UNDERSTANDING CHILDREN’S SELF-REGULATION: AN ANALYSIS OF MEASUREMENT AND CHANGE IN THE CONTEXT OF A MINDFULNESS-BASED INTERVENTION

by

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DISSERTATION ABSTRACT

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Self-regulation in children has been found to be prognostic of both normative and problematic social and emotional development in later childhood and adolescence. In particular, regulation of attention is deemed central to the ability to self-regulate other behaviors. Attention regulation is commonly measured by using rating scales and by obtaining children's behavioral and neurophysiological responses during laboratory tasks. Despite the widespread use of a variety of measurement strategies, the convergent validity of diverse measurements of attention regulation has not been systematically tested. This insufficiency is problematic for understanding individual differences in self-regulation and for evaluating interventions designed to improve attention regulation in children. Mindfulness-based interventions, an increasingly influential and powerful modality of psychosocial intervention, are hypothesized to improve attention regulation directly. Improvements in psychosocial adjustment following mindfulness-based intervention are hypothesized to be mediated through attention regulation. Nevertheless, research exploring the relation between mindfulness intervention and attention regulation is limited. This study explored the construct validity of attention regulation by (a) examining the measurement model for attention regulation that incorporates questionnaire ratings, behavioral data, and neurophysiological (electroencephalographic event-related potentials) measures, and (b) testing direct effects of mindfulness intervention on multiple measurements of attention regulation and indirect treatment effects on psychosocial outcomes with attention regulation as a mediator, using data collected from a randomized controlled trial of a mindfulness-based intervention with 47 children ages 9–12 years. Results confirmed that varying measurements of attention regulation were not empirically related. Results also supported previous findings that mindfulness-based interventions improved some indices of attention regulation in children. However, results did not support the hypothesis that attention regulation served as a mediator in mindfulness-based intervention treatment effects on psychosocial outcomes. Discussion suggests approaches to the measurement of attention regulation and new directions in mindfulness-based intervention research with youth.

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DEDICATION

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CHAPTER I

INTRODUCTION

The goals of this research were to use rating scale, behavioral, and neurophysiological measures of the construct of attentional regulation in children to (a) test the nomological models of measurement, and (b) study the malleability of these constructs in response to a randomized mindfulness-based intervention involving children and their parents.

Mental Health Problems in Children and Adolescents

Middle childhood and early adolescence is a turbulent period of the human lifespan. In addition to normative stressors and hardships, epidemiological research suggests that this period has high rates of psychopathology (SAMHSA, 2008). Mental health problems have been estimated to occur in as much as 20% of the United States population (U.S. Department of Health and Human Services, 1999), with an equal proportion of children meeting criteria for a diagnosable mental, behavioral, or emotional condition (Ray, Henson, Schottelkorb, Brown, & Muro, 2008). This period of development is also associated with the beginning of problem behaviors such as drug use and risky sexual practices (Greenberg et al., 2003) and are predictive of later difficulties, such as high school drop out (Stoep, Weiss, Saldanha, & Cohen, 2003) and adult mental health problems. Unfortunately, these early psychosocial problems are often not treated in as much as 20-38% of the population (American Academy of Pediatrics Policy Statements, 2004; Weist, Stiegler, Stephan, Cox, & Vaughan, 2010). Youth in today's society are evidencing substantial psychosocial difficulties; those who provide services for children and adolescents are in need of research and interventions to address this problem.

Self-Regulation in Children's Social and Emotional Development

Research increasingly suggests that attention regulation may provide a key to understanding the development of psychosocial problems in school aged youth. Indeed, the ability to self-regulate behavior and attention in children as young as 9 months old can be predictive of problem behavior much later in life (Harman, Rothbart, & Posner, 1997). Attention regulation partially defines a child's susceptibility to pathogenic parenting and negative peer environments (Belsky et al. 2007; Dishion and Patterson 2006), and is implicated in numerous psychological disorders (Rothbart & Posner, 2006). Attention regulation has also been suggested to play an important role in moderating the impact of problematic environments (i.e., stress and peer deviancy) on later development and adjustment (Dishion & Connell, 2006). Youth with high levels of self-regulation are also less susceptible to deviant peer influences on problem (Compas et al., 2001; Dishion, Felver-Gant, et al., 2010). The ability to control and regulate attention has also been found to play an important role in academic adjustment and achievement, lagging in importance only behind beginning math and reading skills (Duncan et al., 2007) as key predictors. There is mounting evidence to suggest that self-regulation is strongly related to psychosocial development, although more research is needed to better understand this complex relation.

The Definition and Measurement of Self-Regulation

Self-regulation, the ability to control or alter thoughts and feelings within a given context in line with preferred standards (Vohs & Baumeister, 2004), is one of the most important outcomes of successful childhood development, and is perhaps the underlying objective in all psychotherapeutic intervention. Self-regulation is considered to subsume other important regulatory constructs, including emotion regulation, inhibitory control, and the effortful control of attention. Given the complexity and magnitude of stimuli present at any one point in time, being able to intentionally enhance the processing of certain information while simultaneously excluding other information is central to effective self-regulation and psychosocial development (Eisenberg, Smith, Sadovsky, & Sprinrad, 2004). The ability to control attention by both focusing awareness on relevant stimuli and ignoring irrelevant stimuli, relative to an objective, is known as attention regulation.

Attention regulation is commonly measured by assessing a child's ability to perform a task in the face of distracting environmental stimuli. These tasks can be used to measure a child's behavioral performance (e.g., accuracy or reaction time) or neurophysiological performance (e.g., electrocortical activation). Attention regulation is also measured with rating scales of child behavior. These rating scales frequently measure parent report and child self-report of a child's temperament, or their predisposition towards certain behaviors over time.

Because it is an important factor in child development and functioning, attention regulation is often measured as a key variable in psychosocial research.

With these numerous research endeavors come an equally large number of measurement methodologies, including rating scales (Rothbart, Ahadi, & Hershey, 1994), behavioral measurements (Fan et al., 2002), and various neurophysiological measurement paradigms (Posner & Rothbart, 2000). Although it is commonly assumed that each of these measurement approaches taps into the same underlying construct of attention regulation, surprisingly little research has explicitly examined this important assumption. Research has shown convergent validity among diverse measures of attention regulation, for example, that questionnaire data are correlated with behavioral performance (Gerardi-Caulton, 2000) or that behavioral and neurophysiological measurements are correlated (Rueda, Posner, Rothbart, & Davis-Stober, 2004), yet no research to date has simultaneously explored the relation between all three measurement methodologies. Research that explicitly explores the construct of attention regulation by incorporating multiple measurement techniques (i.e., questionnaire, neurophysiological, behavioral) and multiple laboratory tasks could theoretically provide an innovative and robust measurement model, and contribute to the overall understanding of the self-regulation of attention.

Mindfulness and Self-Regulation

Increased self-regulation is often viewed as a primary treatment objective in child-focused interventions for psychosocial difficulty. Despite its importance in psychological intervention, there are currently few interventions that directly target self-regulation. However, accruing research suggests that a novel intervention approach, broadly coined mindfulness-based interventions, may explicitly enhance self-regulation to affect positive change, specifically by teaching skills and daily practices that strengthen attention regulation (Semple, Lee, Rosa, & Miller, 2009; Shapiro, Carlson, Astin, & Freedman, 2006).

Inherent to the construct of mindfulness is attention regulation; indeed mindfulness is defined as “the self-regulation of attention so that it is maintained on immediate experience … [and] is characterized by curiosity, openness, and acceptance” (Bishop et al., 2004). Mindfulness-based interventions focus on teaching individuals strategies to disengage attention away from internal reactions (e.g., thoughts and feelings) to experience that elicit distress, and to instead engage attention on present experience directly without elaborative cognitive appraisals or interpretations. By resting attention on the immediate experience, individuals are able to become more aware of which aspects of immediate experience are worth responding to, ignoring, or simply observing. Moment-by-moment decision making is done with deliberate intention and careful attention. Mindfulness interventions use exercises and practices to explicitly train attention to the present moment. The construct of mindfulness is inextricably related to attention regulation, and further, mindfulness-based interventions are hypothesized to operate through directly enhancing attention regulation (Shapiro et al., 2006), although more research is needed to empirically support this theoretical assertion.

Mindfulness Intervention Effects on Attention Regulation

Because mindfulness and attention regulation are theoretically highly related (or perhaps nested) constructs, practices that promote mindfulness (i.e., mindfulness-based interventions) should also improve attention regulation. Indeed, there is tentative support for mindfulness-intervention related effects on attention regulation. Jha and colleagues (2007) examined the effect of mindfulness training on attentional capabilities using the Attention Network Test (ANT; Fan et al., 2002). Following 8-weeks of mindfulness-training, adult participants improved in their voluntary attention regulation relative to wait-list controls. Similarly, other research has demonstrated improvements on different measures of attention regulation in adults following both brief (Wenk-Sormaz, 2005) and long-term (Valentine & Sweet,1999) mindfulness training.

In the only study to date exploring the effects of mindfulness interventions on attention regulation in youth, Saltzman and Goldin (2008) randomly assigned a non-clinical sample of parent-child dyads to either mindfulness treatment (*N* = 24) or wait-list control (*N* = 8) conditions. Children's behavioral performance on the ANT was measured before and after the treatment group completed the 8-session intervention. Following completion of the mindfulness-based intervention, children in the treatment group had significantly greater behavioral performance on the ANT subsystem of conflict monitoring, an index of attention regulation.

Although there is emerging evidence to support the claim that mindfulness-based intervention enhance attention regulation, results from the aforementioned studies need to be considered with caution. The aforementioned adult studies have been criticized for their employed methodologies (Jensen, Vangkilde, Frokjaer, & Hasselbach, 2012), and there has been reported evidence of null-effects in research attempting to replicate findings (Anderson et al., 2007).

Treatment effects in children (i.e., Saltzman & Goldin, 2008) were reported in a book chapter, and as such did not provide extensive methodological detail to allow for critical interpretation of results. Furthermore, all of the studies to date examining treatment effects of mindfulness intervention did not employ a multi-method measurement of attention regulation, which is suggested as best-practice in child assessment (Merrell, 2008). Research replicating treatment effects of mindfulness intervention on attention regulation incorporating methodologically sophisticated measurement is needed to advance the scientific community's understanding of how mindfulness and attention regulation are related.

Mindfulness Intervention Effects

Mindfulness-based interventions have become increasingly popular method of psychosocial intervention (Brown, Ryan, & Creswell, 2007) due in large part to research documenting positive treatment outcomes. In a meta-analysis of 39 peer-reviewed studies of the effects of mindfulness-based therapy on anxiety and mood symptoms in clinical and nonclinical samples, researchers found moderate to large effects, with Hedge's g values between .59 and .97 (Hofmann, Sawyer, Witt, & Oh, 2010). Two other meta-analyses have shown similar results for the efficacy of mindfulness-based intervention on various measures of physical and psychological well-being for a variety of populations, with effect sizes ranging in the moderate to large range (Baer, 2003; Grossman, Niemann, Schmidt, & Walach, 2004). Interventions incorporating mindfulness-training are becoming more prevalent in the armamentarium of psychosocial treatment because of research supporting its clinical effectiveness.

There is also emerging research suggesting the utility of mindfulness-based intervention for use with children. In a recent review of the literature, Burke (2009) detailed findings from 15 studies of mindfulness intervention with youth. This review concluded that there is “a reasonable base of support for the feasibility and acceptability of mindfulness-based interventions with children and adolescents” (p.143), but also that further empirical support is needed for novel and adapted interventions. Calls for research have been further spurred by emerging evidence demonstrating the efficacy of mindfulness-based interventions for school-age populations (Greco, Barnett, Blomquist, & Gevers, 2008; Lee, Semple, Rosa, & Miller, 2008; Semple, Lee, Rosa, & Miller, 2010) and in educational settings (Napoli, Krech, & Holley, 2005; Saltzman & Goldin, 2008; Singh, Wahler, Adkins, Myers, & The Mindfulness Research Group, 2003). Although results to date have been promising, more research exploring treatment effects of mindfulness based intervention to psychosocial outcomes in youth is needed.

Mechanisms of Mindfulness Intervention

The majority of research on mindfulness-based intervention to date has focused on evaluating efficacy and effectiveness of treatment. In this way, researchers have documented the direct impact of mindfulness-based intervention on areas such as psychopathology both in adults (Grossman et al., 2004; Hofmann et al., 2010) and in children (Burke, 2009). A critical next step in advancing mindfulness intervention research is to not just evaluate *if* mindfulness-based interventions affect change, but *how* change is affected through the exploration of underlying mechanisms. It has been suggested that this question be tested using longitudinal designs evaluating mediational effects (Shapiro et al., 2006), specifically by incorporating mediators that are theoretically linked to mindfulness intervention, such as attention regulation. Research following this recommendation is needed to better understand mindfulness interventions and develop more effective psychosocial interventions.

Research Aims and Study Purpose

The overarching objectives of this research were to better understand the measurement and promotion of self-regulation in children. This research aimed to achieve these objectives by exploring a multi-method measurement of attention regulation, and evaluating treatment effects to attention regulation following mindfulness-based intervention.

Research Aim #1: Testing and clarifying the measurement model for attention regulation. Because of the complexity and inherent ambiguity of studying the broad construct of self-regulation, researchers typically focus on specific indicators, such as attention regulation. In measuring attention regulation, researchers generally rely on one of three measurement technologies: questionnaire rating scales, behavioral response data, or neurophysiological indices of brain activity. Although scientists may assume that a particular approach to measuring attention regulation will successfully capture the construct, this assumption may in fact be false and thus compromise the external validity of research findings. As such, the field may be drawing conclusions that are at best misinformed, and at worst, erroneous. Without explicitly evaluating the measurement models used to capture an unobserved latent construct, conclusions drawn could be misleading.

To address this limitation in the research, the current study developed and tested a measurement model for attention regulation that combines rating scale, behavioral, and neurophysiological methodologies. Using factor analytic techniques, this research will explore the correlational structure of these measurement methods of the latent construct of attention regulation, using a data-driven approach to model development (Dishion & Patterson, 1999). Developing and testing this measurement model would be a first step in building models of child and adolescent self-regulation that could inspire the innovation of more effective intervention strategies to treat or prevent problems stemming from poor self-regulation, such as attention deficit disorder, antisocial behavior, early drug use, and emotion dysregulation. Further, this measurement model could lead to an improved measurement of the construct of attention regulation, which could then be employed in future basic and applied research.

As this first research question was exploratory in nature, it was not possible to specify *a priori* hypotheses of results. However, three possible outcomes to the final factor analysis derived factors of attention regulation can be speculated. First, factor/s could be derived that are grouped based on methodology, that is, items within factors will cluster around questionnaire, behavior, or neurophysiological measurement methods (e.g., a factor comprised solely of behavioral variables). Second, factor/s could be derived that are grouped on specific subordinate conceptual dimensions of attention regulation (e.g., just inhibitory control or conflict monitoring). Third, factor/s could be derived based on a specific laboratory task (e.g., just items from the Stroop task). Fourth, factor/s could be derived containing items grouped in a novel manner. Should items cluster into factors in such a way, it could offer new directions to the understanding and measurement of attention regulation.

Research Aim #2: Evaluating the relation between mindfulness intervention and the self-regulation of attention. Research exploring the relation between attention regulation and mindfulness has established a tentative relation. Some studies have found significant treatment effects following intervention, although these studies were primarily conducted with adults, and had methodological limitations including relying solely on behavioral measurement of attention regulation.

The current research addressed these limitations by evaluating the impact of a mindfulness-based intervention on children's attention regulation using multiple measurement approaches including individual rating scale, behavioral, and neurophysiological indices of the construct. Further, this research tested a novel measurement approach of attention regulation based on results following Research Aim #1 by using the derived factor variable as an outcome.

Two hypotheses were tested for Research Aim #2. First, it was expected that results would replicate previous research of treatment effects to attention regulation following mindfulness intervention with children. Specifically, it was hypothesized that there would be significant treatment effects to the conflict monitoring subsystem of the ANT, replicating previous research (Saltzman &

Goldin, 2008). Second, it was expected that the measurement of attention regulation derived from multi-method factor analysis (as detailed in Research Aim #1) would evidence significant treatment effects. As this novel measurement approach was expected to improve the existing measurement of attention regulation, it was theorized that this new measurement would capture the expected change to attention regulation where other indices of the construct might not. It was expected that results from this research question would advance the field of psychosocial intervention research by providing more conclusive evidence of the relation between mindfulness and attention regulation, thus suggesting new directions in developing targeted intervention for youth.

Research Aim #3: Understanding the mechanisms of mindfulness. The majority of research on mindfulness-based intervention has focused on evaluating efficacy and effectiveness of treatment on psychosocial outcomes and psychopathology. To advance the field, theoretically implicated mediators must be explored and tested. The current study tested the proposed mediator of attention regulation in a mindfulness intervention in children.

It was hypothesized that there would be statistically significant indirect treatment effects of random assignment to a mindfulness intervention, through attention regulation, on psychosocial outcomes. Specifically, the indices of attention regulation that yielded significant treatment effects (see Research Aim #2) were used to test for mediation. It was expected that results from this research question would elucidate the mechanistic underpinnings of mindfulness-based interventions and suggest new directions to improve psychosocial treatments.

CHAPTER II

LITERATURE REVIEW

This section reviews two topics germane to the current study. First is a review of attention regulation measurement technologies employed in this study, including a rating scale of temperament, a description of three laboratory tasks, and the neurophysiological methodology of electrophysiological event-related potential measurement. Second, a brief description of two common mindfulness-based interventions is provided. These practices are both common in the field of mindfulness research and were used to test for treatment effects in this study's sample.

The Measurement of Attention Regulation

Questionnaire rating scales. Parent- and self-reports of behavior are commonly employed methods used to measure attention regulation. This study used the effortful control subscale of the Early Adolescent Temperament Questionnaire-Revised (EATQ-R; Ellis & Rothbart, 2001). This scale combines the subscales of behavior activation control, attention control, and inhibitory control to form the composite of effortful control of behavior. The effortful control scale of the EATQ-R theoretically measures attention regulation (Rothbart, Ellis, & Posner, 2004) and has been used to assess attention regulation in both children (Rothbart et al., 2003) and adolescents (Ellis, Rothbart, & Posner, 2004).

Laboratory tasks. Another typical measure of attention regulation comes in the form of laboratory tasks. One way to measure attention regulation is through the examination of *conflict tasks*. Conflict tasks measure behavioral response to different conditions of stimuli which are designed to elicit competing response patterns. A common example of a conflict task is a flanker paradigm, where an individual is instructed to determine the direction of a target stimuli that is surrounded by either congruent stimuli (e.g., arrows pointing in the same direction) or incongruent competing stimuli (e.g., arrows pointing in the opposite direction). The differences in performance between these stimulus conditions is used an indicator of an individual's ability to pay attention to relevant stimuli and ignore irrelevant stimuli, or their ability to regulate attention. Another method of measuring attention regulation is through *inhibitory control* tasks. These tasks establish a prepotent behavioral response pattern to a given stimuli, which is then interrupted with an infrequent but topologically similar stimuli requiring a different response. An individual's performance between these stimulus conditions is used as an indicator of attention or vigilance, and can be construed as an indicator of attention regulation.

This study used three commonly used laboratory tasks to measure attention regulation: the Attention Network Task (ANT; Posner & Peterson, 1990), the Stroop task (Stroop, 1935), and the Go/No-Go task (described in detail below in the Methods section). The executive control subscale of the ANT is a conflict monitoring task, in which the participant determines which direction a target arrow is facing (either left or right) in a condition where flanking non-target arrows are either pointing in the same direction (congruent) or in the opposite conflicting direction (incongruent). A participant's performance between the congruent and incongruent conditions yields a measure of conflict resolution and attentional self-regulation. Two other subsystems from the ANT, alerting and orienting, provide unique measurements of attention that are distinct from the conflict monitoring subscale (Fan et al., 2002). These subscales were included as they have been implicated by other research in mindfulness intervention (Anderson et al., 2007), and have been used to document changes to attention regulation following intervention (Jha et al., 2007).

The Stroop task was another conflict management task used in this study. In this task, participants read a series of color-words printed in various font-colors, and were asked to respond to the color of the printed word, not the word itself. Words were presented in either a congruent condition where the font- and word-color were the same, or in an incongruent condition where they differed. As reading is generally a stronger behavioral response than naming a color, a participant's performance between these conditions yielded a measure of their ability to respond to conflicting stimuli. This construct thus measured a similar variable to the ANT conflict monitoring subscale, and was analyzed given that it was expected to yield convergent evidence.

The Go/No-Go task was considered a measure of inhibitory control. In this task, participants were presented with a higher proportion of "Go" stimuli which require them to make a behavioral response, as compared to a lower proportion of "No-Go" stimuli which required the withholding of a response. Because the "Go" stimuli were presented more frequently, they became a preponderant response. Thus, an individual's ability to inhibit their preponderant response as compared to activating their "Go" response, measured a variant of attention self-regulation. This ability to inhibit a preponderant response has been found to be associated with attention regulation (Fuentes, 2004).

Neurophysiological measurement. There are many methodological approaches to measuring neurophysiological functioning. The present research focuses on one such approach using electroencephalography (EEG) and the event-related potential (ERP) technique.

Electrophysiological measurement. Neurons are the individual cellular units that make up the functional matter of the human brain. Using electrical and chemical messaging systems, neurons form networks that allow them to send signals throughout the human nervous system. Due to the invasive nature of such measurement, collecting information of the electrical signal of any individual neuron is impossible in most experimental human research. However in 1929, Hans Berger discovered that by placing an electrical recording device called an electrode on the scalp and then amplifying the recorded electrical signal, the summative electrical output of neurons within the brain can be measured. This technique and resulting output has become known as *electroencephalography*.

Today electroencephalography, or EEG, is a commonly used practice to record the fluctuation of voltage in the brain. In the clinical application of EEG, multiple electrodes are placed in different locations on the human scalp to measure electrical activity of different regions or lobes of the brain. Although differences in electrical output are obtained based on spatial placement of these electrodes, which correspond to anatomical regions of the brain, it is important to note that the output measured on the scalp is actually the summation of hundreds or thousands of different neurons' electrical activity. Electrical output measured by EEG is a relatively small voltage amount compared to most typical household appliances (e.g., a cellular phone can run on a 3 volt battery), typically ranging from 20-100 microvolts (μv).

The event-related potential (ERP). The disproportionately large nature of muscular electrical activity to the output obtained on the scalp necessitates that EEG recording take place only when individuals are either sleeping or remaining very still. However, EEG can be recorded in response to sensory stimulation even while remaining motionless. The resulting electrical output of the brain measured by EEG in response to stimuli is called an *event-related potential*, or commonly an ERP. One advantage of the ERP for psychologists is that it helps to isolate neuro-cognitive processes from the relatively coarse signal of the EEG. Whereas the data obtained from EEG recording actually represents a conglomeration of numerous individual neural activities, by the process of simply averaging the output of electrical signal in response to dozens if not hundreds of repeated exposures to a given stimuli, an ERP begins to differentiate pattern or signal representing more specific brain activity (said differently, the random noise cancels itself out and the signal becomes more clearly defined).

A few properties of the ERP are relevant to the current research. One is the resolution of ERP methodology relative to other neurophysiological measurement techniques. Because the electrical signal obtained from ERP can measure changes in activity to the millisecond, it is considered to have high temporal resolution relative to other approaches, such as functional magnetic resonance imagery (fMRI) which typically captures activity in the range of several seconds. This exponential difference in temporal resolution is important for research that aims to measure fleeting cognitive processes, such as attention, which would otherwise not be measurable using alternative methodology. A relative weakness of the ERP method is that because the signal obtained on the scalp is actually the summation of hundreds or thousands of neurons in 3-dimensional space, each with their own physical orientation producing unique vectors of electrical output (called dipoles), the actual location or orientation of neurons is not determinable. Because an infinite combination of neurons in the brain could yield a given output of scalp voltage, ERP methodology is generally considered to have poor spatial resolution, thus it is difficult to determine the anatomical origination of observed electrical activity. This being said, cutting-edge ERP techniques that utilize hundreds of electrodes (e.g., 256), which enables signal triangulation and identification, coupled with convergent research using similar paradigms and high spatial neurophysiological measurement techniques (e.g., fMRI), suggest that the location of certain ERP components in the brain can be determined, although this remains a controversial topic in the field (Luck, 2005).

Measuring attentional self-regulation using ERP. A subject's response to laboratory tasks of attention regulation can be measured behaviorally, as previously noted by recording speed and accuracy to stimuli conditions. Subjects' responses can also be recorded using EEG ERP methodology. Instead of measuring an individual's behavioral response, EEG data is collected for a given stimuli, from which the time-locked ERP waveforms (i.e., the EEG signal relative to a temporally fixed presentation of stimuli) are subsequently extracted. From the summation of these ERP waveforms over the many presentations of a stimuli or trial type in a task, a portion of the waveform is then extracted for measurement. These ERP waveform portions are named by their temporal and topological features. For example, a large positive-voltage section of the ERP waveforms which occurs approximately 300 milliseconds following presentation of a stimulus is called the P3 or P300, with the “P” referencing it being a positive waveform, and the “3” or “300” referring to it’s temporal location following presentation of stimulus.

The aforementioned tasks of attention regulation, such as conflict and inhibitory control tasks, each have specific associated ERP waveforms which can be extracted to measure the neurophysiological dimension of attention regulation. Neurophysiological measurement may be a more sensitive measure of attention regulation than behavioral indices, as has been the case in other research (Bruce et al., 2009; Handy et al., 2001).

Mindfulness-Based Interventions

Following is a brief outline of two mindfulness-based interventions that are commonly used in treatment research. These two interventions are briefly detailed to illustrate some of the common practices implemented when teaching mindfulness.

Mindfulness-Based Stress Reduction*.* The most frequently studied method of mindfulness training is Mindfulness-Based Stress Reduction (MBSR;

Kabat-Zinn, 1990). Although MBSR was originally developed in the context of behavioral medicine for patients suffering from chronic pain, its use has since been implemented and studied among a wide variety of populations ranging from normative community samples to individuals with severe physical and psychological illness. The MBSR program is an intensive, 8-week group intervention that is standardized and designed to teach and promote the use of mindfulness in everyday life. Individuals meet once a week for 2.5 hours of group instruction, discussion, and practice in mindfulness techniques. Three core mindfulness practices are taught. *Mindful breathing* involves focusing concentration on the sensation of breathing while, at the same time, remaining open to other bodily sensations, thought processes, and emotions as they arise in consciousness. During the *body-scan* exercise, participants progressively apply awareness to different parts of their body (i.e., first feeling sensation in the toes, then ankles, then shins, etc.). During *mindful stretching,* participants consciously move through a series of slow stretches or yogic poses. Participants practice these three techniques for up to 45 minutes a day as homework, initially guided by audiotaped instruction. Didactic group instruction encourages and teaches participants to expand their mindfulness practice to any and all areas of their lives (e.g., mindfully taking out the trash, mindfully conversing with a difficult family member, or mindfully paying attention to physical pain), thus generalizing the mindfulness instruction to outside of the formal mindfulness practice. A central component of MBSR is to practice self-regulating attention to the immediate experience.

Mindfulness-Based Cognitive Therapy. A variant of MBSR, Mindfulness-Based Cognitive Therapy (MBCT; Segal, Williams, & Teasdale, 2002) was developed to prevent relapse of depression for individuals with a history of major depressive episodes, although its uses have been expanded to incorporate the management of other problems. MBCT is based on a fusion of traditional cognitive therapy and mindfulness concepts. Its theoretical background posits that vulnerability to psychopathology lies in part in an individual's lack of awareness about his or her own internal functioning and mental state. Individuals are taught to become mindfully aware of response patterns that contribute to impairment and pathology and then learn to use cognitive–behavioral techniques to address and combat these patterns. Increased awareness about internal behaviors (e.g., thoughts, feelings) and external behaviors (e.g., sleeping patterns, self-injurious habits) enables participants to detect the precursors to pathological functioning and then address and/or seek treatment for them before they escalate. The primary objective of MBCT is to teach the self-regulation of attention to cognitions and behavior in the present moment.

Summary

There are currently many methods for measuring attention regulation, including behavioral, questionnaire, and neurophysiological indices. These different techniques are all postulated to measure the construct of attention regulation from different methodological angles. This research tested this assumption by exploring the correlations among these measurements and using factor analysis, as detailed in Research Aim #1. Mindfulness and attention regulation are theoretically related constructs; indeed mindfulness-based interventions are largely designed to train the self-regulation or attention towards immediate experience using a variety of exercises. Research Aims #2 and #3 were designed to explore and empirically evaluate this relation.

CHAPTER III

METHODS

Participants

This research analyzed extant data taken from a randomized control trial of a family centered mindfulness-based intervention adapted from MBSR: Mindful Family Stress Reduction (MFSR). Forty-seven child participants were recruited from a medium-sized city in the Pacific Northwest (44% female). The mean age of children recruited for the study was 11 years and 1 month (*SD* = 12 months). Dyads were randomly assigned (balanced within gender) to either the MFSR intervention condition (*N* = 24), or the wait-list control condition (*N* = 23).

Recruitment

Parent-child dyads were recruited for the study in one of two ways: either through direct phone calls to parents listed on the University of Oregon's developmental database, or via flyers placed on community bulletin boards. Inclusion criteria for children included age between 9 and 12 years of age, being able to read and comprehend English, no history of psychological diagnosis (i.e., post traumatic stress disorder, major depressive disorder, or any form of an anxiety disorder), and no history of epilepsy or seizures (exclusion criteria for EEG data collection).

Intervention

The mindfulness-based intervention used, MFSR, was based on the most established mindfulness interventions to date (MBSR; Kabat-Zinn, 1990; MBSR for Children; Lee, Semple, Rosa, & Miller, 2008). The MFSR intervention group met for 90 minutes once a week for 8 consecutive weeks at a local community wellness center, and held up to a maximum of parent-child 24 dyads (i.e., 48 people), although the average attendance was generally less due to attrition and non-attendance (parents attended an average of 6.13 (*SD* = 1.70) classes; children 6.46 (*SD* = 1.59)). Each session followed a similar format, including both didactic and experiential mindfulness components based on the manualized MBSR curriculum. During the first 30 minutes of the class, the entire group met to practice, reviewed the previous week's material, and reviewed the new topic for discussion that week. The middle 30 minutes of the class had the parents and child split into separate groups in different rooms to practice sustained silent mindfulness activities (parent) and shorter child-friendly activities (child) relevant to the lesson focus of the week. The final 30 minutes of the class summarized the lesson for the day, included a short practice or activity, and reviewed the home practice for the week. Formal mindfulness instruction (e.g., mindful breathing, basic yogic poses) and informal mindfulness instruction (e.g., mindful eating, mindful conversations) were taught every week. Each week participants were asked to practice techniques learned during the session at home for approximately 15–20 minutes per day and record the number of minutes they spent practicing. Participant daily practice sheets were collected, reviewed, and recorded each week by the course instructors.

The MFSR class included the basic structure and curriculum of MBSR, but was adapted to meet the needs of parents and children, and included age appropriate material and modifications in line with current research on child family mindfulness intervention practices (Duncan, Coatsworth, & Greenburg, 2009; Dumas, 2005; Thompson & Gauntlett-Gilbert, 2008). Table 1 gives a session outline of the MFSR curriculum. MFSR incorporated alternative sensory modalities in a way that is more akin to a game than a static meditation exercise, to help children be engaged with the mindfulness activity (Thompson & Gauntlett-Gilbert, 2008). An example of such an activity is the “Sound Scavenger Hunt”, where children were asked to close their eyes, sit upright, and try to “find” (i.e., detect) as many novel sounds inside and outside of the room as possible for 5 minutes. After “searching” for sounds, a list was generated of all the noises that were observed by children. This activity taught children to maintain their attention on a single focus (i.e., hearing and not other sensory modalities or cognitions) in a nonjudgmental and curious manner, thereby directly targeting both attention regulation and the qualitative aspect of acceptance inherent in mindfulness.

Fidelity of intervention administration was collected during intervention sessions based on the manualized MFSR intervention; fidelity remained above 90% for all class sessions. The class was administered by the principal investigator and the co-investigator of the research, both of whom have received MBSR training and preliminary certification, and have extensive experience in mindfulness practice and intervention.

Measurement Procedures

Measurement occurred at three time points relative to the MFSR intervention group: pre-intervention (Time 1), post-intervention (Time 2), and at 10-week follow-up (Time 3). The wait-list control group completed assessments

Table 1

Description of Mindful Family Stress Reduction (MFSR) Intervention

Lesson Title	Description of Activities and Practices
Week 1: Autopilot and defining mindfulness	-concentrating on listening to sound
	-mindful stretching (yoga)
	-mindful eating
	-mindful abdominal breathing (sitting meditation)
	-mindfulness of somatic sensations (body scan)
Week 2: Wandering mind and barriers to practice	-sitting meditation and body scan
	-discussion of barriers to home practice
Week 3: Experiences with sitting meditation	-sitting meditation and discussion
	-yoga and discussion of yoga
Week 4: Acceptance and pleasant/unpleasant events	-sitting meditation, yoga, and body scan
	-distress tolerance activity and discussion
Week 5: Stress and responding vs. reacting	-sitting meditation, yoga, and body scan
	-stress activity (walking in airport)
	-brief mindfulness exercise (3 minute meditation)
Week 6: Thoughts are not facts and mindful communication	-imagery meditation
	-mindful communication exercise and discussion
	-sitting meditation
Week 7: Points of view and perspective taking	-perspective taking activity and discussion
	-sitting meditation
	-point of view exercise and discussion
	-yoga
Week 8: Summary and continuing practice	-sitting meditation, yoga, and body scan
	-writing letter to future self
	-discussion of continuing practice
	-wrap-up activity – MFSR graduation

within the same time frame as the intervention group (i.e., yoked temporal assessment between the two conditions). All assessments took place within two weeks prior to the beginning of the mindfulness intervention, and within two weeks following completion of the intervention. Table 2 details the measurements collected at the three time points.

Pre- and post-intervention assessment sessions lasted approximately 2 hours each. In each session, parents and children jointly completed a video-recorded dyadic interaction task (~20 minutes). Next, parents completed questionnaires about themselves and their child. While the parent was completing questionnaires, child participants had the EEG net applied, and then completed a 5-minute relaxation exercise (i.e., simply asked to close their eyes and relax) followed by the three aforementioned lab tasks (i.e., ANT, Stroop, and Go/No-Go tasks). Following the lab tasks, children completed their self-report forms. Families were compensated $40 for each assessment session, $20 for each mindfulness class attended, and an additional $50 if they attended all 8 classes. Participants completed only self-report questionnaires at the 10 week follow-up time point (Time 3), which occurred before the wait-list control group began the MFSR intervention.

Measures

The Child Behavior Checklist (CBCL; Achenbach & Rescorla, 2001). The CBCL is a 118-item parent-report of child problem behaviors and psychopathology. Total score of psychopathology on the CBCL was measured to capture the general construct of psychopathology in this non-clinical sample; broad band subscales of psychopathology (i.e., internalizing and externalizing behavior) were also scored. The alpha coefficients at Time 1 for the CBCL in the

Table 2

Constructs, Measures, and Assessments in Study

Domains, constructs, subscales, measures and reporting agents	Time Point When Data Collected Pre-intervention (Time 1)	 Post-intervention (Time 2)	 Follow-up (Time 3)
Psychopathology and psychosocial functioning			
Child Behavior Checklist			
Total problem behavior scale (P)	X	X	X
Internalizing subscale (P)	X	X	X
Externalizing subscale (P)	X	X	X
Strengths and Difficulties Questionnaire			
Internalizing subscale (P, C)	X	X	X
Externalizing subscale (P, C)	X	X	X
Prosocial behavior subscale (P, C)	X	X	X
Social Emotional Assets and Resilience Scale – Parent form short form total scale (P)	X	X	X
Adult Child Relationship Scale total scale (P)	X	X	X
Community Action for Successful Youth – Positive family relations subscale (P)	X	X	X
Child and Adolescent Mindfulness Measure (C)	X	X	X
Rating scales of effortful control of attention			
EATQ-R			
Effortful control factor scale (P, C)	X	X	X
Attention control subscale (P, C)	X	X	X
Inhibitory control subscale (P, C)	X	X	X
Activation control subscale (P, C)	X	X	X
Laboratory tasks to measure effortful attention control			
Attention Network Task			
Conflict monitoring subsystem			
Reaction time	X	X	
N2 ERP	X	X	
P1 ERP	X	X	
P3 ERP	X	X	
Orienting subsystem			
Reaction time	X	X	
P1 ERP	X	X	
Alerting subsystem			
Reaction time	X	X	
P1 ERP	X	X	
Stroop task			
Reaction time	X	X	
N450 ERP	X	X	
Go/No-Go task			
Go trial accuracy	X	X	
No-go trial accuracy	X	X	
ERN ERP	X	X	
N2 ERP	X	X	

Note: C = child report; P = parent report current sample was .96 for the total score, .87 for the internalizing subscale, and .91 for the externalizing subscale.

The Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997; Goodman, et al., 1998). The SDQ is a 25 item parent-report and child self-report measure psychosocial strengths and problem behaviors. When using the SDQ in a low-risk general community sample, the SDQ is recommended to be divided into the subscales of internalizing symptoms, externalizing symptoms, and prosocial behavior (Goodman, et al., 2010). The SDQ provided supplementary information to the CBCL, as it is considered to be less targeted on psychopathology than the CBCL and may be more sensitive to change in a normative sample (Goodman & Scott, 1999). The alpha coefficients at Time 1 for child self-report on the SDQ in the current sample was .76 for externalizing symptoms, .55 for internalizing symptoms, and .67 for prosocial behavior. The alpha coefficients at Time 1 for parent report on the SDQ in the current sample was .80 for externalizing symptoms, .69 for internalizing symptoms, and .72 for prosocial behavior.

Student Assets and Resiliency Scale- Parent report form (SEARS-P; Merrell, Felver-Gant, Tom, 2010). The SEARS-P short form is a 12 item, parent-report, strength-based measure of psychosocial functioning. This scale was measured to assess for positive psychosocial attributes. The alpha coefficient for the current sample at Time 1 was .854.

Child and Adolescent Mindfulness Measure (CAMM; Greco, Baer, & Smith, 2011). The CAMM is a 10 item child self-report measure of mindfulness, largely in terms of a dimension of mindfulness known as experiential avoidance. The CAMM was included to measure subjective mindfulness. The alpha coefficient for the current sample at Time 1 was .64.

Adult–Child Relationship Scale (ACRS; Pianta & Nimetz, 1991). The ACRS is a 15 item parent report of parent-child relationship. Parent child interpersonal variables are theoretically implicated as an outcome in mindfulness-based intervention (Duncan, Coatsworth, & Greenburg, 2009), as such the total score from the ACRS was included for measurement. The alpha coefficient for the current sample at Time 1 was .88.

Community Action for Successful Youth questionnaire (CASEY; Metzler, Biglan, Rusby, & Sprague, 2001). Twenty-three parent report items from the CASEY were collected; current analysis used the 6 items comprising the positive family relations subscale. The alpha coefficient for this subscale at Time 1 in the current sample was .77.

Early Adolescent Temperament Questionnaire—Revised (EATQ-R; Ellis & Rothbart, 2001): Effortful Control factor scale (Rothbart, Ellis, & Posner, 2004). The effortful control subscale of the EATQ-R is a parent report (18 item) and child self-report (16 item) questionnaire measure of attentional self-regulation. The effortful control subscale is comprised of three dimensions: Attention Control, Inhibitory Control, and Activation Control. Each of the three dimensions of effortful control, and the total effortful control subscale, was collected for measurement. These scales served as the questionnaire method for assessing attention regulation. The alpha coefficients for child self-report in the current sample at Time 1 was .74 for the effortful control subscale, .67 for the activation control dimension, .75 for the attention control dimension, and .36 for the inhibitory control dimension. The alpha coefficients for parent report in the current sample at Time 1 was .83 for the effortful control subscale, .86 for the activation control dimension, .76 for the attention control dimension, and .62 for the inhibitory control dimension

Attention Network Task (ANT, Fan et al., 2002). The ANT measures subsystems of attention based on the tripartite model of attention postulated by Posner and Peterson (1990) and has been used with children (Rueda, Posner, & Rothbart, 2004). The ANT subsystems include alerting (ability to maintain a state of vigilance or preparedness to environmental stimuli), orienting (directing and limiting attention to specific stimuli), and conflict monitoring (prioritizing cognitive attentional resource allocation among competing stimuli, a form of attentional self-regulation). A more detailed description can be found elsewhere (Fan et al., 2002). In brief, the ANT involves participants viewing a computer screen and determining in which direction the central (target) of five horizontally aligned arrows is pointing (i.e., left or right). The arrows are presented either above or below the central fixation point, pointing in either the same left or right direction (e.g., **=>=>=>=>=>**) in the congruent condition (50% of trials), or with the central arrow pointing in the opposite direction of the four surrounding arrows (e.g., **=>=><==>=>**) in the incongruent condition (50% of trials). Trials are preceded by a cue (central cue, spatial cue, no cue), with cue types presented with equal probability. Participants gaze at the central fixation point and respond with either the left or the right thumb according to the direction in which the central arrow points. Except for no-cue trials, all trials started with the presentation of the cue for 100 milliseconds (ms). The cue was followed by a 400 ms delay. The target stayed on the computer screen 1700 ms or until the participant made a response (whichever occurred first). The delay between trials varied from 400 to 1600 ms; trial presentation was randomized. Following a short practice session with performance feedback, six blocks of 50 trials were presented to subjects; the total time to complete the ANT was approximately 20 minutes including breaks and practice trials.

To measure alerting, orienting, and conflict monitoring subsystems, difference scores between the different cue and stimulus trial-types were calculated. To calculate the conflict monitoring subsystem (often referred to as executive attention control), the congruent trial condition was subtracted from the incongruent. To calculate the alerting subsystem of the ANT, the center cue condition was subtracted from the no-cue condition; the orienting subsystem was calculated by subtracting the spatial cue from the center cue condition.

Behavioral indices on the ANT were calculated using reaction time for correct responses to a trial type, standardized by an individual's mean reaction time. Neurophysiological indices were calculated using EEG ERP recordings for correct responses to a trial type, standardized by the individuals mean voltage across all trials. ERP waveforms components extracted from the ANT's conflict monitoring subsystem include the N2 and the P3 components, both of which have been measured in children using the ANT (Rueda et al., 2004). The N2 component is generally related to the inhibition of a prepotent response (Luck, 2005), a dimension of attention regulation. The P3 component is broadly related to the engagement of attention through the detection of novel stimuli in the environment (Luck, 2005). The P1 ERP waveform, an early component related to visuospatial attention (Hillyard & Anllo-Vento, 1998), was also extracted for analysis from all three ANT subsystems to index an added dimension of attention regulation, as has been done in other studies (Racer et al., 2010).

Stroop color-naming task (Stroop, 1935). In a slightly modified version of the original task (Larson et al., 2010), participants were presented with one of three color-words (red, green, or blue) printed in one of three font colors (red, green, or blue). In congruent trials, the color-words matched the font color (e.g., the word "blue" presented in blue-colored font). In incongruent trials, the color-words and font colors are different (e.g., the word "green" presented in red-colored font). Participants responded with a button press to one of three color-coded response keys to signal the font color the word is presented in (not the word itself). The color-words were presented on the computer screen for up to 5000 ms. There was an inter-trial interval of 1000 to 2000 ms between trials. Following a short practice session with performance feedback, three blocks of 57 trials were (31% incongruent) were presented; the total time to complete the Stroop task was approximately 10 minutes including breaks and practice.

To calculate this measure of attention regulation, congruent trial data (i.e., behavioral and neurophysiological) were subtracted from incongruent trial data. Behavioral indices on the Stroop task were calculated using the reaction time to correct responses in each trial type, standardized by mean individual overall reaction time. Neurophysiological indices were calculated using EEG ERP recordings for correct responses to a trial type, standardized by the individual's mean voltage across all trials. The ERP waveform component extracted from the Stroop task was the N450, a large component which gives a general index of attention regulation in conflict tasks (Jongen & Jonkman, 2008).

Go/No-Go task. This classic inhibitory control task was used to assess for attention regulation. The Go/No-Go paradigm is largely thought to capture the response inhibition system of the brain, a dimension of attention regulation in specific, and the self-regulation of behavior in general (Wiersema & Roeyers, 2009). The Go/No-Go task has been used in several studies with children to measure self-regulatory processing (Vaurio et al., 2009; Wiersema & Roeyers, 2009). In the Go/No-Go task, participants pressed a button (GO) when presented with an "X" on the computer monitor, or withheld a button push (NO-GO) when presented with an "O." GO trials occurred at a rate of 80%, which created a preponderant behavioral response toward the stimulus class, and made it difficult to inhibit responding on the NO-GO trials. Each stimulus (i.e., "X" or "O") was presented for 200 ms; subjects had up to 500 ms to respond. The inter-trial interval was between 700 and 1300 ms. Following a short practice session with performance feedback, three blocks of 100 trials were presented; the total time to complete the Go/No-Go task was approximately 10 minutes including breaks and practice.

Behavioral data collected from the Go/No-Go task included GO and NO-GO trial accuracy. To calculate the inhibitory system (a dimension of attention regulation), EEG waveforms from correct GO trials (i.e., button press within time limit) were subtracted from correct NO-GO trials (i.e., withholding button press) to yield the N2 waveform (Jodo & Kayama, 1992; Jonkman et al., 2003). To calculate the error-related negativity ERP waveform (ERN; Falkenstein, Hoormann, Christ, & Hohnsbein 2000), a robust measure related to the commission of errors, EEG waveforms from correct GO trials (i.e., button press within time limit) were subtracted from incorrect NO-GO trials (i.e., button press within time limit). The ERN is theoretically linked to attention regulation as the awareness of an error necessitates attention to one's behavioral performance.

ERP Waveform Component Data Acquisition

Scalp electroencephalographic (EEG) data were acquired using a 256-channel HydroCel Geodesic Sensor Net (Electrical Geodesics, Inc., Eugene, OR). Artifact rejection, averaging, filtering, and other analyses were accomplished offline using Net Station (Electrical Geodesics, Inc., Eugene, OR) software. EEG segments were created for each experimental trial.

Trials were scanned across all channels using two algorithms, the first checked for large voltage transients across very few samples or for otherwise unstable recordings as manifested in abnormally high voltage values, the second checked for the presence of eye movements or eye blinks. Trials containing such abnormalities were replaced using another algorithm which calculated a voltage estimate using signals from surrounding electrodes (i.e., mathematical imputation). Trials were then scanned for abnormal voltages a second time; the percentage of remaining trials with abnormal voltages was recorded for each participant in each experimental task.

Average waveforms were computed for each condition of interest in a time window between 200 ms pre- and 1000 ms poststimulus or postresponse. The mean amplitude of the N2, P3, P1, ERN, and N450 components were measured in the unfiltered averages as the mean voltage between approximately 150 and 250 postresponse for the N2, approximately 300-380 poststimulus for the P3, approximately 100-180 poststimulus for the P1, approximately 50 and 120 ms postresponse for the ERN, and approximately 350 to 500 ms poststimulus for the N450. Mean amplitudes were calculated relative to the 200 ms prestimulus or preresponse baseline interval.

Time windows and locations were adjusted as necessary on the basis of visual inspection of the waveforms. Electrode sites are reported according to international 10-20 positions. The N2 component was extracted using the mean amplitude within a 40 ms window centered around the most negative voltage between 180 and 260 ms post-stimulus at channel Fcz in the ANT, and within a 50 ms window centered around the most negative voltage between 200 and 400 ms at channel Fz in the Go/No-Go task. The P3 component was extracted using the mean amplitude within a 40 ms window centered around the most positive voltage between 300 and 380 ms post-stimulus at channel Pz in the ANT. The P1 component was extracted using the mean amplitude within a 40 ms window centered around the most positive voltage between 100 and 200 ms poststimulus at 7-electrode hemispheric occipital-parietal clusters that included O1 and O2 in the ANT. The ERN component was extracted using the mean amplitude within a 50 ms window centered around the most negative voltage between 50 and 200 ms post-stimulus at channel Fcz in the Go/No-Go task. The N450 component was extracted using the mean amplitude within a 50 ms window centered around the most negative voltage between 430 and 600 ms post-stimulus at channel Cz in the Stroop task.

Data Analysis

Research Aim #1: Testing and clarifying the measurement model for attention regulation. To explore the underlying dimensions of attention regulation, all of the measurements (i.e., questionnaire, behavioral, and neurophysiological) from participants at the pre-intervention time point (Time 1) were subjected to factor analytic procedures. Factor analyses removed items not statistically related to the construct of attention regulation as measured in this data set, and created new measurement variables.

To conduct factor analyses, it is important that the correlation coefficients between variables be stable. Comrey and Lee (1992) suggest that a sample size of 50 is considered “very poor” for estimating this stability. As this study has a sample of 47, it is likely that the variable correlations are not reliable or stable. In light of this fact, the decision was made to use principal component analysis (PCA), rather than exploratory factor analysis (EFA). EFA relies on the computed positive diagonal of the correlation matrix to derive its solution (Stevens, 2002; Tabachnick & Fidell, 2007), which was likely to be unreliable given the sample size. PCA uses the value of one in its positive diagonal (Stevens, 2002; Tabachnick & Fidell, 2007), thus distributing all variance into extracted components, and allowing for a more stable computation of derived component solutions.

Iterative PCA procedures evaluated the quality of items by their communality values (a measure of how well extracted components represented individual item variance) and component loading values. Items were removed from analysis if they fell below an accepted the low communality value of .40 (Stevens, 2002). Items were also removed if they loaded onto multiple components, as this did not allow for a clear component interpretation. The number of components extracted was determined at each iteration by interpreting whether the item content within a given factor was theoretically rational, and by examining the scree plot of extracted factors. The final PCA model results were then used to compute variable/s for derived component/s at Time 1 and Time 2.

Research Aim #2: Evaluating the relation between mindfulness intervention and attention regulation. To explore whether mindfulness-based interventions affect attention regulation, an analysis of intervention effects on multiple indices of attention regulation was conducted, including all individual rating scale questionnaires, behavioral, and neurophysiological measures, and the derived components from Research Aim #1. It was hypothesized that of these indices of attention regulation, the behavioral measurement of the ANT conflict monitoring subsystem would evidence a change following mindfulness intervention, as has been reported in previous studies (Saltzman & Goldin, 2008).

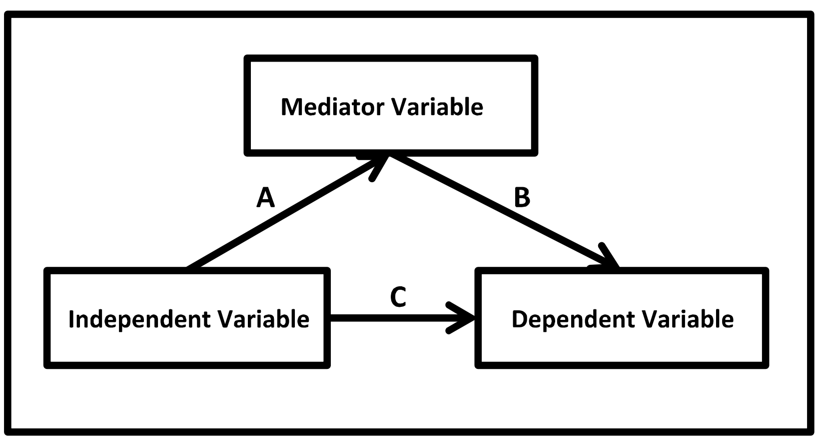
It was also hypothesized that the derived components from Research Aim #1 would evidence treatment effects, as they were theorized to improve the measurement of attention regulation.

To test for treatment effects of mindfulness-based intervention on the aforementioned indices of attention regulation, a series of hierarchical multiple regression analysis procedures were used. The first block of the multiple regression included participants' pre-intervention scores to control for attention regulation prior to intervention and to assess for change following intervention, as well as the covariates of age or gender. In the second block, intervention condition was entered as a predictor to test for intervention effects. In the third block, the interaction term between the covariate of age or gender was entered. Were covariate main effects and/or interaction terms found to be non-significant, the covariate was then dropped from the analysis. The dependent variable was the post-intervention (Time 2) measurement of attention regulation. Beta weights, full model significance, and individual variable contribution to the dependent variable were interpreted.

Research Aim #3: Understanding the mechanisms of mindfulness. To explore mechanistic underpinnings of mindfulness-based intervention, mediation analyses were conducted. It is necessary that only mediators that were significantly affected by the independent variable be included for analysis (Baron & Kenny, 1986). Subsequently, these mediational models only included indices of attention regulation which evidenced significant direct treatment effects, as measured by Research Aim #2. The dependent variables in these analyses consisted of the variables for psychopathology and psychosocial functioning at post-intervention and follow-up (Time 2 and 3), as detailed in Table 2.

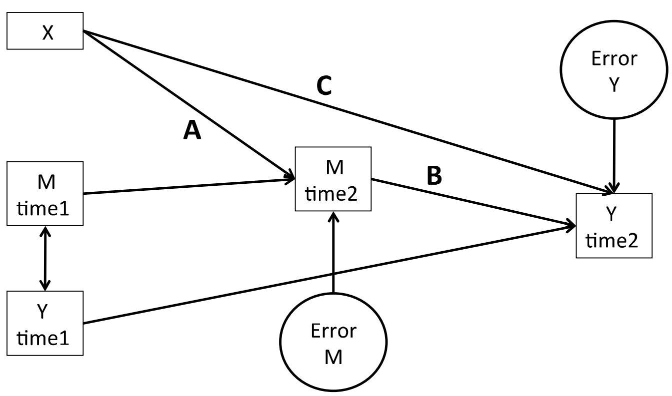
To test for mediation, a longitudinal adaptation of the classic model proposed by Baron and Kenny (1986), depicted in Figure 1, was employed. In this classic model, the total effects of the independent variable on the dependent variable are composed of the direct effect (path "C") and the indirect effect (path "A" multiplied by path "B"). To test for mediation, first a relation between the independent and dependent variables is established (path "C"), then a relation between the independent and mediating variables is established (path "A"), and finally the relation between the independent and dependent variable is again assessed for (path "C") while controlling for the effect of the mediating variable (paths "A" and "B").

Figure 1. Baron and Kenny 1986 model for mediation



A longitudinal adaptation of the Baron and Kenny (1986) mediation model is depicted in Figure 2. In this model, the total effects of the independent variable (i.e., group assignment) on the dependent variable are composed of the direct effect (path “C”) and the indirect effect (path “A” multiplied by path “B”). The indirect, or mediated, effect then is the proportion of the total effect of assignment to the mindfulness intervention condition on psychopathology/psychosocial functioning that can be attributed through attention regulation. Scores on the mediator and dependent variable at pre-intervention (Time 1) were controlled for to account for changes occurring to the individual over time not directly related to group assignment to intervention.

Figure 2. Mediational model controlling for pre-intervention scores



M = Mediator (effortful control of attention variable)

X = group assignment to mindfulness-intervention or wait-list control

Y = dependent variable (psychopathology or psychosocial functioning)

Because this longitudinal analysis was lacking in statistical power, bootstrapping techniques were used, as per suggestions for small sample data sets (Shrout & Bolger, 2002). To determine if attention regulation significantly mediated the effects of mindfulness intervention on dependent measures, the indirect path beta weights were interpreted in the bootstrapped model output.

Power considerations. Effect sizes for ERP studies are not often reported in the literature, thus making power analysis difficult to compute. However, because the frontal midline components of interest in the current study produce relatively large ERP deflections, and the researchers responsible for the original data collection followed guidelines and procedures (Luck, 2005) designed to maximize the likelihood of detecting effects in their sample, it was anticipated that the current study would have adequate statistical power. To address the limited statistical power of the sample size needed to compute mediational analysis, bootstrapping procedures were used to test for effects. Mediational analysis has been conducted in studies of mindfulness intervention with comparable sample size (Semple, Lee, Rosa, & Miller, 2010).

CHAPTER IV

RESULTS

Data were coded and analyzed using Predictive Analytic SoftWare statistics package (PASW) 16.0 for Mac. Mediation analyses were conducted using Mplus version 6.11 software (Muthén & Muthén, 2011).

Multi-method Analysis of Attention Regulation

To develop an empirical multi-method construct for the self-regulation of attention, Principal Component Analytic (PCA) procedures were employed. Twenty variables measured before the intervention group began the MFSR course (i.e., after group assignment but before any intervention took place, Time 1) all of which ostensibly measure attention regulation were included in the analyses (see Table 2). These items included: 6 questionnaire measures (i.e., parent and child report from the EATQ-R effortful control subsystem components), 6 behavioral measures from the laboratory tasks, and 8 neurophysiological measures from the laboratory tasks (i.e., ERP's).

Iterative Principal Component Analyses. Initial analysis extracted components only if they had an eigenvalue greater than 1 (Kaiser's Rule; Kaiser, 1960). This resulted in 8 components being extracted accounting for 79% of the variance in the items. Examination of the items within each component was not conceptually interpretable (i.e., items within component were clustered in an uninterpretable fashion not in line with any conceptual or theoretical rational). Following visual interpretation of the component scree plot, the decision was made to re-analyze the same 20 variables forcing a 3-component solution. The subsequent 3-factor solution accounted for 45% of the variance in the 20 items. The item content within these three components was more conceptually interpretable, as some items appeared to be clustered by methodology (e.g., questionnaire items all falling within one component).

To improve the component structure, items were removed based on their communality and component loadings values. Items with low communality values were removed as the variance in these items was not being adequately captured by the extracted components, and thus not useful in this process of developing a universal underlying construct for attention regulation. Items loading highly on two or more components were removed as these items were not differentiating between extracted components, and thus conflating the specificity of underlying latent constructs. Decision rules were based on standards used in other studies where item reduction procedures occurred in the context of factor analytic procedures (Merrell, Felver-Gant, & Tom, 2011).

Results from this first round of item reduction can be seen in Table 3. Nine items were identified to be removed from the pool of items: 8 items had communality values less then .40 and 2 items had multiple component loadings greater than .35 (one item had a marginal item communality of .37 and was kept in for further analysis, where it was subsequently removed in the second step of item reduction). A PCA was then run on the remaining 11 items again using Kaiser's Rule to extract components. This resulted in a four component solution accounting for 75% of the variance in the items. Examination of the item content within the four components was again theoretically uninterpretable. Visual inspection of the component scree plot suggested a two-component solution. The 11 items were re-analyzed forcing a two-component solution which accounted for 56% of the variance within the items. Item content within the components was theoretically interpretable. Examination of the item communality values led to the decision to remove 3 items due to low communality values below .40 (see Table 3). The remaining 8 items were re-analyzed using the previously determined two-component solution. The resulting model accounted for 70% of the variance in the items, an increase of 15% in variance accounted for over the previous model, suggesting that the removal of the three aforementioned items was appropriate. The items comprising the final two components and their loadings can be seen in Table 4.

Using PCA results to construct multi-method variables for attentional self-regulation. Component scores were created for the components derived from the PCA procedures (henceforth referred to as Component One and Component Two). Component scores were calculated by multiplying the individual item value within a component with its corresponding component loading value, and then summing these multiplication products. Component scores were calculated at two time points (pre- and post-MFSR intervention) using the component loadings derived from the PCA analysis of data at the pre-intervention time point (Time 1).

Treatment Effects of Mindfulness-Based Intervention

To test for treatment effects of mindfulness-based intervention (i.e., MFSR), linear regression analyses were used. These analyses controlled for

Table 3

Items Included in the Principal Component Analyses and Details of Item Properties Resulting in Item Reduction

Item	1st round of item reduction: Communality less than .40	1st round of item reduction: Loads more than .35 on two components	1st round of item reduction: Item Removed	2nd round of item reduction: Communality less than .40 and item removed
Questionnaire – EATQ-R				
Attention control (child)	X		X	
**Activation control (child)*				
Inhibitory control (child)		X	X	
**Attention control (parent)*				
**Activation control (parent)*				
**Inhibitory control (parent)*				
Behavioral – Lab tasks				
ANT conflict monitoring	X		X	
ANT orienting				X
ANT alerting	X		X	
**Go/no-go – go trial acc*				
Go/no-go – no-go trial acc	X			X
Stroop task		X	X	
Neurophysiological ERP's				
**ANT conflict monitor P3*				
ANT conflict monitor N2	X		X	
**ANT conflict monitor P1*				
ANT orienting P1	X		X	
ANT alerting P1				X
Go/no-go ERN	X		X	
**Go/no-go N2*				
Go/no-go N450	X		X	

*Note: Items in with an * and written in italics retained in final PCA analyses and resulting components. All behavioral item values are measured originally in reaction time (milliseconds) except for the Go/No-Go task which is measured as a percentage of accurate responses in the trial condition and is denoted with "acc".*

Table 4

Final Principal Component Matrix Structure with Component Loadings

	Component Loading	
Item (method)	Component One	Component Two
Go/no-go N2 (neurophysiological)	.93	-.04
Go/no-go – go trial accuracy (behavioral)	.88	.14
ANT conflict monitor P3 (neurophysiological)	.82	-.05
ANT conflict monitor P1 (neurophysiological)	.79	-.13
EATQ-R Attention control (parent report on child)	-.01	.92
EATQ-R Activation control (parent report on child)	.08	.86
EATQ-R Inhibitory control (parent report on child)	-.06	.71
EATQ-R Activation control (child self-report)	.07	.67

baseline (i.e., pre-MFSR intervention, Time 1) scores on the variable being tested and the covariates of age and gender, and tested for treatment effects of group assignment (i.e., intent to treat) on the same dependent test variable at a later point in time (i.e., post-MFSR Time 2, or at follow-up Time 3). Interaction terms of age and gender with group assignment were also tested.

In all of the following analyses, a series of models was tested. The first regression model included the pre-MFSR intervention score (i.e., Time 1) of the variable being tested and the two covariates of age (in months) and gender (dummy coded) in the first block, and group assignment (dummy coded as treatment being a value of 1 and wait-list control a value of 0) in the second block, and the interaction between age and intervention, and gender and intervention, in the third block. The dependent variable in all regressions was matched to the variable being tested at either post-MFSR intervention (Time 2) or at the follow-up after MFSR intervention (Time 3). Unless otherwise noted (see Tables 7, 8 and 11 in Appendix), there were no main effects for age, gender, or their corresponding interaction terms, each of which was tested for independently.

The second regression model included the pre-MFSR intervention score of the variable being tested in the first block, and group assignment in the second block. Details on all analyses including intervention effects and overall model statistics can be found in Tables 7, 8, and 11 in the Appendix.

Effects on components derived from PCA. Components derived from the PCA analysis were analyzed to test for treatment effects using the aforementioned linear regression analysis procedures. There was no main effect for age or gender in the first block ($p > .05$) in analysis of either component, these variables were subsequently removed from further analysis. The second series of linear regressions included pre-MFSR intervention scores on the two derived components in the first block, and group assignment in the second block.

There were no statistically significant treatment effects on either Component One or Two in these final models ($p > .10$, see Table 7 in Appendix). The mindfulness-based intervention reduced the intervention group's scores on Component One relative to the control group ($\beta = -.19$, $t = -1.28$, $p = .20$) and had little effect on Component Two relative to the control group ($\beta = .01$, $t = .20$, $p = .83$).

Effects on questionnaire, behavioral, and neurophysiological indices of attentional self-regulation. The same series of linear regression analyses were applied to different methodological measurements of attention regulation in children.

Questionnaire indices of attention regulation. Parent report (of child) and child self-report of effortful control, inhibitory control, activation control, and attention control subscales on the Early Adolescent Temperament Questionnaire-Revised (EATQ-R) were analyzed to test for treatment effects using the aforementioned linear regression analysis procedures (see Table 8 in Appendix). There were no treatment effects on any of the child self-report measures for either Time 2 or Time 3 ($p > .10$). There were no treatment effects on any of the parent reports for Time 2 ($p > .10$). There were statistically marginal (i.e., $p < .10$) and significant treatment effects of MFSR intervention on Time 3 (follow-up) parent report of child effortful control ($\beta = -.20$, $t = -2.40$, $p = .02$), inhibitory control ($\beta = -.21$, $t = -2.21$, $p = .03$), and attentional control ($\beta = -.17$, $t = -1.84$, $p = .07$), although all of these effects were opposite to the hypothesized direction, meaning that parents reported less attention regulatory behaviors in their child as a result of mindfulness-based intervention.

Behavioral indices of attention regulation. Child behavioral performance (i.e., measurement of reaction time or accuracy to trial conditions) on laboratory tasks of attention regulation were analyzed to test for treatment effects using the aforementioned linear regression analytic procedures (see Table 8 in Appendix). There were no significant treatment effects on behavioral performance for the Stroop Color-Naming Task or the Go/No-Go Task ($p > .10$).

There were significant treatment effects on behavioral performance on the Attention Network Task. Children in the mindfulness-based intervention group had statistically significant reductions in their conflict monitoring scores ($\beta = -.27$, *t* = -2.45, *p* = .01) and marginally significant reductions in their orienting scores (*β* = -.26, *t* = -1.81, *p* = .07). Children had marginally significant increases in their alerting scores as a result of assignment to the mindfulness intervention condition (*β* = .29, *t* = -1.89, *p* = .06).

Neurophysiological indices of attention regulation. Child neurophysiological performance on the ANT, Stroop, and Go/No-Go tasks were analyzed to test for treatment effects using the aforementioned linear regression analysis procedures (see Table 8 in Appendix). There were no significant treatment effects to neurophysiological performance on the Attention Network Task, Stroop Color-Naming Task, or the Go/No-Go Task for any measured ERP difference waveform (*p* > .10).

Correlations Between Measures of Attention Regulation

To further explore the construct of attention regulation, correlations were calculated between select variables at Time 1. Of primary interest was the only individual measure of attention regulation to evidence a treatment effect following the MFSR intervention (the behavioral measurement of the ANT's conflict monitoring score), and the two components derived from the aforementioned PCA analyses. These three variables were correlated with all individual questionnaire, behavioral, and neurophysiological measures of attention regulation. Also included in this correlational analysis were two additional questionnaire variables: parent report on the Social Emotional Assets and Resilience Scale (SEARS) – Short Form was included because this scale largely measures self-regulation in general (Merrell, Felver-Gant, & Tom, 2011) and the

Child and Adolescent Mindfulness Measure (CAMM) was included because this research is interested in the relation between attention regulation and mindfulness.

Results of this correlational analysis can be seen in Table 5. The ANT conflict monitoring subsystem was marginally significantly correlated with parent report on the EATQ-R inhibitory control subscale ($r(46) = .272$, $p < .10$) and the SEARS ($r(46) = .278$, $p < .10$), as well as child self-report on the CAMM ($r(46) = -.276$, $p < .10$). Of note, these correlations suggest that parent reported increase in self-regulatory abilities is associated with decreased attention regulation on the ANT, whereas child self-reported mindfulness is associated with better ANT performance. Component One was statistically significantly correlated with the ANT orienting subsystem's P1 ERP waveform ($r(38) = -.370$, $p < .05$). Component Two was statistically significantly correlated ($p < .05$) with EATQ-R scores that were not already included in this component (i.e., child self-report) and with the SEARS ($r(46) = .365$, $p <.05$).

Mediation Analysis of Attention Network Task Conflict Monitoring

To further explore the relation between attention regulation and treatment effects following mindfulness-based intervention, mediational analyses were conducted (see Table 9 in Appendix). Following recommendations by Baron and Kenny (1986), tests for mediation can only be conducted in circumstances where the independent variable has a significant effect on the mediator. In the current work, all mediation analyses were therefore conducted using the behavioral score on the ANT conflict monitoring subscale as the mediator. All of the

Table 5

Bivariate Correlations of the ANT Conflict Monitoring ,Principle Components One and Two, and Other Indices of Attentional Self-Regulation (N = 46 for self-report and behavioral variables; N = 38 for variables containing ERPs)

Variables	ANT Conflict Monitoring	Component One	Component Two
ANT Conflict Monitoring	-	-	-
Component One	.163	-	-
Component Two	.089	.003	-
EATQ – parent activation control	.014	.026	.876†
EATQ – parent attention	.191	-.017	.907†
EATQ – parent inhibitory control	.272*	.090	.725†
EATQ – parent effortful control	.174	.039	.969†
SEARS	.278*	-.230	.365**
EATQ – child activation control	-.197	-.089	.646†
EATQ – child attention	.165	-.069	.378**
EATQ – child inhibitory control	-.025	.100	.424**
EATQ – child effortful control	-.031	-.034	.605**
CAMM	-.276*	-.199	.227
ANT orienting	.018	.238	.019
ANT alerting	.145	.101	.077
GNG no-go accuracy	.124	-.115	-.034
GNG go accuracy	-.058	.254†	.239
Stroop interference effect	-.031	.275	.129
ANT conflict monitoring P3	.207	.119†	.006
ANT conflict monitoring N2	-.072	-.092	-.003
ANT conflict monitoring P1	.061	.194†	-.097
ANT alerting P1	-.107	.197	-.048
ANT orienting P1	-.036	-.370**	.029
Stroop N450	.211	.187	.286*
GNG ERN	-.020	-.220	-.178
GNG N2	.129	.986†	-.004

Note: *$p < .1$, two-tailed. **$p < .05$, two-tailed. † variable comprises Component One or Two.

measured variables for psychopathology and psychosocial functioning at post-intervention and follow-up (i.e., Time 2 and Time 3) were tested as dependent variables.

In these mediation models, assignment to MFSR intervention condition was used as the independent variable, the ANT conflict monitoring score was used as the mediator, and measures of psychopathology or psychosocial functioning at Time 2 (post-MFSR) and Time 3 (follow-up) were used as the dependent variable. Time 1 (pre-MFSR) scores for the mediator and dependent variables were included to control for change over time; Time 1 scores on the mediator and dependent variable were allowed to covary. Bootstrapping procedures were used (set at 3000 iterations) as is recommended practice when analyzing data with small sample sizes (Shrout & Bolger, 2002). The indirect path of assignment to MFSR condition, through the mediator of ANT conflict monitoring, to the dependent variable was assessed for statistical significance to test for mediation. The model using the dependent variable of CBCL total problem at Time 3 would not converge. The remaining models converged and the aforementioned indirect mediation path was evaluated for statistical significance. No model had a statistically significant or marginally significant indirect mediational treatment effect ($p > .10$).

CHAPTER V

DISCUSSION

The Measurement of Attention Regulation

The self-regulation of attention is an important construct with strong implications in human development. Because of its importance, many researchers commonly include measurements of attention regulation in their studies using multiple methodologies, such as questionnaires, behavioral responses to laboratory administered tasks, and neurophysiological recordings. These differing measures are frequently equated with one another. For example, a researcher wishing to explore a treatment effect upon attention regulation may choose between any of the aforementioned methods and claim to have adequately measured the construct, however previous research provides only limited evidence of convergent validity in a diverse set of studies using unique tasks and measurements. For example, researchers have found correlational evidence in support of parent-reported effortful control of attention being related to youth behavioral performance on attention regulation tasks in early childhood (Chang & Burns, 2005), middle childhood (Simonds, Kieras, Rueda, & Rothbart, 2007) and adolescence (Ellis, 2002). However, although each of the preceding researchers similarly claimed to find a relation between parent-report and behavioral performance of attention regulation, different measures and methods were employed to measure these same constructs. A goal of the current research was to explore this limitation by empirically exploring and developing a construct of attention regulation that incorporates multiple methodologies.

PCA of multiple indices of attention regulation. To address Research Aim #1, principal component analyses were used on a variety of variables that have been empirically demonstrated to be related to attention regulation. The results of the PCA suggest that many of the variables did not load on a unified underlying dimension of attention regulation. In the first round of PCA, all 20 variables (i.e., 6 questionnaire, 6 behavioral, and 8 neurophysiological) were included and liberal component retention criteria (i.e., Kaiser's Rule) were applied. Communality values and multiple loadings were interpreted to aid in item reduction and component development. Communality measures the percentage of variance in an individual variable that is explained by all of the extracted components. Following this first round of PCA, 8 items were identified as having communality values below .40. Even with liberal component retention criteria, the extracted components could only account for less than 40% of the available variance in these 8 items. This is a surprisingly high number of components failing to meet item retention criteria, especially given the fact that these items were expected to be related to one another. These items have been assumed by the research community to be theoretically related and have been used as such. Further iterative PCA procedures reduced the original 20 included items to 8 items that met adequate psychometric standards (i.e., high communality values and definitively loading on to a single component). These eight items comprised two components which were theoretically interpretable. Over half of the original 20 items failed to meet criteria for inclusion in the final PCA analyses, suggesting that these items may not be empirically measuring the same construct of attention regulation.

Content of components derived from PCA analyses. Speculations were made at the outset of this research regarding what the potential item content of the components derived from the PCA would be. One speculation was that item content would fall along methodological lines, that is, there would be components for questionnaires, behavioral measures, and neurophysiological indices. This was partially confirmed. Component Two (see Table 4) included the three measures from the parent-report of effortful attention control and the child self-report of activation control. In the final PCA and in the iterative PCA's conducted prior, questionnaire items were repeatedly grouped together within a component, suggesting that the methodology of using questionnaires is internally valid. Said differently, when using different measurement modalities, questionnaires tended to capture a similar construct separate from either behavioral or neurophysiological indices. This tendency for like methods correlated more highly than those from different measurement methods has been referred to by Cook and Campbell as monomethod bias (Cook & Campbell, 1979). However, no other component was comprised of singularly behavioral or neurophysiological methods either in the final PCA or in any of the iterative preceding analyses.

The second speculation was that component item content would fall into conceptual categories. This speculation stated that final components may be comprised of items related to distinct subordinate attention regulation processes, such as inhibitory control (e.g., inhibitory control questionnaire, Go/No-Go Task no-go trial accuracy, or the N2 ERP waveform) or measures which tapped more in to the construct of conflict monitoring (e.g., ANT conflict monitoring and Stroop Task behavioral or ERP indices). Results from these analyses do not confirm this idea since neither of the final components included items that were all categorically related to each other. Similarly, it could be speculated that similar conceptual ERP waveforms items (e.g., just the P1 waveforms from the three ANT subsystems) would group together within a final component. This was also not supported from the final component item content, suggesting that although these waveforms have similar topographic features for which they share their namesake, they do not in fact relate empirically using these analytic methods. The third speculation was that item content would group along the laboratory tasks from which they were derived (e.g., all of the Stroop Task measurements); however, this was not supported from PCA results.

The fourth speculation was that item content of a given scale may be seemingly unrelated, but that items within the final component could lead to conclusions about the construct of attention regulation. This idea was partially confirmed by the PCA results. Component One from the final PCA analysis included two items taken from the Go/No-Go task, the N2 waveform (which purportedly captures neurophysiological inhibitory control response) and the Go trial accuracy (a measure of behavioral activation control), and two items from the ANT conflict monitoring subsystem, the P3 waveform (a neurophysiological index of novel stimulus recognition) and the P1 waveform (a more general neurophysiological index of early attention). These results suggest that perhaps ERP indices from tasks that generally measure attention regulation may jointly tap into an underlying dimension of the construct (although this conclusion is tentative at best, given that a behavioral variable was also included in the component). Future research should continue to explore the relation between these two tasks, particularly with regards to neurophysiological and behavioral measurement.

Reconceptualizing attention regulation. Taken as a whole, results from the PCA suggest that researchers interested in attention regulation reconsider the measurement of the construct. The analytic steps taken in this research used the PCA technique to explore items, all of which purportedly capture attention regulation. This empirical approach toward model development may have been hindered by the small sample size (*N* = 38), limiting the power needed to more precisely and definitively address the research aim. With this limitation in mind, it is interesting to consider the results of the PCA analysis as a whole. Component 1 contained items that are loosely conceptually related, indeed the individual items do not correlate with each other (see Table 6). This seems to suggest that either the PCA analysis is capturing an element of error and formed a component which is not related conceptually meaningful, or that there is an unknown underlying dimension connecting these items which is not readily measurable or interpretable. Reanalysis with a larger data set may shed some insight into these findings, and could lead to new discoveries concerning the measurement of attention regulation.

Table 6

Bivariate Correlations between Items Comprising PCA Derived Component One (N = 38)

Item	Go/No-Go N2	Go/No-Go go trial accuracy	ANT conflict monitoring P3	ANT conflict monitoring P1
Go/No-Go N2	-	-	-	-
Go/No-Go go trial accuracy	.23	-	-	-
ANT conflict monitoring P3	-.01	-.09	-	-
ANT conflict monitoring P1	.13	-.05	-.17	-

Note: **p* < .1 , two-tailed. ***p* < .05 , two-tailed.

PCA derived Component 2 lends some insight into the measurement of attention regulation. One conclusion which can be drawn is that parents are better reporters of child characteristics than children are of themselves. This is not a surprising finding given that children often lack the metacognitive awareness necessary to be accurate reporters of their own behavior. Perhaps a more important conclusion from these results is that questionnaire reporting on attention regulation is not related to behavioral or neurophysiological responding in this dataset. This finding is inconsistent with previously studies comparing questionnaire to other methodological indices of attention.

Two final conclusions can be drawn from the results of this PCA analysis. One is that the research community at large needs to be very careful in equating measurement of attention regulation. These results suggest that methods of measurement (aside from purely questionnaire methodology) are not related empirically. The question of how to accurately measure a given construct needs to be made based on not purely theoretical rational, but also empirical evidence, as these results do not support a straight-forward relation between different measurements of the same construct. The second major conclusion is that the scientific community should be more conservative in how it describes the construct of attention regulation, lest erroneous conclusions be drawn. As science is truly an iterative process, whereby theories are tentatively assumed, challenged, and built upon, the scientific community needs to be very clear when conclusions are drawn using different measurements of attention regulation which are assumed to be the same, but in fact may not be so. These results suggest that different measurement methods and tasks of attention regulation are not related. One should exercise caution when both selecting measurements of attention regulation and drawing meaningful conclusions.

Effects of Mindfulness-Based Intervention

Previous research exploring the relation between mindfulness-based interventions and attention has yielded mixed results. Participation in mindfulness-based interventions (e.g., MBSR) has been shown to improve attention regulation on tasks of orienting attention (Jha et al., 2007), conflict monitoring (Wenk-Sormaz, 2005) and inhibitory control of attention (Semple, 2010). Other researchers have found that participation in a mindfulness intervention did not affect elements of attention regulation, such as attentional control (Anderson et al., 2007) and conflict monitoring (Semple, 2010).

Treatment effects on ANT conflict monitoring. Results from the current research confirmed the hypothesis that participation in a mindfulness-based intervention would improve children's attention regulation as measured behaviorally with the ANT conflict monitoring subsystem. The ANT conflict monitoring condition measures an individual's ability to self-regulate their attention to a targeted object in the presence of visual distraction. Much of the mindfulness-training curriculum is focused on self-regulating the focus of attention on a selected somatic experience (e.g., the physical sensation of breathing) while at the same time not being distracted by other internal (e.g., thoughts) or external (e.g., sounds) stimuli in the environment. It could be speculated that the practice of ignoring distracting stimuli in the environment strengthened this attentional subsystem in youth, which then in turn allowed them to perform better on the ANT conflict monitoring assessment. This finding should be interpreted with caution though, as a theoretically similar measure of conflict monitoring, the Stroop Task, did not have significant treatment effects, and all other measures of attention regulation (including both behavioral and neurophysiological indices) similarly did not evidence expected treatment effects.

ANT conflict monitoring as a mediator of treatment effects. The field of mindfulness-based intervention has hypothesized that the underlying mechanism for beneficial treatment effects may be the self-regulation of attention. To explore this mechanism, this research tested the hypothesis that mediational analyses using the ANT conflict monitoring subsystem as the proposed mediator would yield significant indirect treatment effects. Results of these analyses did not confirm this hypothesis; there were no statistically significant indirect treatment effects to any measured variable of psychopathology or psychosocial functioning. There are three plausible explanations to this non-significant finding. First, because a normative sample was used, there was little psychopathology or problematic psychosocial behaviors reported by parent and child at baseline assessment. With little variance in these variables to begin with, it could be that there was not enough variability in these data to be affected by the mindfulness-based intervention. This would explain why there were non-significant direct treatment effects, and subsequently, why the indirect treatment effects in the mediational model were also non-significant. Second, the limited sample size could have made the detection of indirect treatment effects statistically unlikely (i.e., Type II error). This explanation is also supported by the relatively poor model fit (see Table 9 in Appendix) observed across models. Third, it could be that the MFSR intervention was ineffective as a psychosocial intervention. Indeed, there were observed instances of trends toward iatrogenic treatment effects (see Table 11 in Appendix). Although this would seem unlikely given the evidence based supporting the utility of mindfulness-based interventions, it should still be considered that the MFSR intervention is ineffective or potentially harmful as an intervention. Future research should therefore exercise caution when implementing mindfulness-based interventions with youth.

ANT conflict monitoring related to other indices of attentional self-regulation. In this work, the conflict monitoring subsystem of the ANT demonstrated the only statistically significant treatment effect following mindfulness-based intervention. This result is consistent the theoretical rational that mindfulness training directly operates on volitional or self-regulatory aspects of attention (Shapiro et al., 2006). It is interesting to consider ANT conflict monitoring relative to other indices of attention regulation, particularly in light of the fact that these other indices did not demonstrate significant treatment effects.

In these data, the ANT conflict monitoring subsystem does not appear to be related to other indices of attention regulation. During the PCA procedures, of the 20 measured self-report, behavioral, and neurophysiological indices of attention regulation, the ANT conflict monitoring behavioral variable stood out as having *the lowest* communality value of all variables, being .045 after the initial PCA. Even with liberal component extraction and retention criteria, all of the extracted components only accounted for less then 5% of the variance in ANT conflict monitoring, suggesting that component vectors derived from the set of 20 variables are not tapping into the same construct as measured by ANT conflict monitoring. Results of bivariate correlations between ANT conflict monitoring and the other indices of attention regulation (see Table 5) indicate that ANT conflict monitoring is not significantly correlated with any other variable. This finding is surprising, especially for variables which have historically been related to behavioral conflict monitoring scores, such as parent-report of effortful attention control (Simonds, Kieras, Rueda, & Rothbart, 2007).

One possible reason for this lack of relation between the ANT conflict monitoring variable and other indices of attention regulation is that it is measuring an orthogonal aspect of the construct. Perhaps the dimension of self-regulation captured by behavioral responses to a conflict monitoring task are different from those measured by self-report or other behavioral markers. Similarly, it could also be that behavioral responses to conflict monitoring are not related to neurophysiological indices, going against conclusions and findings reported in research with adults and children (Rueda, Posner, Rothbart, & Davis-Stober, 2004). A possible explanation could be that the behavioral response measured is too temporally distal from the more temporally proximal neurophysiological cognitive processes following visual presentation of stimuli (Racer et al., 2011).

As the ANT conflict monitoring behavioral index of attention regulation was not related to the other measured indices, it can again be concluded that these different measurements which purportedly all tap in to the same construct may in fact not related. This seemingly erroneous assumption of equal measurements could lead to misleading conclusions. For example, the aforementioned studies demonstrating treatment effects to attention following mindfulness-based intervention used different laboratory tasks to measure the same construct, namely the Stroop task and ANT conflict monitoring (Jha et al., 2007, Wenk-Sormaz, 2005). This current research suggests that the conclusions drawn from these works could be misleading, as treatment effects to attention regulation and resulting conclusions could be different depending on the measurement used.

Synthesis and Conclusions

As previously discussed, the only statistically significant treatment effect in the current study was found on a behavioral measure of attention self-regulation, the ANT conflict monitoring subsystem. This finding was expected based on results of previous studies investigating conflict monitoring (Wenk-Sormaz, 2005) and specifically evaluating the ANT with children (Saltzman & Goldin, 2008). Given that this finding suggests that ANT conflict monitoring can capture changes to attentional self-regulation in children following a mindfulness-based intervention, it is interesting to consider how this variable compares to other indices (see Table 5).

Looking at pre-intervention (Time 1) scores to attention regulation, the only variable that the ANT conflict monitoring score is correlated (in the expected direction) at a trend level is with a child self-report of mindfulness ($r(38) = -.276$, $p < .10$). This suggests that indeed this measure of conflict monitoring is related to the construct of mindfulness. However, this conclusion must be tempered with the fact that ANT conflict monitoring did not significantly correlate with any other variables of attention regulation. Further, the CAMM did not evidence any treatment effect following mindfulness intervention, nor did the Stroop task of conflict monitoring. Several conclusions can be drawn from these facts. The measure of conflict monitoring in the ANT is a variable that is most sensitive to change following mindfulness intervention, and that this variable is what can be used to capture change to attention regulation. It could be that questionnaires of either attention regulation or mindfulness may be insensitive to changes which take place following mindfulness interventions. Perhaps as questionnaire methods of measurement are to a degree subjective in nature, and mindfulness based interventions theoretically change one’s relation and understanding of oneself, this method should be abandoned or carefully reconsidered in future mindfulness intervention studies. As this work used a community sample, it could be that this theoretically healthy population was already well self-regulated and mindful, and thus questionnaires could not capture changes following interventions due to a ceiling effect.

There were not significant treatment effects to the two derived components from the PCA analysis, a finding that contradicts the hypothesized results. It could be that this derived components accurately measured attention regulation, but that this measurement was insensitive to treatment effects. It could be that the small sample size and methods employed to create this model could not accurately construct a model of attention regulation which was stable enough to test for treatment effects. Future research testing for treatment effects to multi-method measurements of attention regulation may elucidate this null result.

Future Directions

The work presented herein suggests that researchers interested in the measurement of attention regulation need to be cautious and critical of the measurement methods employed. Results from this study suggest that commonly equated questionnaire, behavioral tasks, and neurophysiological indices are indeed not related. This raises an important problem, being how to adequately measure the construct of attention regulation.

One alternative to measuring attention regulation would be to replicate the methods here with a larger sample and more variables. With an increase in sample size, more accuracy could be attained in conducting factor analysis, including the use of exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). With a large enough sample, a split half procedure could be used where the sample is randomly divided in half, and then an initial factor structure created from one half of the sample is confirmed on the second half. Work such as this could help elucidate an underlying construct which adequately measures attention regulation. Another approach would be to incorporate direct observation of behavior into a measurement model. Research has used delay of gratification tasks to capture self-regulation; it would be interesting in future work to see how such a derived variable then relates to measures of attention regulation, including neurophysiological indices. This in turn could assist in understanding both the overarching construct of self-regulation, and the more focused construct of attention regulation.

In light of the results of this current study, new directions to the measurement of mindfulness can be considered. There were not direct treatment effects to psychosocial variables, including a questionnaire measure of mindfulness, as a result of participation in a mindfulness-based intervention. It could be that this particular scale of mindfulness does not tap into the underlying construct. Considering the individual items from the Child and Adolescent Mindfulness Measure (Greco, Baer, & Smith, 2011), many items appear to be tapping in to a dimension of mindfulness which has arisen out of the Acceptance and Commitment Therapy literature called experiential avoidance. This dimension is more focused on an individual avoiding unpleasant experiences, with item content such as “I push away thoughts that I don’t like” and “I stop myself from having feelings that I don't like." It could be that this dimension does not completely capture the entire construct of mindfulness, and that a revised measurement tool needs to be created, particularly given the fact that this scale demonstrated question internal consistency (Cronbach's alpha of .64). This could easily occur by taking a larger set of items related to the construct, with item content from multiple leaders in the field (from multiple perspectives, traditions, and practices), and then submitting these items to a factor analysis. A similar procedure was conducted with adult mindfulness measures, leading to a final scale containing five related but distinct factors (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006), one of which was related to experiential avoidance. Future studies may also wish to consider using non-questionnaire measure as proxies of mindfulness, such as conflict monitoring tasks, to assess for the construct. As with any new field of scientific inquiry, there are many questions which have yet to be answered, and the measurement of mindfulness in children is certainly one of them.

Results from this study can also inform future intervention studies exploring mindfulness-based interventions for youth. Similar to educational research exploring treatment effects in classrooms, mindfulness interventions delivered in a group format are inherently "nested" within the group. Because of this, future research would greatly benefit from studies using larger samples with multiple groups subjected to analysis, ideally statistically modeling for nesting effects using hierarchical linear modeling procedures. Future studies could also explore treatment effects in a clinical sample to test for mediation. This study may have been limited to test for mediation as problem behavior and psychopathology were measured as dependent variables. In a healthy community sample, it could be that there were simply not high enough rates of these measures to test for effects. Using a clinical sample could result in a reduction in problem psychosocial factors, and therefore result in enough variation in the dependent variable that mediation of attention regulation could be assessed for. In a related vein, future works could employ more detailed strength based assessments if studying a healthy community sample. For example, the full scale of the SEARS, containing several different factors, could help measure treatment effects to positive variables, and further allow for testing of mediation as well.

Limitations

There are several limitations which need to be considered when interpreting the findings presented herein. A non-clinical sample of children and families was recruited from the community and studied in this work. Thus, it could be that many of the clinical pathology-oriented psychosocial questionnaires employed were ineffective in detecting problem behaviors because the sample was healthy. This would explain the lack of treatment effects found on these variables. Future work exploring intervention effects of MFSR or some other type of mindfulness-based intervention for children may which to employ more strength-based measures to capture assets, rather than deficits, in functioning, as this may be more sensitive to change in a healthy community sample.

This sample used in this study included 48 dyads randomly assigned to mindfulness-based intervention or wait-list control conditions. Although this is a large size for a group intervention of this type (typical MBSR courses contain ~20 participants), this sample size may have limited the statistical power necessary to detect treatment effects. In particular, the mediation models employed may have lacked an adequate sample size to estimate the parameters, which can be assumed by the relatively low model fit (most indices indicating less than adequate standards). Future studies should consider including several groups of children randomly assigned at the group level to increase statistical power.

Regarding the PCA analyses, components derived used the full sample of 48 participants at pre-intervention (Time 1). This time point was selected as individuals had not received treatment and should theoretically be similar. The component loading values derived at Time 1 in the full sample were then used on the individuals at Time 2 to create post-intervention scores. A limitation in this logic is that this procedure assumes that the component structure and loading values are the same at Time 2 as they were at Time 1 (i.e., time invariant component loading structure). A better analytic technique would be to run additional iterative PCA’s on both groups separately at Time 2 in order to empirically test this assumption, and to explore whether mindfulness intervention may have affected the overall component structure. The sample size in the current study prohibited such an approach; future factor analyses of attention regulation with a larger sample size should consider this analytic method.

Post-hoc Analyses and Results

Qualitative analysis of treatment group. To further understand the relationship between the Mindful Family Stress Reduction (MFSR) intervention and changes to the measure of attention regulation that evidenced a treatment effect (i.e., ANT conflict monitoring behavioral score), a post hoc analysis was implemented. The 22 children who were assigned to the MFSR treatment condition were sorted based on the changes to their ANT conflict monitoring scores. Data from the five children who had the greatest and least change following intervention were then selected for analysis. To gain a general qualitative picture of these subjects, select variables were chosen, including gender, age, psychopathology (Child Behavior Checklist – total problem behavior), parent child relationship (Adult Child Relationship Scale – total scale), and child self-reported mindfulness. Data from pre-intervention, post-intervention, and follow-up were also selected, as different time points may suggest a pattern to treatment effects that are not apparent in quantitative analysis. These data are presented in Table 10 in Appendix.

Visual analysis of the variables does not lead to any discernible differences between the groups, with the one exception being age. Subjects who had a greater treatment effect to ANT conflict monitoring scores were on average 11.0 years of age, relative to the low treatment responding group, who were on average 10.2 years of age. These data suggest that older children may benefit more from the practices in MFSR than younger. Future studies implementing MFSR may choose to select older slightly older participants in order to obtain maximum treatment effects to self-regulation. Future studies may also consider modifying MFSR to be more developmentally appropriate for younger children.

Effects on psychopathology and psychosocial functioning. Child self-report and parent report of questionnaires measuring psychopathology and psychosocial functioning were analyzed to test for treatment effects using the aforementioned linear regression analysis procedures employed on indices of attention regulation (see Table 11 in Appendix). There were statistically marginal ($p < .10$) treatment effects on child self-report at post-intervention (Time 2) on the Strengths and Difficulties Questionnaire – Internalizing subscale ($\beta = .19$, $t = 1.73$, $p = .09$) and parent report at follow-up (Time 3) on the Adult Child Relationship Scale – Total score ($\beta = .25$, $t = 2.04$, $p = .11$), Positive Relationship score ($\beta = .29$, $t = 1.89$, $p = .06$), and Conflict Relationship scale score ($\beta = .19$, $t = 1.66$, $p = .10$). However, all of these treatment effects were opposite to the hypothesized direction, meaning that children and parents reported marginal iatrogenic effects to psychopathology and psychosocial functioning. There were no other statistically marginal or significant treatment effects to any other measured variable of psychopathology and psychosocial functioning ($p > .10$).

There were few intervention effects in response to MFSR in the current project. One possible explanation for these null results is that a community sample of healthy participants was used, thus limiting the ability to detect for changes to problem behavior. Another explanation could be the lack of statistical power in a sample size of this magnitude. Another plausible explanation that should be considered is that the MFSR intervention does not produce the intended psychosocial treatment effects. Future replications of MFSR, using larger sample sizes and an at-risk or clinical sample, will be useful to fully understand the results presented in this research.

APPENDIX

ADDITIONAL TABLES

Table 7

Results of Stepwise Multiple Regression of MFSR Intervention on Derived Principal Components of Attentional Self-Regulation

	Intervention Effects			Final Model Statistics			
Variable	β	t	p	R^2	df	F	p
PCA derived variables							
Component One	-.19	-1.28	.20	.12	2,37	2.72	.079
Component Two	.01	.20	.83	.75	2,39	61.52	<.001

Note: Unless otherwise noted, all final models reported include Time 1 in first step of model and MFSR intervention in the second step.

Table 8

Results of Stepwise Multiple Regression of MFSR Intervention on Attentional Self-Regulation

	Intervention Effects			Final Model Statistics			
Variable	*β*	*t*	*p*	R^2	*df*	*F*	*p*
Early Adolescent Temperament Questionnaire – Revise (EATQ-R)							
Parent report							
Effortful control – Time 2	.02	.26	.79	.72	2,39	52.08	<.001
Effortful control – Time 3	-.20	-2.40	.02	.77	2,30	51.64	<.001
Inhibitory control – Time 2	.02	.22	.82	.58	2,39	27.00	<.001
Inhibitory control – Time 3 [a]	-.21	-2.21	.03	.75	3,29	29.77	<.001
Attention control – Time 2	.05	.61	.54	.69	2,39	43.42	<.001
Attention control – Time 3	-.17	-1.84	.07	.72	2,30	39.28	<.001
Child self-report							
Effortful control – Time 2	-.03	-.35	.72	.68	2,39	41.81	<.001
Effortful control – Time 3	.009	.08	.93	.67	2,30	30.91	<.001
Inhibitory control – Time 2	.12	-.44	.65	.48	2,39	18.08	<.001
Inhibitory control – Time 3	-.07	-.50	.61	.32	2,30	7.16	<.001
Attention control – Time 2	-.09	-.70	.48	.30	2,39	8.66	.001
Attention control – Time 3	.02	.15	.87	.48	2,30	14.15	<.001
Attention Network Task (ANT)							
Behavioral							
Conflict monitoring (RT)	-.27	-2.45	.01	.56	2,38	24.29	<.001
Orienting (RT)	-.26	-1.81	.07	.21	2,38	5.24	.01
Alerting (RT)	.29	1.89	.06	.13	2,38	2.92	.06
Electrophysiological							
Conflict Monitoring N2 (ERP)	.14	.94	.35	.31	3,32	4.83	.007
Conflict Monitoring P1 (ERP) [b]	-.04	-.26	.79	.14	3,32	1.74	.17
Conflict Monitoring P3 (ERP)	-.09	-.57	.57	.12	2,32	2.34	.11
Orienting P1 (ERP)	-.08	-.50	.62	.00	2,34	.13	.87
Alerting P1 (ERP)	.08	.49	.62	.007	2,34	.12	.88

Notes: Time 1 denotes pre-MFSR intervention; Time 2 denotes post-MFSR intervention; Time 3 denotes follow-up after MFSR intervention. RT denotes reaction time measured originally in milliseconds; ERP denotes event related potential measured originally in microvolts. Unless otherwise noted, all final models reported include Time 1 in first step of model and MFSR intervention in the second step. Statistically significant main effects for either gender or age are denoted by [a] *(age) or* [b] *(gender) in the variable label column.*

Table 8 (continued)

Results of Stepwise Multiple Regression of MFSR Intervention on Attentional Self-Regulation

	Intervention Effects			Final Model Statistics			
Variable	*β*	*t*	*p*	R^2	*df*	*F*	*p*
Stroop Color-Naming Task							
Behavioral							
Conflict resolution (RT)	.05	.31	.75	.007	2,37	.12	.88
Electrophysiological							
Conflict resolution N450 (ERP)	.05	.28	.77	.23	2,27	4.11	.02
Go/No-Go Task							
Behavioral							
Go trial accuracy [a]	-.18	-1.35	.18	.23	3,38	5.13	.004
No-go trial accuracy [b]	-.08	-.80	.42	.53	3,38	16.73	<.001
Electrophysiological							
ERN (ERP)	.14	.83	.41	.14	2,31	2.58	.09
N2 (ERP)	-.02	-.10	.91	.04	2,30	.69	.50

Notes: Time 1 denotes pre-MFSR intervention; Time 2 denotes post-MFSR intervention; Time 3 denotes follow-up after MFSR intervention. RT denotes reaction time measured originally in milliseconds; ERP denotes event related potential measured originally in microvolts. Unless otherwise noted, all final models reported include Time 1 in first step of model and MFSR intervention in the second step. Statistically significant main effects for either gender or age are denoted by [a] *(age) or* [b] *(gender) in the variable label column.*

Table 9

Longitudinal Mediation Model with ANT Conflict Monitoring Behavioral Data as Mediator and Different Psychopathology or Psychosocial Variables as Dependent Variable

	Total Indirect Path		Model Fit Index Value				Specific Path's **β** (*SE*)					
Dependent Variable	**β** (*SE*)	*p*	CFI	TLI	RMSEA	SRMR	X to M time2	M time 2 to Y time 2	X to Y time2	M time1 to M time2	M time1 with Y time1	Y time1 to Y time2
Child Behavior Checklist												
Total problem Post	-.04 (.03)	.14	.966	.941	.130	.087	-.28 (-.01)	.16 (133.46)	.18 (8.46)	.69 (.59)	-.09 (-.06)	.86 (.88)
Total problem F/U	MODEL WOULD NOT CONVERGE											
Internalizing Post	-.01 (.04)	.73	.950	.913	.141	.086	-.27 (-.01)	.05 (11.28)	.16 (2.08)	.69 (.59)	.17 (.03)	.77 (.72)
Internalizing F/U	.04 (.03)	.20	.997	.996	.030	.073	-.27 (-.01)	-.18 (-42.74)	.08 (1.06)	.69 (.59)	.03 (.17)	.78 (.76)
Externalizing Post	-.05 (.03)	.13	.922	.863	.210	.095	-.28 (-.01)	.17 (46.13)	.13 (1.87)	.68 (.58)	-.16 (-.04)	.89 (.88)
Externalizing F/U	-.01 (.05)	.78	.961	.932	.145	.088	-.27 (-.01)	.02 (7.11)	.08 (1.29)	.69 (.59)	-.016 (-.04)	.92 (1.01)

Note: Regarding variable column notation: ***Post*** *denotes post-intervention time point following MFSR intervention group;* ***F/U*** *denotes follow-up time point for the MFSR intervention group. Regarding the rightmost columns (**Specific Path's**, see diagram XXX for path location):* ***X*** *denotes the independent variable (group assignment to MFSR intervention or wait-list control);* ***M time1*** *denotes the mediator (behavioral ANT conflict monitoring score) at the pre-intervention time point;* ***M time2*** *denotes the mediator at the latter time point (either post-intervention or follow-up);* ***Y time1*** *denotes the dependent variable (psychopathology or psychosocial functioning) at the pre-intervention time point;* ***Y time2*** *denotes the dependent variable at the latter time point (either post-intervention or follow-up).*

Table 9 (continued)

Longitudinal Mediation Model with ANT Conflict Monitoring Behavioral Data as Mediator and Different Psychopathology or Psychosocial Variables as Dependent Variable

	Total Indirect Path		Model Fit Index Value				Specific Path's **β** (*SE*)					
Dependent Variable	**β** (*SE*)	*p*	CFI	TLI	RMSEA	SRMR	X to M time2	M time 2 to Y time 2	X to Y time2	M time1 to M time2	M time1 with Y time1	Y time1 to Y time2
Strength & Difficulties Q'aire												
Internalizing (parent) Post	-.01 (.05)	.78	.938	.891	.122	.066	-.27 (-.01)	.05 (.77)	.005 (.004)	.69 (.59)	-.34 (-.007)	.50 (.30)
Internalizing (parent) F/U	.06 (.04)	.16	.970	.947	.099	.062	-.27 (-.01)	-.24 (-6.89)	.03 (.05)	.69 (.59)	-.34 (-.007)	.64 (.77)
Externalizing (parent) Post	-.01 (.03)	.74	.936	.888	.147	.076	-.27 (-.01)	.04 (.70)	.04 (.04)	.69 (.59)	.21 (<.001)	.71 (.54)
Externalizing (parent) F/U	.02 (.08)	.76	1.00	1.060	.000	.060	-.27 (-.01)	-.04 (-.90)	.08 (.09)	.69 (.59)	.21 (.004)	.68 (.60)
Prosocial (parent) Post	-.04 (.05)	.45	1.00	1.017	.000	.070	-.26 (-.01)	.15 (2.00)	.15 (.11)	.69 (.59)	.02 (<.001)	.66 (.68)
Prosocial (parent) F/U	-.04 (.04)	.32	1.00	1.046	.000	.065	-.27 (-.01)	.16 (1.91)	.14 (.09)	.69 (.59)	.02 (<.001)	.55 (.50)

Note: Regarding variable column notation: ***Post*** *denotes post-intervention time point following MFSR intervention group;* ***F/U*** *denotes follow-up time point for the MFSR intervention group. Regarding the rightmost columns (****Specific Path's****, see diagram XXX for path location):* ***X*** *denotes the independent variable (group assignment to MFSR intervention or wait-list control);* ***M time1*** *denotes the mediator (behavioral ANT conflict monitoring score) at the pre-intervention time point;* ***M time2*** *denotes the mediator at the latter time point (either post-intervention or follow-up);* ***Y time1*** *denotes the dependent variable (psychopathology or psychosocial functioning) at the pre-intervention time point;* ***Y time2*** *denotes the dependent variable at the latter time point (either post-intervention or follow-up).*

Table 9 (continued)

Longitudinal Mediation Model with ANT Conflict Monitoring Behavioral Data as Mediator and Different Psychopathology or Psychosocial Variables as Dependent Variable

	Total Indirect Path		Model Fit Index Value				Specific Path's **β** (*SE*)					
Dependent Variable	**β** (*SE*)	*p*	CFI	TLI	RMSEA	SRMR	X to M time2	M time 2 to Y time 2	X to Y time2	M time1 to M time2	M time1 with Y time1	Y time1 to Y time2
Strength & Difficulties Q'aire												
Internalizing (child) Post	.020 (.043)	.63	1.00	1.022	.000	.060	-.27 (-0.01)	-.07 (-1.59)	.13 (.16)	.69 (.59)	-.04 (-.001)	.70 (.64)
Internalizing (child) F/U	.065 (.066)	.32	.953	.918	.112	.084	-.26 (-.01)	-.24 (-5.41)	.01 (.01)	.69 (.60)	-.04 (-.001)	.59 (.55)
Externalizing (child) Post	-.04 (.05)	.43	.981	.967	.081	.052	-.27 (-.01)	.15 (3.44)	.13 (.16)	.69 (.59)	.16 (.003)	.75 (.82)
Externalizing (child) F/U	-.03 (.04)	.40	1.00	1.034	.000	.049	-.27 (-.01)	.12 (3.41)	.10 (.16)	.69 (.59)	.13 (.003)	.83 (1.04)
Prosocial (child) Post	-.02 (.05)	.61	1.00	1.097	.000	.044	-.27 (-.01)	.09 (.94)	.01 (.01)	.69 (.59)	.03 (<.001)	.59 (.47)
Prosocial (child) F/U	-.05 (.05)	.33	1.00	1.093	.000	.050	-.27 (-.01)	.19 (1.92)	.07 (.04)	.69 (.59)	.05 (.001)	.58 (.43)

Note: Regarding variable column notation: ***Post*** *denotes post-intervention time point following MFSR intervention group;* ***F/U*** *denotes follow-up time point for the MFSR intervention group. Regarding the rightmost columns (**Specific Path's**, see diagram XXX for path location):* ***X*** *denotes the independent variable (group assignment to MFSR intervention or wait-list control);* ***M time1*** *denotes the mediator (behavioral ANT conflict monitoring score) at the pre-intervention time point;* ***M time2*** *denotes the mediator at the latter time point (either post-intervention or follow-up);* ***Y time1*** *denotes the dependent variable (psychopathology or psychosocial functioning) at the pre-intervention time point;* ***Y time2*** *denotes the dependent variable at the latter time point (either post-intervention or follow-up)*

Table 9 (continued)

Longitudinal Mediation Model with ANT Conflict Monitoring Behavioral Data as Mediator and Different Psychopathology or Psychosocial Variables as Dependent Variable

	Total Indirect Path		Model Fit Index Value				Specific Path's ***β*** (*SE*)					
Dependent Variable	***β*** (*SE*)	*p*	CFI	TLI	RMSEA	SRMR	X to M time2	M time 2 to Y time 2	X to Y time2	M time1 to M time2	M time1 with Y time1	Y time1 to Y time2
Social and Emotional Assets and Resilience Scales												
Short form Post	-.01 (.04)	.81	.992	.985	.053	.054	-.27 (-.01)	.04 (.81)	-.01 (-.01)	.69 (.59)	.28 (.004)	.74 (.90)
Short form F/U	-.05 (.05)	.36	1.00	1.03 5	.000	.055	0.26 (-.01)	.18 (3.25)	.10 (.10)	.69 (.59)	.28 (.004)	.63 (.69)
Adult Child Relationship Scale												
Total scale Post	-.04 (.04)	.33	.891	.810	.215	.126	-.28 (-.01)	.14 (64.11)	.22 (5.26)	.69 (.59)	-.22 (-.07)	.84 (.99)
Total scale F/U	-.07 (.05)	.17	.824	.692	.252	.161	-.28 (-.01)	.27 (118.58)	.35 (8.60)	.68 (.58)	-.22 (-.07)	.77 (.91)
Positive relationship Post	-.03 (.04)	.42	.880	.790	.218	.133	-.28 (-.01)	.11 (15.26)	.20 (1.46)	.69 (.59)	2.50 (-.02)	.82 (1.01)
Positive relationship F/U	-.08 (.06)	.20	.698	.472	.300	.195	-.27 (-.01)	.31 (42.33)	.40 (2.97)	.69 (.59)	-.27 (-.02)	.71 (.91)

Note: Regarding variable column notation: ***Post*** *denotes post-intervention time point following MFSR intervention group;* ***F/U*** *denotes follow-up time point for the MFSR intervention group. Regarding the rightmost columns (**Specific Path's**, see diagram XXX for path location):* ***X*** *denotes the independent variable (group assignment to MFSR intervention or wait-list control);* ***M time1*** *denotes the mediator (behavioral ANT conflict monitoring score) at the pre-intervention time point;* ***M time2*** *denotes the mediator at the latter time point (either post-intervention or follow-up);* ***Y time1*** *denotes the dependent variable (psychopathology or psychosocial functioning) at the pre-intervention time point;* ***Y time2*** *denotes the dependent variable at the latter time point (either post-intervention or follow-up).*

Table 9 (continued)

Longitudinal Mediation Model with ANT Conflict Monitoring Behavioral Data as Mediator and Different Psychopathology or Psychosocial Variables as Dependent Variable

	Total Indirect Path		Model Fit Index Value				Specific Path's ***β*** (*SE*)					
Dependent Variable	***β*** (*SE*)	*p*	CFI	TLI	RMSEA	SRMR	X to M time2	M time 2 to Y time 2	X to Y time2	M time1 to M time2	M time1 with Y time1	Y time1 to Y time2
Adult Child Relationship Scale												
Conflict relationship Post	-.03 (.04)	.45	.930	.878	.170	.100	-.27 (-.01)	.12 (42.04)	.18 (3.56)	.69 (.59)	-.16 (-.04)	.83 (.92)
Conflict relationship F/U	-.06 (.05)	.26	.908	.839	.180	.111	-.28 (-.01)	.21 (78.36)	.27 (5.64)	.68 (.58)	-.16 (-.04)	.79 (.92)
Community Action for Successful Youth												
Positive family relation Post	-.07 (.04)	.11	1.00	1.017	.000	.051	-.25 (-.01)	.27 (7.04)	.03 (.04)	.70 (.60)	-.03 (-.001)	.63 (.75)
Positive family relation F/U	-.08 (.05)	.10	1.00	1.110	.000	.043	-.25 (-.01)	.34 (9.32)	.06 (.10)	.70 (.60)	-.03 (-.001)	.50 (.62)

Note: Regarding variable column notation: ***Post*** *denotes post-intervention time point following MFSR intervention group;* ***F/U*** *denotes follow-up time point for the MFSR intervention group. Regarding the rightmost columns (****Specific Path's****, see diagram XXX for path location):* ***X*** *denotes the independent variable (group assignment to MFSR intervention or wait-list control);* ***M time1*** *denotes the mediator (behavioral ANT conflict monitoring score) at the pre-intervention time point;* ***M time2*** *denotes the mediator at the latter time point (either post-intervention or follow-up);* ***Y time1*** *denotes the dependent variable (psychopathology or psychosocial functioning) at the pre-intervention time point;* ***Y time2*** *denotes the dependent variable at the latter time point (either post-intervention or follow-up).*

Table 10

Descriptive Data from Children in the MFSR Intervention Group – Ranked from Largest to Smallest Changes in their ANT Conflict Monitoring Behavioral Score from Pre- to Post-MFSR Intervention

Subject Rank Order	ANT conflict monitoring difference score	Gender	Age (years)	Child Behavior Checklist – Total problem behavior			Adult Child Relationship Scale – Total Scale			Child and Adolescent Mindfulness Measure		
				Time 1	Time 2	Time 3	Time 1	Time 2	Time 3	Time 1	Time 2	Time 3
1	-.054	Male	11.0	88	113	111	56	56	58	1.6	1.3	1.4
2	-.051	Female	9.5	16	17	19	29	38	43	2.9	3.0	2.7
3	-.044	Male	12.4	47	28	37	28	22	43	2.8	2.9	2.9
4	-.043	Female	11.0	30	18	12	30	23	31	2.1	2.7	3.2
5	-.041	Male	11.3	45	39	26	33	42	36	2.9	3.4	2.8
…	…	…	…	…	…	…	…	…	…	…	…	…
18	-.007	Male	9.5	29	7	*N/D*	34	34	*N/D*	3.0	2.1	*N/D*
19	-.006	Female	11.9	3	1	0	36	25	25	3.0	2.0	3.0
20	-.003	Male	8.5	14	9	9	25	18	18	3.3	2.3	2.7
21	-.001	Female	11.4	38	51	*N/D*	40	42	*N/D*	2.3	2.3	*N/D*
22	.016	Female	9.8	37	42	37	42	37	45	2.2	2.9	2.8

Note: Time 1 denotes pre-MFSR intervention; Time 2 denotes post-MFSR intervention; Time 3 denotes follow-up after MFSR intervention. N/D denotes no data for this subject.

Table 11

Results of Stepwise Multiple Regression of MFSR Intervention on Psychopathology and Psychosocial Functioning

	Intervention Effects			Final Model Statistics			
Variable	β	t	p	R^2	df	F	p
Child Behavior Checklist (CBCL)							
Total problem behavior – Time 2	.11	1.38	.17	.75	2,38	58.87	<.001
Total problem behavior – Time 3	.09	1.08	.28	.76	2,30	47.56	<.001
Internalizing – Time 2	.14	1.45	.14	.79	2,39	32.27	<.001
Internalizing – Time 3	.14	1.31	.20	.80	2,30	26.41	<.001
Externalizing – Time 2	.06	.83	.41	.78	2,39	68.82	<.001
Externalizing – Time 3	.07	1.05	.30	.87	2,30	100.85	<.001
Strengths and Difficulties Questionnaire (SDQ)							
Parent report							
Internalizing – Time 2	-.01	-.11	.91	.24	2,39	6.175	.005
Internalizing – Time 3 [b]	.11	.94	.35	.60	3,39	14.42	<.001
Externalizing – Time 2	.02	.23	.81	.51	2,39	20.50	<.001
Externalizing – Time 3 [a]	.11	.91	.37	.57	3,29	12.54	<.001
Prosocial – Time 2	.08	.72	.47	.47	2,39	17.28	<.001
Prosocial – Time 3	.08	.50	.62	.29	2,30	6.24	.005
Child self-report							
Internalizing – Time 2	.19	1.73	.09	.55	2,37	22.65	<.001
Internalizing – Time 3 [b]	.19	1.44	.16	.54	3,28	10.74	<.001
Externalizing – Time 2	.08	.80	.43	.57	2,37	24.81	<.001
Externalizing – Time 3	.09	.90	.37	.67	2,29	29.98	<.001
Prosocial – Time 2 [b]	.001	.01	.99	.34	2,37	9.31	.001
Prosocial – Time 3 [b]	.008	.05	.95	.43	3,28	7.13	.001
Social Emotional Assets and Resilience Scales (SEARS)							
Short form – Time 2	-.03	-.30	.76	.55	2,39	23.70	<.001
Short form – Time 3	.03	.24	.80	.41	2,30	10.52	<.001

Notes: Time 1 denotes pre-MFSR intervention; Time 2 denotes post-MFSR intervention; Time 3 denotes follow-up after MFSR intervention. Unless otherwise noted, all final models reported include Time 1 in first step of model and MFSR intervention in the second step. Statistically significant main effects for either gender or age are denoted by [a] *(age) or* [b] *(gender) in the variable label column.*

Table 11 (continued)

Results of Stepwise Multiple Regression of MFSR Intervention on Psychopathology and Psychosocial Functioning

	Intervention Effects			Final Model Statistics			
Variable	*β*	*t*	*p*	R^2	*df*	*F*	*p*
Adult Child Relationship Scale (ACRS)							
Total scale – Time 2	.15	1.63	.11	.65	2,39	36.22	<.001
Total scale – Time 3	.25	2.04	.05	.56	2,30	18.68	<.001
Positive relationship – Time 2	.14	1.43	.16	.65	2,39	35.98	<.001
Positive relationship – Time 3	.29	1.89	.06	.34	2,30	7.841	.002
Conflict relationship – Time 2 [b]	.13	1.46	.15	.71	4,31	22.81	<.001
Conflict relationship – Time 3	.19	1.66	.10	.60	2,30	22.42	<.001
Community Action for Successful Youth (CASEY)							
Positive family relations – Time 2	-.08	-.63	.53	.39	2,39	12.70	<.001
Positive family relations – Time 3	-.06	-.39	.69	.27	2,30	5.59	.009
Child and Adolescent Mindfulness Measure (CAMM)							
Total scale – Time 2	-.08	-.63	.52	.30	2,39	8.58	.001
Total scale – Time 2	.04	.32	.74	.32	2,30	7.25	.003

Notes: Time 1 denotes pre-MFSR intervention; Time 2 denotes post-MFSR intervention; Time 3 denotes follow-up after MFSR intervention. Unless otherwise noted, all final models reported include Time 1 in first step of model and MFSR intervention in the second step. Statistically significant main effects for either gender or age are denoted by [**a**] *(age) or* [b] *(gender) in the variable label column.*

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