention. Although the findings from Chambers et al. do not speak to MBSR specifically, they suggest that mindfulness-based meditations in general may improve subsystems of attention associated with endogenous processing.

Similarly, Tang et al. (2007) sought to assess changes in the self-regulation of attention following a 5 day intensive training in integrative body-mind training (IBMT; Tang, 2007). IBMT combines features of mindfulness-based meditations to facilitate mind-body awareness. Using the ANT to measure alerting, orienting, and conflict monitoring, the researchers found that, compared to participants in a waitlist control condition, those who completed the five day IBMT retreat showed significant improvements in conflict monitoring. The authors suggested that the significant improvement in conflict monitoring scores following the short retreat suggests that mindfulness based meditations can have a significant effect on endogenous attention systems following relatively little exposure to the practice.

Also relevant to this discussion of mindfulness and attention is Wenk-Sormaz's (2005) study of Stroop interference and word production in a group of meditation naïve

individuals who participated in brief mindfulness meditations (three 20 minute sessions in the first study and one 20 minute session in second study) and a control group. Participants in both groups completed the Stroop task – designed to assess one’s ability to control habitual responding – and a word production task, which uses category production and word-stem completion to assess the distribution of information available to an individual at a given time. Wenk-Sormaz found that, compared to those in the control condition, participants in the mindfulness meditation group showed less Stroop interference and more flexible word production. As with Tang et al’s findings, the results from this study suggest that even brief exposure to mindfulness-based meditations might improve subsystems of attention.

Finally, Valentine and Sweet (1999) assessed performance on the Wilkins’ counting test of sustained attention in a group of Buddhist participants experienced in either mindfulness or concentration-based meditation and matched controls. The test consists of a series of binaural auditory beeps that occur at different rates. Participants were asked to count the number of beeps (between 2 and 12) in each series and record the number at the end of the series. The authors reported that both groups of meditators performed significantly better than controls on the task. Moreover, Valentine and Sweet found that those participants experienced in mindfulness-based meditation performed significantly better than those trained in concentration-based meditation in the detection of unexpected stimuli (i.e., counting beeps in series in which the beeps were

unpredictable and sporadic), suggesting that mindfulness- and concentration-based meditations may differentially affect subsystems of attention.

1.6.4 Summary

In addition to distinctions in meditation exposure and training, studies have shown significant variation with regards to the tasks used to measure subsystems of attention. Thus, while Valentine and Sweet (1999), Leeuwen et al. (2009), and Lutz et al. (2009) observed improvements in sustained attention in meditators relative to controls using the Wilkins' counting, attention blink, and dichotic listening tasks respectively, Anderson et al. (2007) failed to observe similar findings using the Vigil Continuous Performance test. Likewise, although Wenk-Sormaz (2005) reported significant improvements in conflict inhibition in meditators compared to controls using a standard Stroop task, Anderson et al. found no such evidence using an emotion Stroop task. Although distinct tasks may be designed to measure the same constructs, our efforts to interpret contradictions across findings are nonetheless impeded by the use of different measures across studies.

Similarly, although the advent of more mindfulness oriented interventions (such as MBSR and MBCT) has contributed to a growing interest in the distinctions across types of meditation (i.e., concentrative-based vs. mindfulness-based), very little research has examined how attention is uniquely affected by approaches, such as MBSR, that are largely mindfulness-based, but include some training in FA, an arguably concentrative

component. Even among studies that focus exclusively on mindfulness-based meditations and OM, participants are rarely exposed to a framework for learning these meditations that is consistent across studies. Thus, while participants in Chambers et al.'s (2008) experiment were similar to those in Tang et al.'s (2007) experiment in that both received intensive mindfulness training, participants in the former study were taught mindfulness in the context of a Vipassana course, while those in the latter experiment learned a unique type of mindfulness meditation – IBMT – that includes relaxation training drawn from Chinese medicine. Likewise, although Valentine and Sweet (1998) distinguished participants based on meditation type – either concentrative or mindfulness-based – the authors failed to discuss the details of the training each group received or the extent to which these modalities were distinct. This lack of consistency across studies with regards to training protocols limits the extent to which these results can be generalized to other forms of meditation training.

Although the lack of control within and between experiments is disheartening, the studies reviewed in this section provide preliminary evidence for the role of attention in MBSR. Although the results have been mixed with respect to which attentional skills MBSR develops, the findings in aggregate suggest that subsystems of attention are indeed engaged and honed by the type of meditation training offered in MBSR, and that further research into the relationship between attention and meditation is warranted.

1.7 Specific aims and hypothesis

The primary aim of this study was to contribute to research on the role of attention in meditation. Rather than broadly considering constructs such as attention and meditation that are contentious by virtue of their scope, the current study examined the effects of a specific type of meditation training –MBSR, which includes components of FA and OM – and specific subsystems of attention. Although one could potentially examine any combination of attentional skills in a study that aims to assess their role in MBSR, the inclusion of tasks for measuring subsystems of attention was based on current models of mindfulness in the context of MBSR and previous research that attests to their relevance.

Specific Aim # 1A: Examine how individuals experienced in mindfulness-based meditation via training in MBSR compare to control participants on tasks measuring subsystems of attention associated with exogenous processing.

Although subsystems of attention associated with endogenous processing have received the most attention in the meditation literature (Anderson et al., 2007; Chambers et al., 2008; Wenk-Sormaz, 2005), evidence suggests that exogenous processes might also be improved as a function of meditation. Specifically, Jha et al. (2007) reported significant changes in the exogenous process of alerting using the ANT amongst experienced meditators following their participation in a 1-month meditation retreat. Unfortunately, Tang et al. (2007) failed to replicate these findings using the same task in

their study of meditation-naïve participants who participated in a 5 day IBMT retreat. Given that neither the control nor meditation naïve participants who completed the 8-week MBSR program in Jha et al.'s study demonstrated the changes in alerting observed in the retreat condition, changes in subsystems of attention associated with exogenous processing such as alerting, may occur over a longer period of time. Indeed, the retreat participants came into the study with significantly more meditation experience (the average for the group was 60 months of prior meditation practice) than participants in either of the other two conditions; likewise, participants in Tang et al.'s study had no previous experience with meditation and were tested after only 5 days of exposure to IBMT. That said, the experienced meditators in Jha et al.'s study were trained specifically in concentrative meditation, and the one month retreat they attended focused on concentration-based meditation. Nonetheless, researchers theorize that mindfulness-based meditation engages and hones subsystems of attention associated with exogenous processing (Jha et al.). In order to test this hypothesis, the present study compared experienced meditators who had completed an 8-week MBSR course and maintained a regular meditation practice following the conclusion of their course to control participants on the subsystem of alerting using the ANT. The prediction was that experienced MBSR practitioners would show a larger benefit from exogenous cues as reflected by a greater alerting effect.

Specific Aim # 1B: Replicate findings suggesting that meditation practitioners trained in MBSR show a greater ability to orient attention during both input selection and response selection monitoring associated with endogenous processing.

In order to offer further support that MBSR improves subsystems of attention associated with endogenous processing, the current study examined how a group of experienced, MBSR trained meditators compared to controls on the orienting and conflict monitoring components of the ANT. As stated, the ANT has been used to examine differences in alerting, orienting, and conflict monitoring across groups. Given that the experienced meditators had already completed an MBSR course and had an active meditation practice, examining group differences allowed us to comment on the long-term effects of MBSR on subsystems of attention associated with endogenous processing.

Specific Aim # 2: Evaluate group differences in performance on an “inattentional blindness” task.

“Inattentional blindness” (IB) refers to the phenomenon that occurs when individuals engaged in a task that requires a high level of sustained attention fail to notice unexpected objects or stimuli (Most, Simons, Scholl, & Chabris, 2000). Perhaps the most common example of this phenomena is the classic “gorilla task” (Simons & Chabris, 1999) in which participants watch a video of two teams – one dressed in white, the other in black – passing a basketball among them. The participants are instructed to

keep track of the number of passes made by one of the teams (either white or black). In the middle of the task, somebody dressed in a gorilla costume unexpectedly travels through the center of the basketball game and remains within view for approximately 5 seconds before exiting. Observers are then asked whether or not they noticed any unexpected objects while counting the passes. Repeated applications of this experiment suggest that, on average, more than half of participants fail to notice the gorilla.

Most laboratory experiments of IB have examined the existence of the phenomena and factors that influence its occurrence, but recent research has focused on the implications of this effect (Most & Astur, 2007). Findings suggest, for instance, that cell phone usage significantly increases the probability of missing an unexpected object (Scholl et al., 2003). Thus, in addition to providing insight into the function of attention, IB is proving to be an important phenomenon to consider in the context of real world situations in which attention may either improve or inhibit functioning. Given the hypothesis that mindfulness meditation strengthens subsystems of attention and previous findings suggesting that people experienced in mindfulness meditation are significantly better than controls at identifying unexpected stimuli (Valentine & Sweet, 1999), I predicted that a group of MBSR practitioners would exhibit less inattentional blindness than a group of control participants.

Specific Aim # 3: Determine if self-reported mindfulness scores differ significantly between groups and if these scores predict performance on tasks measuring exogenous and endogenous attention.

Research suggests that meditation training is associated with an increase in self-reported mindfulness (Anderson et al., 2007; Chambers et al., 2008; Moore & Malinowski, 2008). Although some evidence suggests that, over time, meditation practitioners show a larger benefit from exogenous cues as reflected by a greater alerting effect (Jha et al., 2007), research has yet to address whether or not mindfulness scores correlate with performance measures on an alerting task. Similarly, although research suggests that mindfulness training improves endogenous processes such as conflict monitoring (Jha et al., 2007; Tang et al., 2007) these changes have not been considered in the context of self-reported mindfulness scores. Given the research reviewed, the prediction was that, consistent with previous findings, experienced MBSR practitioners would score higher on self-reported mindfulness relative to meditation naïve controls; additionally, their mindfulness scores should predict their performance on the alerting, orienting, and conflict monitoring components of the ANT.

2. Methods

2.1 Participants

MBSR Group: Twenty-four participants (mean age = 44, $SD = 15$) were recruited from graduate MBSR courses offered at the Duke Center for Integrated Medicine

(DCIM) during October 2009 and January 2010 and from advertisements placed in the monthly DCIM electronic newsletter. Only individuals who had already completed a MBSR Foundations course at the DCIM and continued to practice the formal meditations taught in the program at least once per week since completing the course were included in this group. The average amount of meditation experience reported by participants in this condition was 291 hours ($SD = 339$ hours), the median was 144 hours. Additionally, inclusion criteria required that the MBSR participants were at least 18 years of age and had no vision problems that might interfere with their ability to complete tasks on a computer.

The majority of the MBSR participants were female (67% female, 33% male) and Caucasian (90% Caucasian, 10% Hispanic). Additionally, the majority were very well-educated (highest level of education: 63% graduate school, 32% four year college, 5% some college), married (48 % married or in a domestic partnership, 26% never been married, 21 % divorced, 5% widowed) and employed (42% employed for wages, 42% self-employed, 10% students, 6% retired.).

Control Group: Twenty-six participants (mean age = 47, $SD = 13$) were recruited at orientation meetings for MBSR Foundations courses in October 2009 and January 2010 and from advertisements placed on the Duke University research web-page. The orientation meetings occurred two weeks prior to the commencement of the Foundations courses; all participants recruited at the orientation meetings were thus run

during this time (i.e., prior to beginning the MBSR Foundations course). The initial aim was to recruit all of the control participants from the orientation meetings so as to minimize variability between the experienced meditator and control groups. Ultimately, we succeeded in recruiting approximately two thirds (21 out of 26) of the control participants through the orientation meetings. In order to increase the number of participants in the control condition, advertisements were placed on Duke University's research web-page, which advertises research opportunities at Duke University and Duke Hospital. Participants recruited via this method were matched to the experienced meditators for age and gender. Finally, in accordance with the inclusion criteria, all of the control participants were at least 18 years of age, had no vision problems that could interfere with their ability to complete tasks on a computer, had not ever taken an MBSR course at the DCIM or any other facility, and had not practiced any form of meditation in the 6 months prior to participating in this study.

With regards to the demographic variables, the control participants were very similar to the experienced meditators. Specifically, the majority were female (77% female, 23% male) and Caucasian (82% Caucasian, 12% Hispanic, 6% African American). The majority of the control participants were also very well-educated (53% highest level of education graduate school, 41% four year college, 6% some college), married (53% married or in a domestic partnership, 35% divorced, 12% never been married) and employed (52% employed for wages, 24% students, 12% retired, 12% out

of work). Preliminary analyses revealed no significant differences between groups with regards to age, gender, ethnicity, education, marital, or employment status.

This study was approved by the Duke University Institutional Review Board, and informed consent was obtained from each participant prior to entry into the study. All subjects were compensated \$10 for their participation.

2.2 Measures

2.2.1 Attention

The attention tasks were administered on a Dell GX755 desktop computer using a 17" monitor.

Attention Network Test (ANT): Participants were given a variant of the ANT, designed by Fan and colleagues, that has been comprehensively described elsewhere (Fan et al., 2003; Fan et al., 2002; Fossella, Posner, Fan Swanson, & Pfaff, 2002). Briefly, participants sat at a comfortable distance from the computer monitor and were instructed to keep their attention focused on a cross ("+") in the center of the screen that functioned as the central fixation point; this central fixation point was part of the standing background throughout the duration of the task. Participants were told that an arrow would appear either above or below the fixation point and that this arrow would be pointing either left or right (for example -> or <-). They were instructed to press the left arrow key on the keyboard using their left index finger when the arrow was pointing left and the right arrow key using their right index finger when the arrow was

pointing right, while keeping their attention focused on the central fixation cross (see Appendix A for ANT instructions). Participants were told that, on some trials, the arrow would be flanked by two arrows pointing to the left and two arrows to the right, but that they should only respond to the direction of the central arrow. Arrows that flanked the center arrow would either point in the same direction as the center arrow (congruent target) or in the opposite direction (incongruent target).

Participants were told that some trials would be preceded by an asterisk that functioned as a cue. When it appeared, this asterisk cue was visible for 100 msec. Participants were told that if the cue was at the center *or* both above and below fixation it indicated *only* that the arrow would appear shortly. If the cue was only above or below fixation, participants were told that it indicated *both* that the trial would occur shortly and where it would occur. A brief (400 msec) delay interval followed the cue after which time the target appeared 1.068 degrees above or below the center fixation. Participants were instructed to try to maintain fixation at all times but were told that they could attend when and where indicated by the cues. The center arrow remained on the screen until either a response was recorded or 1,700 msec passed.

One of four cue conditions preceded the target presentation (see Figure 1):

1. During *no-cue trials* the fixation cross stayed on the screen during the time in which the cue would occur and no cue was presented; no-cue trials thus

indicated neither when (temporal) or where (spatial) the upcoming target arrow would be, the target simply appeared.

2. In the *double-cue trials*, a pair of asterisks appeared at the same time at target positions above and below the central fixation point.
3. During *center-cue trials*, only one asterisk appeared at the center fixation point. The double-cue trials and center-cue trials thus provided a temporal warning of when the target would appear but provided no information pertaining to the spatial location of the upcoming target.
4. In *spatial cue trials*, one asterisk appeared at the location of the upcoming target arrow and was 100 % predictive of the upcoming target's position; spatial cue trials thus indicated when (temporal) and where (spatial) the target would occur.

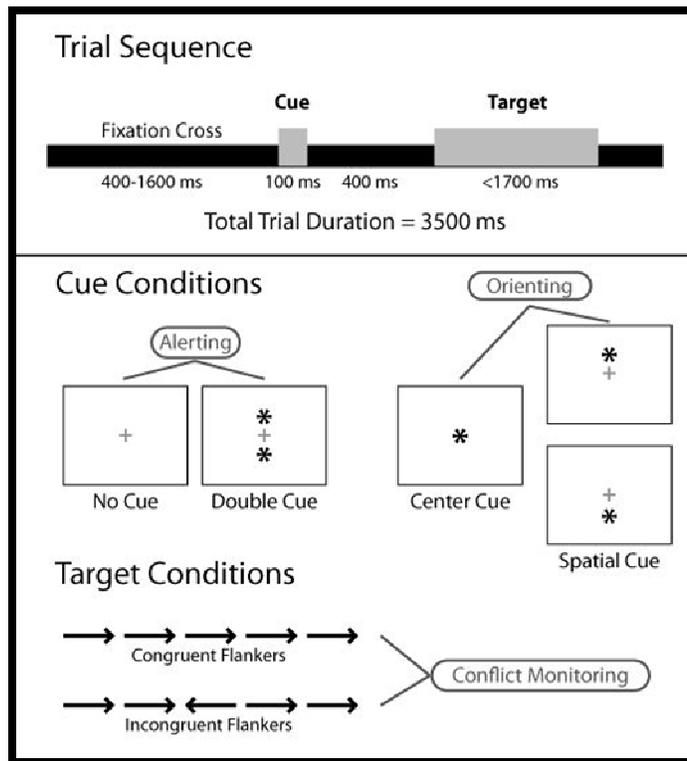


Figure 1: Trial sequence and timing for the ANT. Participants were told to keep their eyes focused on the center cross during all trials. There were four cue conditions and two target conditions.

The experimental design, as described, included two within-subject factors: cue type (no cue vs. double cue vs. center cue vs. spatial cue) and target type (congruent vs. non-congruent). The experiment contained four blocks. The first block was a practice block that included 24-trials. The other three blocks were experimental blocks that contained a total of 288-trials (96 per cue condition). All trial types were randomly presented. The task, including the practice block and breaks between blocks, took approximately 25 minutes to complete.

Performances based on subsystems of attention measured by the ANT (i.e., alerting, orienting, or conflict monitoring) were assessed by paired subtractions across subsets of conditions. Each participant had paired subtractions for their RT and accuracy scores, thereby providing an index of their performance in each of the three subsystems of attention. Alerting was determined by subtracting performance measures on double-cue trials from those on no-cue trials. Orienting was measured by subtracting performance measures on spatial-cue trials from those on center-cue trials. Finally, conflict monitoring was assessed by subtracting performance measures on congruent trials from those on incongruent trials. These paired subtractions are referred to as subsystem difference scores. This method is the most commonly employed in ANT data analysis and has been reported in greater detail elsewhere (Fan et al., 2002).

Inattention Blindness Task: Stimuli were presented on a computer screen while participants sat at a comfortable distance from the screen. All of the events in each trial took place on a gray 12.7 × 15.5 cm display window with a small blue fixation point in the center. Four black and four white squares and circles moved independently on random paths across the screen. As they moved, each of the black and white shapes would occasionally bounce off of the edges of the display screen. Participants were instructed to focus on the central fixation point while silently tracking the total number of times the white shapes bounced off of the edges of the window during each of five 15 second trials. The instructions emphasized that participants should keep track of the

bounces pertaining only to the white shapes, not the black shapes. At the end of each trial, participants were prompted to record the number of bounces they observed.

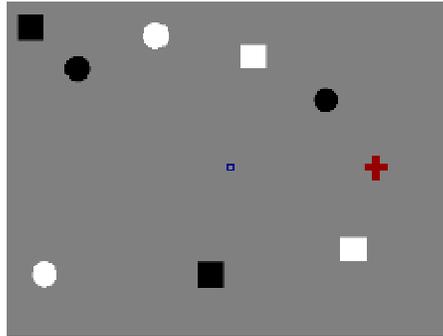


Figure 2: Inattention blindness task. Track the total number of times the white shapes bounce off the screen.

Trials in this task were modeled after previous experiments on inattention blindness (Mack & Rock, 1998). No unexpected events occurred during the first two trials, but five seconds into the third trial (the critical trial) a red cross unexpectedly appeared at the right side of the screen and moved horizontally on a linear path through the center of the screen. The cross moved behind the fixation point and exited on the left side of the screen remaining visible for a total of 5 seconds. As the participants were not told to anticipate a cross, its appearance was unexpected. Following the critical trial, a question appeared on the computer asking the participant if they noted anything unusual on the screen during the trial. Participants were then asked to report (or guess, if they failed to see the object) the details of the object (its color, shape, and direction of motion). Participants then completed a fourth trial in which the cross again appeared. Though they were not instructed to look for the cross, the previous questionnaire alerted

them to the possibility that an additional object may appear in the task. This trial thus assessed perception in a *divided-attention* condition. Following the conclusion of the fourth trial, participants answered another set of questions that were identical to those presented after the third trial. On the fifth trial, participants were given slightly different instructions. Rather than counting the number of bounces the target shapes made, they were instructed to simply keep their eyes focused on the fixation point. As participants were no longer preoccupied with counting bounces, they could presumably devote their full attention to the formerly unexpected cross. Following the conclusion of this *full-attention* trial, participants again answered a set of questions identical to those completed after the third and fourth trials. This condition was used as a control condition to confirm that participants understood and followed the task instructions, as the majority of participants have been shown to see the cross in these full-attention trials (Mack & Rock, 1998; Most et al., 2001). The administration and completion of the task and questions associated with it took approximately 10 minutes per subject. Participants received scores for accuracy in the counting task, and group differences in unexpected object detection in both the critical and divided attention trials were assessed.

2.2.2 Self-report measures

Inclusion Criteria Questionnaire: Participants recruited for the MBSR condition completed questions regarding their meditation experience and estimated practice time (see Appendix B); additionally, participants were asked when they had completed the

MBSR Foundations course at the DCIM. Inclusion in the experienced meditation group required that participants practiced the formal meditations at least once per week since completing the MBSR course.

Demographic Questionnaire: This form assessed demographic variables including age, gender, race, marital status, employment status, and education (see Appendix C).

The Mindful Attention Awareness Scale (MAAS; Brown & Ryan, 2003): The MAAS is a 15 item, 7-point scale (1 = almost always, 6 = almost never) self-report measure designed to assess core characteristic of mindfulness, namely, open or receptive awareness of and attention to what is taking place in the present (see Appendix D). The MAAS is one of several empirically supported mindfulness measures; others include the Five Facet Mindfulness Questionnaire (FFMQ; cite), the Philadelphia Mindfulness Scale, and the Toronto Mindfulness Scale (TMS; cite). The MAAS was chosen for this study because it emphasizes attention and the frequency of mindfulness states over time. Specifically, the MAAS is designed to assess the presence or absence of one's attention to, and awareness of, events and experiences that occur in the present moment (Brown & Ryan, 2003; Klatt, Buckworth, & Malarky, 2009). Evidence suggests that the MAAS is a valid measure of mindfulness (MacKillop & Anderson, 2007) with good convergent and discriminant validity, as well as high internal consistency (alpha = .82; Brown & Ryan). The scale shows strong psychometric properties and has been validated with college, community, and cancer patient samples. Additionally, research suggests that the MAAS

is a particularly useful measure for assessing changes in mindfulness attributed to MBSR (Brown & Ryan, 2003; Dobkin, 2007; Klatt et al., 2009).

2.3 Data analysis

1. Verified that the data did not violate the homogeneity of variance assumption of the one-tailed independent *t*-test and examined distributions for their approximation to a normal distribution
2. Compared participants in the MBSR group to those in the control condition on all continuous dependent variables (i.e., accuracy and response time difference scores for the alerting, orienting, and conflict monitoring subscales of the ANT, and MAAS scores) via one-tailed independent *t*-tests.
3. For the inattentive blindness task data, the percentage of participants from each condition (i.e., mindfulness vs. control) who observed the unexpected object in the critical trial was compared using the chi-square test. Differences in error rates on the counting task in the critical trial were assessed by comparing the error rates of those who noticed the unexpected stimulus to those who did not irrespective of subject condition. Finally, differences in error rates by group were examined.

4. The percentage of participants from each condition (i.e., mindfulness vs. control) who observed the cross in the divided and full-attention trials was compared using the chi-square test.
5. To assess the relationship between mindfulness and subsystems of attention associated with exogenous and endogenous processing, correlations between MAAS scores and the alerting, orienting, and conflict monitoring performance scores of the two groups combined were computed.

3. Results

3.1 Preliminary Analyses

According to the preliminary analyses, the RT and accuracy difference scores for alerting, orienting, and conflict monitoring were normally distributed: each had skew and kurtosis statistics $< \pm 1$, and, according to the Levene test statistic, did not violate the homogeneity of variance assumption. In reviewing the box and whisker plots for these scores, two outliers were identified among the orienting RT subscores for the control participants. Removing these outliers did not significantly affect the results of this test, as such, these scores were not included in the analyses reported here. Similarly, preliminary analyses of the error rates on the critical trial of the IB task revealed that the data were skewed due to an extreme outlier (i.e., one subject reportedly lost track of counting and entered 0 for this value). Following the removal of this outlier, the data appeared normally distributed (i.e., skew and kurtosis statistics $< \pm 1$) and, according to

the Levene test statistic, did not violate the homogeneity of variance assumption.

Regarding the MAAS scores, they were normally distributed but violated the homogeneity of variance assumption according to Levene's test ($p < .05$). Equal variance was thus not assumed in the interpretation of results pertaining to the MAAS scores.

Finally, as stated in Chapter 2, there were no significant group differences with regards to any of the demographic variables (i.e., age, gender, education, employment, marital status).

Although the subsystems of attention (i.e., alerting, orienting, and conflict monitoring) assessed in this study are theoretically independent (Fan, McCandliss, Fossella, Flombaum, & Posner, 2005), correlations were calculated to confirm that they were statistically unrelated. Indeed, the Pearson product moment correlation coefficients used to assess the association of these subsystems suggested that they are empirically independent (see Table 1). Given the independence of these variables, independent samples *t*-tests were used to assess differences between the two groups specific to the hypotheses of this study.

Table 1: Pearson correlation coefficients between subsystems of attention

	Alerting	Conflict Monitoring	Orienting
Alerting	1	-.02	.13
Conflict Monitoring	-	1	.01
Orienting	-	-	1

Note: None of the scores were significant at $p < .05$

3.2 Primary Analyses

3.2.1 Effects of mindfulness on endogenous and exogenous attention

ANT data for 4 participants (3 from the control group and 1 from the MBSR group) were lost on account of errors in program administration. Data are thus reported here for 23 experienced MBSR practitioners and 23 control participants. The RT and accuracy difference scores obtained in this study were comparable to mean values previously reported by Fan et al. (2002). Notably, overall task accuracy was very high for both groups (control 97.8%, $SD = 1.8\%$; MBSR practitioners 98.5%, $SD = 1.2\%$). All analyses were performed on difference scores for both RT and accuracy for each pair of conditions specific to each subsystem of attention. Not surprisingly, given the ceiling effect observed for overall task accuracy, no significant differences were observed between groups with regards to the paired subtractions performed on the accuracy

scores for each of the three subsystems. Given the lack of meaningful differences between groups on the accuracy paired subtractions, tables and figures are presented only for the RT difference scores calculated for alerting, orienting, and conflict monitoring.

Exogenous, bottom-up, hypothesis: Experienced MBSR practitioners would show superior exogenous stimulus detection relative to control participants.

Independent samples *t* tests of the RT and accuracy difference scores for alerting were used to investigate the hypothesis that experienced MBSR practitioners would show a larger benefit from exogenous cues as reflected by a greater alerting effect. This analysis revealed no significant differences between the RT difference scores of participants in the control condition relative to those in the MBSR condition (see Table 2). Likewise, there was not a significant difference between groups with regards to the accuracy difference scores, $t(44) = -.81, p = .42$.

Table 2: Between group analyses of the RT difference scores for alerting, orienting, and conflict monitoring

	Control <i>M</i> (<i>SD</i>)	MBSR <i>M</i> (<i>SD</i>)	<i>t</i>	<i>p</i>	95% CI
Alerting	39 (24)	32 (27)	.99	.33	-7.76, 22.8
Orienting	48 (28)	49 (29)	-.18	.88	-18.02, 15.41
Conflict Monitoring	155 (52)	126 (35)	2.21	.03	2.6, 55.7

Endogenous, top-down, hypothesis: Consistent with previous research regarding the effects of MBSR training on endogenous processing, it was hypothesized that meditation practitioners trained in MBSR would evidence superior orienting and conflict monitoring relative to control participants.

Independent samples *t* tests of the accuracy and RT difference scores for orienting and conflict monitoring were used to investigate the hypothesis that MBSR training enhances the response benefits associated with spatial cues (orienting), in addition to improving performance scores in the context of cognitive conflict (conflict monitoring). No significant differences between groups were observed in either the orienting, $t(44) = -1.78, p = .08$, or conflict monitoring, $t(44) = .41, p = .68$, accuracy difference scores.

Interestingly, although the analyses revealed no significant differences between the RT difference scores of participants in the control group compared to those in the MBSR condition specific to orienting (see Table 2), there was a significant group difference with regards to the RT difference scores for conflict monitoring (see Table 2), such that the RT difference scores for participants in the control condition were, on average, higher than the RT difference scores for the experienced MBSR practitioners (see Figure 4A). However this analysis does not clearly show which condition (incongruent or congruent) accounted for this difference. The mean RTs for the congruent and incongruent trials were thus examined and suggested that the effect was

in the anticipated direction with experienced MBSR practitioners responding faster (mean RT = 756, $SD = 88$) during the incongruent trials relative to the controls participants (mean RT = 782, $SD = 90$), while there was little difference between groups with regards to mean RTs for the congruent trials (control mean RT = 626, $SD = 91$, MBSR mean RT = 628, $SD = 88$). Although the difference between groups with regards to mean response times during the incongruent trials is observable (see Figure 4B) this difference was not statistically significant, $t(44) = .77, p = .44$.

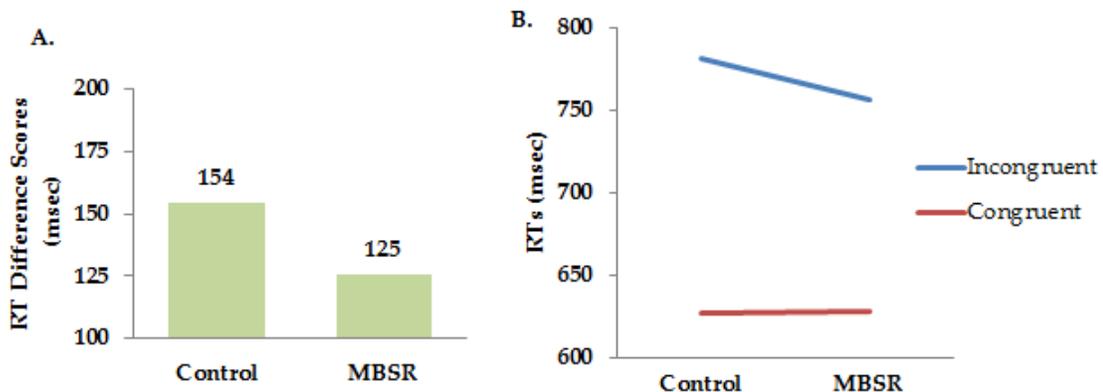


Figure 3: (A) RT Difference scores for the conflict monitoring component of the ANT were computed by subtracting response times (RTs, in milliseconds) on congruent target trials from those on incongruent target trials. This difference was significant at $p < .05$. (B) Mean RTs (in milliseconds) for the control and MBSR groups on congruent and incongruent trial types.

3.2.2 Effects of mindfulness on inattentional blindness

Inattentional blindness hypothesis: Experienced MBSR practitioners would exhibit less inattentional blindness than a group of control participants.

Data are reported here for 50 participants (24 from the MBSR group and 26 from the control group). The presence of inattentional blindness was determined by

participants' ability to see the unexpected cross during the critical trial of the IB task. Observers were regarded as having seen the unexpected object if they answered "yes" when asked if they had seen anything on the critical trial that had not been present before and if they were able to describe its color, motion, or shape (see Appendix E). Nearly everyone who endorsed having seen something was able to describe one of these three features. Across both groups only 1 participant who claimed to have seen something was actually coded as having failed to see the stimulus because of their inaccurate description.

Initial power analyses suggested that, given a sample size of 50, the chi square test used to assess group differences in observation had a 94% chance of detecting a large effect, a 56% chance of detecting a medium effect, and only an 11% chance of detecting a small effect with alpha set at .05. These data suggest that the test suffered from a lack of statistical power on account of a small sample size. Not surprisingly, although the experienced MBSR practitioners were nearly twice as likely as participants in the control condition to notice the unexpected stimulus in the critical trial of the IB task (42% in the MBSR condition relative to 23% in the control condition; see Figure 5), this difference was not statistically significant $X^2(1, N = 50) = 1.98, p = .16$. The size of this effect, w , was .2, which, according to Cohen (1988), constitutes a small effect.

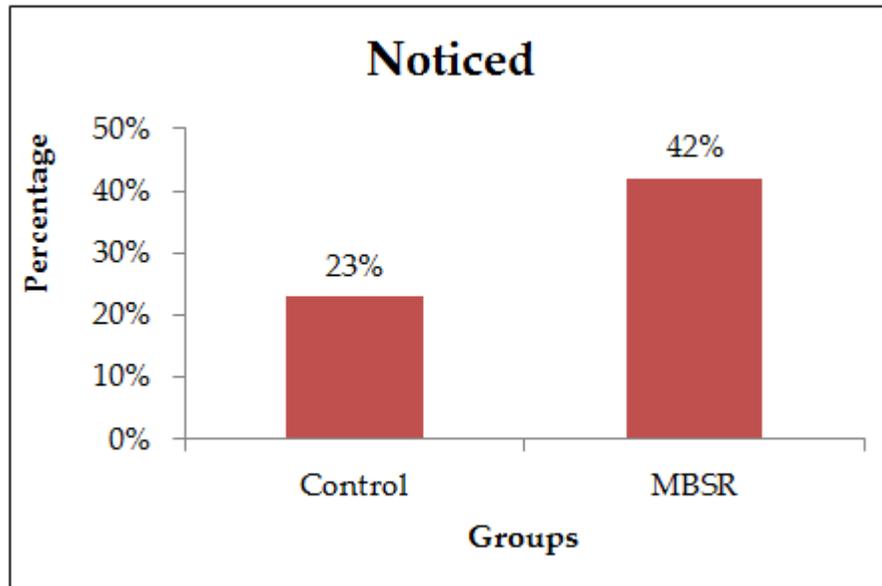


Figure 4: The percentage of participants from each group who noticed the unexpected object in the critical trial of the IB task.

Although groups in the divided attention trial differed slightly, with 55% of subjects from the control condition and 45% of the experienced MBSR practitioners reporting that they noticed the cross, this difference was insignificant $X^2(1, N = 50) = .72, p = .4$. Finally, results from the full-attention trial were comparable to values previously reported (Mack & Rock, 1998; Most et al., 2001). Specifically, 100% of the subjects in each group saw the cross in the full-attention trial suggesting that participants understood and followed the task instructions.

Error rates from the critical trial were calculated by subtracting each participant's count from the actual number of bounces on that trial and then dividing that difference by the number of actual bounces. The average of these error rates represents the percentage error relative to the total number of bounces. Error rates from the counting

task on the critical trial averaged across groups did not differ significantly between those who noticed the unexpected stimulus (mean error = 17%, $SD = 12\%$) and those who did not (mean error = 21%, $SD = 14\%$), $t(48) = 1.1, p = .28$. In addition, no significant difference was obtained in error rate on the critical trial averaged across observation type (i.e., noticed vs. did not notice) between participants in the control condition (mean error = 20.4%, $SD = 13\%$) and the experienced MBSR practitioners (mean error = 19%, $SD = 13.5\%$), $t(48) = .37, p = .71$.

3.2.3 Self-reported mindfulness and task performance

Self-reported mindfulness hypotheses: Experienced MBSR practitioners would be more mindful than a group of meditation naïve controls as evidenced by higher scores on a self-reported mindfulness measure. Mindfulness scores were hypothesized to predict performance on tasks measuring subsystems of attention associated with exogenous and endogenous attentional processes.

An independent samples t test was used to assess group differences in self-reported mindfulness measured using the MAAS; lower scores on this measure are indicative of increased mindfulness. The results of the t -test support the hypothesis that MBSR practitioners evidenced higher mindfulness relative to their meditation naïve counterparts. Specifically, experienced MBSR practitioners scored significantly lower (mean = 44.42, $SD = 8.85$) than the control participants (mean = 52.65, $SD = 13.2$), indicating a higher degree of self-reported mindfulness, $t(48) = 2.6, p = .01$.

The MAAS scores did not, according to the Pearson product moment correlation coefficients, correlate with the RT difference scores specific to alerting, $r(44) = .14, p = .35$, or orienting, $r(42) = -.02, p = .9$. Interestingly, although significant group differences were observed with regards to the conflict monitoring RT difference scores, conflict monitoring RT difference scores and MAAS scores did not correlate, $r(44) = .09, p = .54$.

3.2.4 Secondary analyses

As noted in Chapter 2, the experienced MBSR practitioners 291 hours (SD = 339 hours) of meditation experience. Analysis of these data revealed several outliers, including two participants whose self-reported meditation experience was two standard deviations above the mean. Practice times ranged from 70 to 1176 hours with a median of 144 hours; given the wide range in times reported, the median may represent a more accurate estimate of the central tendency of these data.

Not surprisingly, given the wide range in times, the practice time data did not conform to a normal distribution (skew statistic = 1.57; kurtosis = 1.45). Given that the data did not conform to a normal distribution, the Spearman rho statistic was calculated to assess correlations between self-reported practice time and each of the continuous dependent variables. No significant correlations were observed.

Although practice time in hours provides a more precise estimate of practice experience, some studies report meditation experience in terms of months. So as to facilitate comparisons across studies, these data were also collected and showed that

participants averaged a total of 34 months of experience, with a median of 24 months. The Spearman rho statistic again revealed no significant correlations between practice time in months and any of the continuous, dependent variables.

4. Discussion

This study was designed to test the hypothesis that individuals trained in MBSR would show greater efficiency in the functioning of sub-systems of attention associated with endogenous and exogenous processing relative to meditation naïve control participants, in addition to lower inattention blindness and higher self-reported mindfulness. This discussion will begin with a review of the findings pertaining to each of the specific hypotheses, followed by comments regarding the limitations of the current study and directions for future research.

4.1 The exogenous attention hypothesis

This study failed to confirm the hypothesis that participants who were trained in MBSR would show superior exogenous stimulus detection relative to participants without MBSR experience. Specifically, no group differences were found on either the accuracy or RT difference scores specific to alerting. Given that the ANT is designed to maximize accuracy so that distinctions in reaction time can be observed, significant differences in any of the accuracy difference scores calculated for each of the three subsystems was improbable and have not previously been reported in the meditation research (Jha et al., 2007; Tang et al., 2007).

However, reaction time effects for the alerting component of the ANT have been documented in the meditation literature: Experienced meditators who had recently completed a meditation retreat maintained significantly faster RTs during no-cue trials of the ANT relative to less experienced meditators and meditation naïve controls (Jha et al., 2007). The current study did not find significant differences between experienced MBSR practitioners and control participants on the RT difference scores calculated for alerting.

In an effort to explain why participants in the retreat condition showed a reduction in RT difference scores relative to participants in the MBSR and control groups in Jha's study, one might hypothesize that changes in exogenous, bottom-up processing occur over a longer period of time. According to this hypothesis, the faster alerting scores observed amongst the retreat participants may be attributed to the fact that they had significantly more meditation experience than the MBSR participants who had only recently completed an 8-week MBSR course. If extensive meditation training results in a reduction in alerting RTs, then one would expect a group of experienced MBSR practitioners to show faster RTs on an alerting task relative to a group of meditation naïve participants. On the contrary, the results from the current study indicated that experienced MBSR practitioners with a median of 144 hours of meditation experience were no faster than control participants on the alerting component of the ANT.

Several factors should be taken into consideration when comparing the results of the present study with those reported by Jha et al. (2007). First, although Jha et al. (2007) observed a significant group difference in the RT alerting difference scores, this effect was obtained only after combining data from a post-MBSR group with that of a control group and then comparing the scores of this combined group to those from experienced meditation practitioners immediately following their participation in an intensive 1-month retreat. Indeed, the initial contrast between the post-MBSR and control groups revealed no significant differences in the RT alerting difference scores (Jha et al., 2007). Importantly, the retreat group was markedly different from the MBSR group not only with regards to the amount of meditation experience they had but also in the type of meditation they practiced. The authors noted that the participants in the retreat condition were trained in concentrative, as opposed to mindfulness-based, meditation. Moreover, the meditation retreat in which they participated purportedly emphasized “concentrative attention” in which meditation instruction directed participants to allocate their full attention to the out-breath. The retreat participants from Jha et al.’s study thus had no previous training in MBSR and did not participate in an MBSR retreat. The extent to which unique types of meditation training differentially affect attention has been discussed in depth elsewhere (see Chapter 2).

Additionally, and perhaps most importantly, in addition to being more experienced than their MBSR counterparts, participants from the retreat condition in Jha

et al.'s (2007) study had, according to the study design, just completed a 1-month residential retreat. The method section does not indicate how soon after the retreat subjects from this group were tested (simply stating that it was "soon after" the retreat). However, given that the retreat participants did not differ from the control and pre-MBSR participants with regards to their alerting difference scores prior to completing the retreat, the group differences observed by Jha et al. at Time 2 may be in large part attributable to either the intensive nature of the meditation retreat or other retreat specific factors, such as decreased stress due to time off from work, physical and psychological relaxation, and so forth. Had the retreat participants evidenced superior alerting performance prior to participating in the meditation retreat, then one could conclude that these differences were potentially a function of their substantive meditation experience. In the absence of such findings, the differences that emerged subsequent to completing the retreat were probably not attributable to their meditation experience alone.

Only three other published studies have presented data pertaining to the relationship between MBSR training and attention, and only one of these studies examined changes in alerting performance specifically. The results reported here are consistent with the only other published data to examine performance on an alerting task and suggest that MBSR is not associated with improvements in this type of bottom-up, exogenous processing (Jha et al., 2007). However, a recent study did observe MBSR-

related changes in the visual attention-related parietal and occipital regions of the brain associated with alerting (Goldin & Gross, 2010). Taken together, these collective results suggest that MBSR may contribute to some cognitive changes associated with alerting; however, these changes are either not reflected in alerting performance as indexed by the ANT or are not significant enough to affect alerting performance generally.

4.2 The endogenous attention hypothesis

The current study showed no group differences in the RT difference scores calculated for orienting; however, a significant difference was obtained between groups on the RT scores calculated for conflict monitoring. These findings regarding conflict monitoring are consistent with the only other studies to examine the effects of meditation on conflict monitoring using the ANT and suggest that meditation generally, and MBSR specifically, may contribute to significant improvements in the executive attention network.

Although previous research suggests that participation in an 8-week MBSR course is associated with significant improvements in orienting (Jha et al., 2007), the present findings suggest that these may not be long-term changes. Specifically, participants in Jha et al.'s study evidenced superior orienting immediately following the completion of an 8-week MBSR course relative to a group of experienced meditators and a group of controls; however, there was no follow-up assessment to determine if these changes were sustained. Given that the experienced MBSR practitioners in the current

study did not evidence superior orienting relative to the control participants the improvements in orienting observed among MBSR completers in Jha et al.'s study may reflect a short-term effect of the intensive 8-week MBSR training program, which involved group and retreat components that are not typically part of meditators' home practice. Indeed, the experienced meditation practitioners in Jha et al.'s study did not evidence superior orienting relative to the other two groups despite their substantive meditation experience.

Additionally, the way in which the constructs of alerting, orienting, and conflict monitoring are conceptualized by Jha et al. (2007) may provide insight into the pattern of results observed in the current study. Specifically, Jha et al. suggested that orienting and conflict monitoring both represent subsystems of attention associated with endogenous processing. However, research regarding the distinctions between exogenous and endogenous processing suggests that orienting may be an exogenous or an endogenous process depending on the stimulus onset asynchronies (SOAs). Data suggests that the largest effects of cueing (facilitation, costs, and benefits) are achieved at 100ms in exogenous processing and not until 800ms for endogenous processing (Mayer, Dorflinger, Rao, & Seidenberg, 2004). Importantly, the duration of the cue in the ANT is only 400 msec, meaning that orienting, in the context of the ANT, is neither a purely endogenous nor exogenous process.

Because orienting combines both endogenous and exogenous processing, recent research suggests that it is a unique attention network, distinct from the clearly exogenous process of alerting and the endogenous, executive functioning of conflict monitoring (Askenazi & Henik, 2010). Thus, although Jha et al. (2007) suggested that orienting and conflict monitoring both represent endogenous, top-down processes, recent cognitive research suggests that orienting is not strictly a top-down process (Askenazi & Henik, 2010; Mayer et al., 2004). As a result, one might observe significant group differences in executive functioning, as indexed by conflict monitoring, in the absence of significant differences in orienting, as was reported in the current study. Given that neither alerting nor orienting scores were found to differ between groups, one hypothesis is that substantive MBSR experience is associated with improvements in executive functioning and may not have as pronounced an effect on exogenous processes such as alerting or on networks requiring both exogenous and endogenous processing such as orienting. Indeed, Jha et al., found that the experienced meditators in their study performed comparably on the alerting component of the ANT relative to participants in the other groups prior to taking the retreat but showed superior conflict monitoring. Tang et al. (2007) reported a similar pattern of results with regards to ANT performance, as did Chan and Woollacott (2007), who observed significant improvements in executive processing (i.e., Stroop performance) in the absence of

improved orienting amongst a group of experienced meditation practitioners relative to controls.

Finally, although a significant group difference with regards to the RT difference scores for conflict monitoring was observed in the current study, this alone does not reveal the direction of the effect. In order for the RT difference scores for conflict monitoring to suggest improved executive functioning, one would need evidence of a between group difference on RTs for incongruent trials (thereby indicating reduced flanker interference) rather than for congruent trials (which could reflect slower processing of congruent stimuli). Indeed, analysis of the RT difference scores for conflict monitoring in the present study suggested that the experienced meditation practitioners showed lower flanker interference relative to the control participants as evidenced by decreased RTs on incongruent trials, although this difference was not statistically significant. Tang et al. (2007) reported similar findings with regards to between group differences on RT difference scores for conflict monitoring, but they did not provide data to clarify the direction of these results. The current findings thus generally support the hypothesis that MBSR results in improved executive functioning, but future MBSR research should confirm that group differences in conflict monitoring reflect more efficient processing of incongruent stimuli rather than inefficiencies in the processing of congruent stimuli.

4.3 The inattention blindness hypothesis

Although participants who had been trained in MBSR were nearly twice as likely as untrained participants to notice the unexpected object during the critical trial of the IB task, this difference was not statistically significant. The lack of a significant statistical difference despite an observable group difference most likely reflects a lack of statistical power. One obvious means by which to increase the power of the chi square test is to increase the sample size. Indeed, previous studies in which IB effects have been observed generally included sample sizes ranging from 75 – 300 participants (Most et al., 2001; Most & Astur, 2007; Most, Chun, Widders, & Zald, 2005; Most et al., 2000). Unfortunately, limited funding prohibited the recruitment of more subjects for the current study.

4.4 Self-reported mindfulness

The current study contributes to research suggesting that meditation training is associated with a higher degree of self-reported mindfulness (Anderson et al., 2007; Chamber et al., 2008; Moore & Malinowski, 2008). Although some evidence suggests that improvements in mindfulness following training in MBSR are correlated with improvements in performance on attentional tasks, namely object detection, (Anderson et al.), no evidence was obtained to suggest a correlation between performance on attention tasks and self-reported mindfulness scores in the current study.

Although greater increases in mindfulness were correlated with object detection amongst the MBSR participants in Anderson et al.'s (2007) study, MBSR and control participants did not differ significantly in their performance on the object detection task. Additionally, the object detection task used by Anderson et al. was not implemented in the current study. Similarly, Anderson et al. assessed mindfulness using the Toronto Mindfulness Scale (TMS; Bishop et al., 2003), whereas mindfulness in the current study was measured using the MAAS. Obviously using different tasks and measures across studies hampers our ability to draw meaningful conclusions regarding differences in outcome.

4.5 Limitations and directions for future research

4.5.1 Limitations

This study provides support for the hypothesis that individuals trained in MBSR show greater efficiency in the functioning of subsystems of attention associated with top-down, endogenous processing. The data do not, however, support the hypothesis that MBSR training is associated with improvements in subsystems of attention associated with bottom-up, exogenous processing. Additionally, although the MBSR participants were nearly twice as likely as their control counterparts to identify the unexpected target on the critical trial of the IB task, this difference was not significant. Finally, though MBSR practitioners reported significantly higher levels of mindfulness, mindfulness scores did not correlate with performance on the attention tasks. As

research regarding the relationship between attention and MBSR is in its infancy, these results should be considered preliminary and in conjunction with the following limitations.

First, the data reported here are specific to a convenience sample of experienced and novice MBSR participants. Subjects were recruited at orientation meetings for advanced and introductory MBSR courses and participation was voluntary. It is thus plausible that the individuals from the orientation meetings who chose to participate in this research were systematically different from those who opted not to participate and are thus not representative of the general population of MBSR practitioners. For instance, individuals with less time and resources may have been less inclined to participate in this research given the time commitment and travel required.

Second, as the experienced MBSR practitioners were recruited at orientation meetings for advanced MBSR training, these individuals may have been more committed to their practice and/or more convinced of its utility than other MBSR practitioners. Although this allows us to comment on the potential long-term effects of a more consistent and rigorous MBSR practice, this particular group may not be representative of experienced MBSR practitioners generally.

Similarly, although the predominantly wealthy, educated, female sample recruited for this study was comparable to other MBSR groups with regards to demographic characteristics, people who practice different types of meditation other

than MBSR may not be represented by this sample. Given that most MBSR programs require that individuals participate in a weekly 2 hour course in addition to paying for the program, the changes attributed to this practice may in part be moderated by variables such as education and income.

Finally, given that this was the first study of its kind to examine differences in IB amongst meditation practitioners and meditation naïve participants, these results should not be considered conclusive. With regards to the task administration, the unique training of MBSR practitioners in both narrowing attention in the context of FA and expanding awareness via OM may have influenced their performance on the IB task. After completing the experiment, several of the experienced MBSR practitioners stated that the instructions to count as many of the bounces as possible cued them to narrow their focus exclusively to counting, thereby causing them to miss the unexpected target during the critical trial. Less explicit instructions or the use of language that encouraged open monitoring may have clarified the distinction between groups. Additionally, the small sample size and subsequently low power may have interfered with the detection of an effect.

4.5.2 Directions for future research

At present, many outcome studies report associations between MBSR participation and improved physical and psychological functioning across a broad range of disorders. Current models of mindfulness in the context of MBSR have all speculated

that attention is a primary component of mindfulness that may contribute directly or indirectly to the behavioral effects reported in the research literature. In light of this, researchers should empirically examine the extent to which attention is engaged and influenced through MBSR. Although attention has generally been explored in the context of meditation, it has only recently become a topic of serious inquiry in the MBSR research. Given the wide range of meditation methods and approaches, data addressing the role of attention in meditation widely does not substitute for research on MBSR specifically. Moreover, while other mindfulness-based practices may be similar to MBSR, we should not conclude that research pertaining to said practices can necessarily be extended to practitioners of MBSR. In sum, future research regarding the role of attention in MBSR specifically is critical to improving current theoretical models and advancing our understanding of MBSR.

The present study only measured top down, endogenous processing via the conflict monitoring component of the ANT. In light of the MBSR-related improvements in conflict monitoring performance among the experienced MBSR practitioners relative to the control subjects reported here, future research should examine MBSR-related changes in executive functioning more generally. Meditation related improvements in executive processes ranging from working memory to cognitive inhibition have been documented in the meditation research literature (Chambers et al., 2008; Chan & Woolacott, 2007); exploring the extent to which these changes generalize to MBSR

practitioners could provide insight into the specific mechanisms of change that underscore the well-documented improvements in physiological and psychological functioning associated with MBSR.

Additionally, future studies may aim to examine more fully the effects of consistent and sustained meditation practice amongst MBSR practitioners. Although a pre-post study design provides an efficient means by which to examine the immediate effects of a standard 8-week MBSR program, it is not optimal for assessing changes that occur over an extended period of time, as a function of prolonged practice. Longitudinal designs that allow follow-up assessments over time are ideal; alternatively, although less controlled, designs such as those employed in the current study allow researchers to examine differences in cognitive functioning that may be attributed to extensive meditation experience.

With regards to the IB task, future studies may consider providing less explicit instructions or using language that encourages open monitoring. Another alternative would be to have MBSR participants engage in an OM meditation prior to commencing the IB task. An OM meditation induction might facilitate the type of open awareness that is posited to decrease IB. Similarly, given the promising results of this study, future researchers are encouraged to explore the phenomenon of IB following MBSR training in a larger sample of MBSR practitioners and control subjects.

Finally, recent efforts have been made to operationalize the various components of MBSR. These initiatives have been essential in advancing theories of how attention is engaged in MBSR. Specifically, this research has suggested that MBSR uniquely employs meditation techniques that are both concentrative in nature (FA) as well as more mindfulness oriented (OM). The degree to which these distinct facets predict and contribute to the positive effects associated with MBSR has yet to be adequately explored and is an exciting direction for future research.

Appendix A

ANT Task Instructions

This is an experiment investigating attention. You will be shown an arrow on the screen pointing either to the left or to the right. With your left index finger on the left arrow key and your right index finger on the right arrow key, identify the direction of the arrow. On some trials, the central arrow will be flanked by arrows pointing in the same direction as the central arrow or arrows pointing in the opposite direction of the central arrow. Your task is to respond to the direction of only the central arrow only.

There will be a cross in the center of the screen and the arrows will appear either above or below the cross. You should try to fixate on the cross throughout the experiment.

Finally, on some trials there will be asterisk cues indicating when or where the arrow will appear. If the asterisk is at the center or both above and below fixation, it indicates only that the arrow will appear shortly. If the asterisk is only above or below the fixation cross, it indicates both that the arrow will appear and where it will occur. Please remember to try to keep your eyes focused on the center cross; however, you may attend when and where indicated by the asterisks.

Appendix B

Inclusion Criteria Questionnaire

1. When did you complete your MBSR course at the Duke Center for Integrative Medicine?
2. How frequently do you practice the formal mindfulness meditations you learned in the MBSR course (e.g. daily, once per week, etc.)?
3. On average, how long are your formal meditation sessions (e.g. 20 minutes, 1 hour, etc.)?
4. How often do you practice the informal mindfulness techniques you learned in the MBSR course (e.g. daily, once per week, etc.)?

Appendix C

Demographic Questionnaire

Age

What is your birthday? (MM/YYYY) _____/_____

Sex

Please identify your sex.

1. Male
 2. Female
-

Race/ethnicity

How do you describe yourself? (Please check the one option that best describes you)

1. Asian or Asian American
 2. Black or African American
 3. Hispanic or Latino
 4. Caucasian
-

Marital status

Are you:

1. Married
2. Divorced
3. Widowed
4. Separated
5. Never been married
6. A member of an unmarried couple

Employment status

Are you currently:

1. Employed for wages
2. Self-employed
3. Out of work for more than 1 year
4. Out of work for less than 1 year
5. A homemaker
6. A student
7. Retired
8. Unable to work

Education completed

What is the highest grade or year of school you completed?

1. Never attended school or only attended kindergarten
 2. Grades 1 through 8(Elementary)
 3. Grades 9 through 11 (Some high school)
 4. Grade 12 or GED (High school graduate)
 5. College 1 year to 3 years (Some college or technical school)
 6. College 4 years (College graduate)
 7. Graduate School(Advance Degree)
-

Appendix D

Mindfulness Attention Awareness Scale

Please indicate the degree to which you agree with each of the following items using the scale below. Simply circle your response to each item.

	1	2	3	4	5	6
	almost always	very frequently	somewhat frequently	somewhat infrequently	very infrequently	almost never
1. I could be experiencing some emotion and not be conscious of it until some time later.	1	2	3	4	5	6
2. I break or spill things because of carelessness, not paying attention, or thinking of something else.	1	2	3	4	5	6
3. I find it difficult to stay focused on what's happening in the present.	1	2	3	4	5	6
4. 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
5. I tend not to notice feelings of physical tension or discomfort until they really grab my attention.	1	2	3	4	5	6
6. 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
7. It seems I am "running on automatic" without much awareness of what I'm doing.	1	2	3	4	5	6
8. I rush through activities without being really attentive to them.	1	2	3	4	5	6
9. I get so focused on the goal I want to achieve that I lose touch with what I am doing right now to get there.	1	2	3	4	5	6
10. I do jobs or tasks automatically, without being aware of what I'm doing.	1	2	3	4	5	6

- | | | | | | | |
|---|---|---|---|---|---|---|
| 11. I find myself listening to someone with one ear, doing something else at the same time. | 1 | 2 | 3 | 4 | 5 | 6 |
| 12. I drive places on "automatic pilot" and then wonder why I went there. | 1 | 2 | 3 | 4 | 5 | 6 |
| 13. I find myself preoccupied with the future or the past. | 1 | 2 | 3 | 4 | 5 | 6 |
| 14. I find myself doing things without paying attention. | 1 | 2 | 3 | 4 | 5 | 6 |
| 15. I snack without being aware that I'm eating. | 1 | 2 | 3 | 4 | 5 | 6 |

Appendix E

Inattentional Blindness Task Instructions:

The following four questions were asked after the critical (trial 3), divided-attention (trial 4), and full-attention (trial 5) conditions. Participants answered each question in sequence and were not able to see any question before answering the previous one.

1. On the last trial, did you see anything other than the black and white squares and circles? Please answer yes or no.
2. If you did see something on the last trial that had not been present in the previous trials, please describe it.
3. If you did see something on the last trial that had not been present in the first two trials, what color was it? If you did not see something, please guess. (Please indicate whether or did see something or are guessing)
4. If you did see something during the last trial that had not been present in the first two trials, please indicate the direction in which it was moving (e.g. up, down, left, or right).

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Biography

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