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UNDERSTANDING THE RELATION BETWEEN MINDFULNESS-BASED INTERVENTIONS, READING AND ATTENTION

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Abstract

According to the National Assessment of Educational Progress (NAEP), roughly one third of American 4th and 8th grade students perform at or above the proficient level, suggesting that further interventions are needed to support student reading skills. Mindfulness interventions have generally been implemented to impact attentional, social-emotional needs, and internalizing symptoms such as stress and anxiety. However, mindfulness interventions have only recently been deployed to increase academic skills such as reading. This current research evaluated the effects of a brief year-long mindfulness intervention on reading and attention skills across an ethnically diverse at-risk sample of 7th grade students. Five 7th grade English-Language Arts (ELA) classrooms were randomized to either a mindfulness (*n* = 3) or an active control condition (*n* = 2). The students in the mindfulness classrooms (*n* = 36) began each ELA class with a five-minute guided mindfulness practice audio track. The students in the control classrooms (*n* = 20) began each ELA class with a brief five-minute assignment related to class content. Participants completed measures at three time points (i.e., pre-intervention, midway through the school year, & post-intervention) to assess self-reported levels of mindfulness, executive attention, and reading comprehension. Results indicate that students assigned to the mindfulness intervention classroom condition had significantly higher reading comprehension scores than their control counterparts at the end of the school year. Results also suggest that the brief mindfulness intervention did not significantly increase student self-reported levels of mindfulness, or executive attention measured via a computerized behavioral Flanker task. In conclusion, the current research indicates that brief a daily mindfulness intervention may be associated with increased student reading comprehension performance.

Keywords: mindfulness, reading, attention, academic interventions

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INTERVENTIONS, READING AND ATTENTION

by

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Understating the Relation Between Mindfulness-based Interventions, Reading and Attention.

William James described attention as “taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought” (pp. 403-404; James, 1890), and reported that focalization and concentration of consciousness are essential components of attention. Contemporary psychologists studying the construct of mindfulness have shed a unique perspective on the definition and roles of attention. For instance, mindfulness was previously discussed as a state of consciousness *attending* to moment-to-moment experiences, with an open and nonjudgmental attitude (Shapiro, Carlson, Astin, & Freedman, 2006). Therefore, the constructs of attention and mindfulness appear to be interconnected as both definitions typically include an emphasis on focusing one’s concentration. However, the empirical validation of the conceptual relation between attention and mindfulness has only begun, with preliminary evidence indicating that further research is necessary (Felver et al., in press).

The application of mindfulness-based interventions to support academic functioning has only begun to be empirically evaluated in recent years (Felver & Jennings, 2016). Conceptually, the utilization of mindfulness-based interventions to support academic skills such as reading has merit, as empirical evidence suggests that attention is an important variable for one’s reading skills and ability (Reynolds & Besner, 2006), and mindfulness practices may increase one’s ability to direct and maintain attention (Chiesa Calati, & Serretti, 2011; Felver et al., in press). Therefore, it is postulated that mindfulness practices may be a beneficial strategy to increase one’s reading skills indirectly by enhancing attentional capabilities. The current research was designed to empirically examine if a brief mindfulness intervention is an effective strategy to increase reading performance as mediated through the role of attention.

The current study will begin with a literature review of research related to (a) attention, (b) the role of attention in reading, (c) the role of attention in mindfulness, and (d) the relation between mindfulness and reading. The remaining sections of this document will outline the specific goals, hypotheses, and purpose of the current research. This research intends to examine if a brief, daily mindfulness intervention was successful at increasing adolescent student's self-reported levels of mindfulness (Aim 1), if mindfulness practices were successful in increasing student reading comprehension scores (Aim 2), and if these potential differences in reading performance were mediated by changes in executive attention skills (Aim 3). The final section of this research study will outline the specific methods, procedures, data analysis, and results.

Attention

This section will review research pertaining to the construct of attention. Specifically, Posner and Petersen's (1990) tripartite model of attention will be outlined. This theory of attention highlights separate subordinate components of attention, which include the alerting, orienting, and executive networks.

Tripartite Model of Attention

One of the most influential theoretical models of attention in the past thirty years is Posner and Petersen's tripartite model of attention (1990). The tripartite model postulates that there are three attentional networks with independent anatomical structures to handle incoming information, to make decisions, and to produce outputs, and that these anatomical areas are responsible for carrying out different cognitive functions. The tripartite model is subdivided into three independent networks: alerting, orienting, and executive attention networks (Posner & Petersen, 1990; Petersen & Posner, 2012).

Alerting Network

The purpose of the *alerting network* is to achieve and maintain a vigilant or alert state of preparedness (Jha, Krompinger, & Baime, 2007; Posner & Petersen, 1990). The alerting network was also described as *sustained attention* (Chiesa et al., 2011). Within a cognitive psychology perspective, the role of the alerting network is described as maintaining optimal vigilance and performance during tasks. The alerting network was empirically studied by presenting participants with a warning signal prior to a target event. The warning signal produces a phasic change in alertness, thus replacing the resting state of awareness with a novel state of preparation for detecting and responding to the target event. Additionally, the alerting attentional network was studied through tonic alertness. This paradigm typically includes a rather long and static task that requires intermittent behavioral responses to measure sustained vigilance (Posner & Petersen, 1990; Peterson & Posner, 2012). In sum, Posner and Petersen's (1990) original tripartite model of attention suggests that the role of the alerting network is to achieve and maintain a vigilant or alert state of preparedness.

Orienting Network

The orienting network was also described as *selective attention* (Chiesa et al., 2011). The purpose of the *orienting network* is to direct and limit attention to a subset of potential inputs (Jha et al., 2007). In other words, the function of the orienting network is to prioritize input from sensory organs (Petersen & Posner, 2012). The orienting network directs and concentrates attention towards a sensory modality such as vision and guides an individual in the concentration of attention towards a specific location and stimulus. Put another way, the orienting network would be utilized if an individual focused their attention to a flashing light. The orienting network would assist with the focusing of attention by shifting it to the visual modality and the spatial location of the flashing light. In sum, the tripartite model of attention suggests that the orienting network is focused primarily on the ability to prioritize sensory stimuli by means of selecting a physical modality of attention, and a spatial location to direct attention towards.

Executive Attention Network

The *executive attention network*, which is also referred to as the *conflict monitoring* or *target detection* network, prioritizes attention among competing tasks or responses (Jha et al., 2007). In other words, the executive attention network is the subcomponent of attention that resolves conflict among multiple competing responses to sensory inputs (van den Hurk et al., 2010). Posner and Petersen (1990) used a spotlight analogy in their original description of the executive attention network. Specifically, executive attention was described as a spotlight that directs and focuses attentional abilities to a specific stimulus, while ignoring other irrelevant or distracting stimuli. Put another way, the executive attention network or the spotlight of attention would assist an individual on focusing on one stimulus, while other stimuli such as sounds or sights in the environment or non-goal directed cognitions are ignored. The set of processes involved with the executive attention network are related to the set of processes that limit the capacity of the attention system and has often been referred to as focal attention. Petersen and Posner (2012) explain that the executive attention network may be useful for producing top-down regulation (i.e., cognition that is goal-directed) or control over the attentional system. In sum, the executive attention network of the tripartite model of attention is thought to resolve conflict among multiple responses, and thus prioritizes where attention is focused from competing tasks and responses.

Goal-Directed and Stimulus-Driven Attention

Utilizing research from behavioral, neuroimaging, lesion, and electrophysiological studies, Corbetta and Shulman (2002) formulated a two-part partially segregated model of attention. The first part of the model is entitled the *goal-directed* system. The goal-directed or top-down attention system assists with the orientation of attention. The second part of the model is entitled the *stimulus-driven* or bottom-up attentional network. This stimulus-driven network is described as an alerting attentional system that activates when there are sudden changes in sensory stimuli, especially when the changes in sensory stimuli are unexpected (Corbetta & Shulman, 2002; Jha et al., 2007).

Fan, McCandliss, Fossella, Flombaum, and Posner (2005) demonstrated overlap among the tripartite model of attention (Posner & Petersen, 1990), and the goal-directed versus stimulus-directed model of attention (Corbetta & Shulman, 2002; Corbetta et al., 1998). Specifically, Fan et al. (2005) utilized the attention network test (ANT; Fan, McCandliss, Sommer, Raz, & Posner, 2002) and functional magnetic resonance imaging (fMRI) data to explore if the alerting, orienting, and executive attentional networks are anatomically independent. The attention network test is a task that is devised to identify behavioral and neural indices of the alerting, orienting, and executive attention networks, and examines the effects of cues and targets within a single reaction time test (Jha et al., 2007; Fan et al., 2005). Results indicated that there was high overlap between the tripartite alerting network and the ventral attention system as described by Corbetta and Shulman (2002). This would suggest that Posner and Petersen's (1990) theory of the alerting network is stimulus driven and is especially active when there are unexpected changes in stimuli. Further, results indicated that both the orienting and executive attention networks overlapped with the dorsal system sub regions. These results suggest that the tripartite model orienting network and executive attention network are related to voluntary, goal-directed mechanisms of attention (Jha et al., 2007; Fan et al., 2005). In sum, Fan et al. (2005) provide neuroimaging data to suggest that Posner and Petersen's (1990), and Corbetta and Shulman's (2002) models of attention are not independent of each other, and instead both models have high levels of overlap.

Attention and Reading

This section will provide a discussion pertaining modern conceptualizations of reading, and how reading and attention may be related. First, the dual route model of reading will be discussed to highlight the two distinct strategies that readers rely on to convert print into speech (Coltheart, Curtis, Atkins, & Haller, 1993). Second, LaBerge and Samuels' (1974), and Logan's (1997) theories of automatic information processing in reading will be discussed to emphasize the role that attention plays in accurate and fluent reading and reading comprehension.

Reading

Oral language is a skill that does not need to be specifically taught, as young children who are exposed to their natural language will generally develop skills related to spoken language. Oral language is hundreds of thousands of years old and is present across all societies on earth; however, *reading* is a relatively new and complex skill. Reading requires a plethora of skills including: developing an awareness that spoken language is segmented into phonological elements; identifying letters; learning the rules for how print maps onto sounds; recognizing whole words accurately and rapidly; formulating a vocabulary; and extracting the meaning from printed words (Shaywitz & Shaywitz, 2008). The multi-component process of reading was studied for many decades, and one influential theory that has been proposed is the *dual-route* model of reading (Shaywitz & Shaywitz, 2008; Tarrasch, Berman, & Friedmann, 2016).

The fundamental assumption of the dual-route model of reading is the notion that skilled readers utilize two distinct strategies for converting print into speech. In a broad sense, one strategy is a mental dictionary procedure, while the other strategy is a letter-to-sound procedure (Coltheart et al., 1993; Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001). The mental dictionary procedure is termed the lexical route, and it relies on a mental or orthographic lexicon in which representations of printed words are stored in a mental database. Put another way, the lexical route may assist a reader who sees the word “Syracuse” and retrieves the accurate pronunciation from a stored mental lexicon. The letter-to-sound route is termed the sublexical route and is activated for words that the reader has not seen before, and therefore lexical entries do not exist within the mental lexicon. For example, the sublexical route may be activated for nonwords such as “dorlishane”, or for irregular words such as “colonel”. The sublexical route relies on the serial mapping of letters from left to right, and of combining each letter in a letter string with its corresponding sound. Once the letters are mapped, the word can be read aloud (Coltheart et al., 1993; Shaywitz & Shaywitz, 2008). Coltheart and colleagues (1993) outlined that the dual-route model of reading is utilized by both skilled readers who can read printed words accurately and fluently, as well as young children who are just beginning to learn the skill of reading. In sum, the dual-route model of reading suggests that the critical process of translating letters to sounds occurs across two different mechanisms: the lexical, which stores mental pronunciations of printed words, and the sublexical route, which produces pronunciations of printed words via the phonological code from left to right (Shaywitz & Shaywitz, 2008).

Reading and Attention

Reynolds and Besner (2006) suggest that attention is a component of reading that is often overlooked yet is critical for translating printed words into fluent reading. Specifically, the authors indicate that the concept of automaticity has shaped how researchers have previously examined the skill of reading. The authors discuss the possibility that reading does not occur through an automatic information processing system as previously thought, and instead, attention is a fundamental variable that leads to the successful translation of print to speech. General evidence of the notion that attention is a critical component of successful reading is provided from studies that emphasize the comorbidity of dyslexia and attention-deficit/hyperactivity disorder (ADHD) that are often observed clinically within the same individual (Shaywitz & Shaywitz, 2008; Germano, Gagliano, & Paolo, 2010).

In their influential model of automatic information processing in reading, LaBerge and Samuels (1974) describe a theory of reading in which visual information is transformed across different processing stages involving visual, phonological, and episodic memory systems that eventually leads to the comprehension of text. Within this model, readers progress through a series of stages in which each subskill of reading is learned, beginning with an attention demanding process of learning to read a word accurately, and progressively moving towards the stage in which words can be read fluently and accurately (Shaywitz & Shaywitz, 2008). LaBerge and Samuels (1974) identified accuracy and automaticity as the criteria for assessing if a stage within the model was adequately achieved. More specifically, the role of attention is a crucial factor when determining if a reader is ready to advance to the next stage of reading, as the model assumes that individuals are only able to attend to one variable at a time. In other words, LaBerge and Samuels (1974) suggest that accuracy in reading alone is not sufficient for determining if a reader is ready for the next stage, but rather the amount of attention required should be evaluated to predict a reader’s ability to complete a more difficult stage of reading. In sum, LaBerge and Samuels (1974) formulated an information-processing model of reading that places high emphasis on the role of attention in terms of learning how to read, and in progressing to more difficult stages of reading. This model of reading suggests that as lower level subskills of reading become automatic, less attention is required for decoding printed words, and eventually this process leads to higher-level functions such as semantics and text comprehension (Shaywitz & Shaywitz, 2008).

Logan (1997) utilized LaBerge and Samuel’s (1974) general theory of automatic processing in reading and developed the *instance theory* to conceptualize how individuals learn complex skills such as reading. The instance theory suggests that automaticity of a skill such as reading is facilitated through episodic memory mechanisms (Shaywitz & Shaywitz, 2008). Specifically, the instance theory includes three fundamental assumptions: obligatory encoding, obligatory retrieval, and instance representation.

Obligatory encoding suggests that attention directed towards an object or an event is sufficient to cause the stimuli to be encoded into memory. *Obligatory retrieval* suggests that attention towards an object or an event is sufficient to cause associations that were previously paired with the stimuli to be retrieved from memory. *Instance representation* suggests that each trace of past objects or events is separately encoded, stored, and retrieved, even if the stimuli has been experienced before (Logan, 1997). Therefore, Logan’s (1997) instance theory indicates that the development of automaticity related to reading is due to increasingly greater ease in the retrieval of such information. Put another way, with increased practice, the number of memory traces or representations of words will increase ease of retrieval and result in faster print to speech translations (Shaywitz & Shaywitz, 2008). In sum, Logan (1997) conceptualized how individuals learn skills such as reading, and specifically postulated how automaticity develops with regards to reading. Attention was outlined as a critical variable for both the encoding and retrieval stages of this model, further implicating the role of attention as an essential component of reading.

In sum, Laberge and Samuels (1974) and Logan (1997) have clearly highlighted the importance of attention with regards to reading. The former theory highlights that the allocation of attentional resources is a critical component in evaluating which stage of reading that an individual is currently at, whereas the latter research highlights the role of attention in the process of learning to read. These concepts are strengthened by Reynolds and Besner (2006) who demonstrated that both routes of the dual-route model of reading rely on the presence of attention to successfully translate printed words into speech. Specifically, Reynolds and Besner (2006) have identified that both assembled phonology, which is the sublexical route, and addressed phonology, which is the lexical route, demand the use of attention to process information (Coltheart et al., 1993; Shaywitz & Shaywitz, 2008).

Alerting Network and Reading

As previously mentioned, the *alerting* network is also referred to as *sustained attention*. Lam and Beale (1991) examined the relation between sustained attention and children's reading abilities and teacher ratings of problematic behaviors. Children (n = 190) aged 7 to 10 were administered the Continuous Performance Task (CPT; Klee & Garfinkle, 1983) and the Progressive Achievement Test (PAT; Elley & Reid, 1969), while the teachers were administered the Conners Teacher Rating Scale (CTRS; Werry & Hawthorne, 1976). The Continuous Performance Task is a measure of sustained attention in which individuals typically are asked to respond by pressing a keyboard key only if the target letter is followed by a particular letter (e.g., participants are asked to respond by pressing a designated key only when the letter X is followed by the letter A). The Comprehension Test and Reading Vocabulary Test from the Progressive

Achievement Test were administered to obtain a measure of the children's reading comprehension and reading vocabulary, and the Conners Teacher Rating Scale was completed by the children's teachers to obtain a measure of hyperactivity and inattention. Results indicated a significant correlation among the Continuous Performance Task, Progressive Achievement Test, and teacher reports of inattention, suggesting that sustained attention may play a pivotal role in students reading skills and ability to manage and control behavior.

Stern and Shalev (2013) provide further insight into the role of sustained attention with regards to reading abilities among students. Specifically, the authors evaluated the relation between sustained attention and reading comprehension among adolescent students (*n* = 40) with and without a diagnosis of ADHD. Sustained attention was evaluated using a Conjunctive Continuous Performance Task (CCPT; Avisar & Shalev, 2011; Shalev, Ben-Simon, Mevorach, Cohen, & Tsal, 2011). During the Conjunctive Continuous Performance Task, participants were asked to press the space bar when a target geometric shape appeared on the computer screen, and refrain from responding whenever a geometric shape that was different from the target shape was presented. Reading comprehension was evaluated by having participants read expository text from a high school level history textbook. After reading the texts, students completed a ten-item questionnaire at the completion of each of the eight trials. Results indicated that the subjects with higher sustained attention performances were significantly more likely to answer reading comprehension questions correctly, as well as read text faster relative to participants with medium sustained attention and low sustained attention scores. Additionally, results indicated that students who were diagnosed with ADHD performed significantly worse on the Conjunctive Continuous Performance Task than students without a prior diagnosis. Stern and Shalev (2013) concluded that an inability to maintain a relatively stable state of attention (i.e., sustained attention) impairs an individual's reading effectiveness, thus hindering reading fluency and comprehension.

Orienting Network and Reading

As previously outlined, the *orienting network* is also referred to as *selective attention*. Vidyasagar and Pammer (2010) have highlighted the role of selective attention among early literacy acquisition. Namely, the authors discuss the widely held belief that phonological deficits in terms of difficulties in sounding out words may not be the root of reading difficulties observed among readers with dyslexia. Instead, Vidyasagar and Pammer (2010) used neurological research to propose that difficulties with reading, specifically phonological sensitivity, are related to attentional mechanisms controlled by the goal-directed mechanisms of attention (e.g., orienting and executive networks; Fan et al., 2005; Corbetta & Shulman, 2002). Specifically, the authors postulate that visual selective attention is necessary to serially scan letters while reading and sounding out words. Therefore, any deficits or impairments with visual selective attention will result in a cascade of effects that include impairments in the visual processing of graphemes into sounds, the development of phonemic awareness, and thus reading fluency and comprehension (Vidyasagar & Pammer, 2010).

Further evidence of the importance of selective attention on reading skills was provided by Stevens and colleagues (2013). Stevens et al. (2013) used neurophysiological data (e.g., electrophysiological event-related potentials (ERP)) to examine the neural mechanism of selective attention among kindergartners who were at-risk for reading disabilities (*n* = 8), and students who were assessed to be on-track (*n* = 6) with early literacy skills as determined using the *Dynamic indicators of Basic Early Literacy Skills* (DIBELS; Good & Kaminiski, 2003) measures. The at-risk group of children received supplemental instruction through the Early Reading Intervention (ERI; Kame'enui & Simmons, 2003), and both groups of children completed DIBELS early literacy measures (e.g., Letter Naming Fluency, Phoneme Segmentation Fluency, and Nonsense Word Fluency) and electrophysiological measures both pre and post the at-risk group completing the Early Reading Intervention.

Selective attention was measured using electrophysiological event-related potentials as children were presented two auditory stories simultaneously and asked to attend to one specific story. Additionally, images from the target story were presented on a computer screen to the children, and the children were asked three comprehension questions at the completion of the story to encourage them to pay attention to the target story. The electrophysiological event-related potentials data were separated to obtain an average measure of selective attention directed towards the target story and the unattended channel. Results indicated that prior to the Early Reading Intervention, the at-risk children demonstrated significantly lower scores across all DIBELS Early Literacy measures and lower selective attention abilities as measured by the electrophysiological event-related potentials. Results after the completion of the Early Reading Intervention indicated that there were no longer significant differences between the two groups on all DIBELS Early Literary measures and electrophysiological event-related potentials measures of selective attention (Stevens et al., 2013). In sum, Stevens et al. (2013)

provide further evidence of the role of selective attention with regards to early literacy skills and demonstrate that selective attention related skills are prone to intervention.

Casco, Tressoldi, and Dellantonio (1998) have provided further insight into the role of selective attention with reading skills among children. Casco and colleagues (1998) administered a cancellation task to eleven and twelve-year-old Italian students (*n* = 590) who were free of neurological and sensory problems, and who evidenced typical intellectual functioning for their age. The cancellation task was presented to obtain a measure of visual selective attention as the children were instructed to cross out all the target letters or numbers from a larger array of similar looking letters or numbers. For example, one condition of the visual selective attention task requested students to find the letter “U” in a large array of non-target “V” letters.

The results on the cancelation task were used to divide the total number of participants into four categories based on their visual selective attention efficiency scores (e.g., Category 1 performed the lowest, and Category 4 performed the highest). Next, Casco et al. (1998) administered a measure of reading ability to small portions of Category 1 (*n* = 19), and Categories 3 and 4 (*n* = 19) to observe if the differences in visual selective attention were related to measures of reading rate and accuracy. Results indicated that the children from Category 1 demonstrated significantly slower reading rates than children in Categories 3 and 4. Finally, Casco et al. (1998) presented the original 590 participants three linguistic tasks to observe the relations between letter search and reading performance. While there were not significant differences between categories across the Lexical decision task and the Syllable control task, there were significant differences observed between Category 1 and 4 on the Lexical search task.

The Lexical search task required participants to find a word that has been embedded in a string of letters forming a non-word (e.g., finding the word "HIT" embedded in HUYHITY). Therefore, the results suggest that differences in visual selective attention may also be related to abilities of whole word segregation required to perform the lexical search task (Casco et al., 1998). Taken together, this research further suggests that selective attention is a crucial variable required for quick and accurate translations of printed words into spoken language.

Executive Attention and Reading

The relation between executive attention and reading in terms of Posner and Petersen's (1990) tripartite model of attention is a relatively under studied area of research. However, it is important to note that the potential relation between executive attention and reading is addressed through exploring the relation of executive functioning and working memory capacity and reading. McCabe and colleagues (2010) discussed that attentional control, or the executive attention network is conceptualized as executive functioning (EF) in neuropsychology research, and as working memory capacity (WMC) in experimental psychology research. Across multiple measures of working memory and executive functioning, McCabe et al. (2010) observed a very strong correlation of $r = 0.97$. In addition, McVay and Kane (2009) have provided a theory of executive functioning, working memory capacity, and attention, which suggests that executive functioning and working memory capacity share an underlying common construct of executive attention. Therefore, further insight of the relation of executive attention and reading is gained by evaluating the research pertaining to executive functioning and working memory capacity and reading.

Maricle and Avirett (2012) have discussed that executive functioning is a broad term used to describe complex cognitive processes that are goal-directed. The authors identify that the terminology used for executive functioning is often inconsistent, but there are domains of the construct that are generally accepted: the regulation of cognition, emotion, and behavior; the completion of complex tasks; working memory; and attentional control. The relation between executive functioning and reading is considerably more developed than the link of executive attention and reading. For instance, Cantin et al. (2016) observed that executive functioning mediated age differences in reading comprehension as measured by the reading comprehension subtest of the Wechsler Individual Achievement Test – Third Edition (WIAT-III; Wechsler, 2009). Put another way, the authors of this study observed that three components of executive functioning (e.g., working memory, flexibility, and inhibition) can be used to predict reading comprehension achievement of students aged 7 to 10. This observation is consistent with de Abreu et al. (2014) who studied the relation between executive functioning and reading achievement across a diverse sample of 6 to 8 year- students. Conclusions from this study suggest that deficits in components of executive functioning old (e.g., working memory and cognitive flexibility) may be contributing factors to difficulties with reading achievement.

Working memory capacity was defined as the capacity of the system that retains access to a limited amount of information while complex cognitive operations are occurring (Moran, 2016). Individual differences in working memory capacity have been previously observed to significantly predict reading comprehension in the moderate to strong range (r = 0.30 to r = 0.52; Daneman & Merikle, 1996). Further, the executive-attention view of working memory capacity suggests that the control of attention (i.e., executive attention) is one important mechanism that underlies tasks of both working memory capacity and reading comprehension, thus being partially responsible for the covariation of working memory capacity and reading comprehension (McVay & Kane, 2012; Engle & Kane, 2003). Due to the moderate to strong relationship between working memory capacity and reading comprehension, and the executive attention view of working memory capacity, McVay and Kane (2012) explored the influence of mind wandering on reading comprehension. The authors identified that mind wandering represents a breakdown or lapse of executive attention, therefore it was predicted that participants who demonstrated increased mind wandering (i.e., decreased executive attention) would be also demonstrate decreased reading comprehension performances.

McVay and Kane (2012) required undergraduate students aged 18 to 35 years (*n* = 242) to complete: three working memory capacity tasks (operation, reading, and spatial span tasks); four measures of reading comprehension (Verbal Scholastic Assessment Test (SAT), Inference Verification Test (Griffin, Wiley, & Thiede, 2008); and comprehension questions after having read peer-reviewed journals, novels, and short stories). Additionally, participants were asked mind wandering probes (e.g., what were you just thinking about?) intermittently across the reading measures and completed measures of executive attention that included the Numerical Stroop, Semantic Sustained-Attention-to-Response task (SART; McVay & Kane, 2009), and Antisaccade tasks. Results indicated that mind wandering (i.e., a lack of executive attention) was a significant mediator in the relation between working memory capacity and reading comprehension, suggesting that the moderate to strong relation between WMC and reading comprehension is in part driven by the executive attentional network (McVay & Kane, 2012).

In conclusion, previous empirical evaluations of the relation between attention and reading have identified how each attentional network relates to reading skills. Selective attention appears to relate to the development of early literacy skills such as phonemic awareness, or the successful scanning of letters in print (Vidyasagar & Pammer, 2010; Stevens et al., 2013; Casco et al., 1998). Sustained attention was previously observed to relate to reading comprehension and vocabulary (Lam & Beale, 1991; Stern & Shalev, 2013). Executive attention was found to mediate the relation between working memory capacity and reading comprehension (McVay & Kane, 2012). The literature concerning the relation of attention and reading impacts the framing of how mindfulness interventions may be utilized to impact reading and attention related skills. As the next portion of the paper will discuss, executive attention is believed to be impacted by relatively brief mindfulness interventions, thus making executive attention a potentially malleable attentional network to target within the school context.

Attention and Mindfulness

This section will focus on the construct of mindfulness and how it relates to attention. Specifically, there will be a discussion of how mindfulness has previously been operationally defined for use in scientific inquiries, and a review of the theoretical putative mechanisms that underlie mindfulness and mindfulness-based interventions. Following the discussion of the construct and theory of mindfulness, there will be a specific review of previous studies that have examined the relation between mindfulness and attention.

Mindfulness

The process of mindfulness was described as the cultivation of awareness in moment-to-moment experiences with elements of openness and non-judgment (Kabat-Zinn, 2001). The concept of mindfulness and mindfulness-based practices are rooted in Buddhist philosophy, but the construct has gained considerable secular attention among clinicians and researchers in the past thirty years (Bishop et al., 2004; Chiesa, Calati, & Serretti, 2011). For example, mindfulness-based stress reduction (MBSR; Kabat-Zinn, 1990) is a structured group-intervention program that has been empirically evaluated since 1979. Considerable research has indicated the benefits of mindfulness-based stress reduction program for a variety of individuals, including those suffering from chronic pain, cancer, anxiety disorders, depression, and stress (Rosenzweig et al., 2010; Ledesma & Kumano, 2009; Serpa, Taylor, & Tillisch, 2014; Shapiro, Astin, Bishop, & Cordova, 2005).

Bishop et al. (2004) has outlined that mindfulness is taught across a wide range meditation practices (e.g., yoga, sitting meditation, body scan meditation), but the exercises are similar in the basic procedures and goals. For example, sitting mindfulness meditation is a common approach in which an individual will maintain an upright-seated position either in a chair or sitting comfortably on the floor. Seated mindfulness practices typically ask individuals to maintain attention on a target focus, which is commonly the somatic sensation of breathing. If attention wanders to some type of external or internal stimuli other than the somatic sensations of the breath, the individual is asked to simply recognize when attention has wandered and return to paying attention to the breath without producing a judgment of completing the practice "correct" or "poorly." As this form of concentrative meditation is practiced, it is common for individuals to begin seated mindfulness meditations in which there is a new emphasis on paying attention to whatever the mind happens to wander to and accept each object of awareness without making judgments or placing additional meanings on the internal or external stimuli. Bishop and colleagues (2004) discuss that the aforementioned mindfulness practices over time generally lead to a mindful disposition in which a dispassionate state of self-observation occurs, and this state is thought to produce a buffer between one's perception and potential responses. Therefore, mindfulness is postulated to increase an individual's ability to respond to situations more *reflectively* as opposed to *reflexively* (Bishop et al., 2004).

Bishop and colleagues (2004) expanded on their discussion of mindfulness and proposed one of the first operational definitions designed to increase the construct's precision and testability. Specifically, mindfulness was proposed as a two-component model. One component involves the self-regulation of attention in which focus is directed or maintained on the immediate experience. The second component involves adopting a particular attitude towards one's experiences in the present moment that is characterized by openness, curiosity, and acceptance. This second component of Bishop and colleague's (2004) model suggests that the orientation of mindfulness begins with an element of curiosity. An attitudinal trait of curiosity is thought to assist an individual to examine where the mind wanders when the action occurs and explore the different objects and thoughts that occur at any given moment. Further, an orientation of acceptance is described as not striving for a state of relaxation, but instead an orientation to simply notice each thought, feeling, and sensation that arises in the stream of consciousness. Finally, an orientation of openness is believed to increase receptivity to whatever happens to occur in the field of awareness, without feeling pressure to change or adapt the current moment-to-moment experience (Bishop et al., 2004).

Although Bishop et al. (2004) provided one operational definition of mindfulness, Shapiro et al. (2006) provided a theory into the putative mechanisms that underlie how mindfulness-based practices may elicit change. Specifically, the theory begins through outlining three axioms, or fundamental blocks, of mindfulness. These core components of mindfulness include intention, attention, and attitude. *Intention* is a crucial aspect of mindfulness as it sets the stage or initiates the subsequent components of attention and attitude. *Attention* is indubitably a core feature of mindfulness, as most practices revolve around paying attention to one's moment-to-moment experiences. How one attends, or in other words, the *attitude* in which one attends, is the last core feature of mindfulness.

Building on the three axioms of mindfulness, Shapiro et al. (2006) proposed the Intention-Attention-Attitude (IAA) model of the potential mechanisms of mindfulness that suggests that *intentionally* paying *attention* with an *attitude* of openness and non-judgmentalness leads to a significant shift in perspective. This significant shift in perspective is termed *reperceiving* and is postulated to be a meta-mechanism in which one is able to separate or disidentify from the contents of the conscious. Further, reperceiving allows an individual to view moment-to-moment experiences with increased clarity and objectivity. Put another way, reperceiving is a fundamental shift in perspective in which individuals are able to stand back from their personal narrative, and simply witness the information without behaving reflexively. Reperceiving is believed to direct additional mechanisms such as self-regulation and self-management. Shapiro and colleagues (2006) outline “intentionally cultivating nonjudgmental attention leads to connection, which leads to self-regulation and ultimately to greater order and health” (p. 380). Specifically, the significant shift in perspective related to reperceiving is believed to increase one’s ability to attend to information contained in each present moment, and therefore afford more access to data that may have been previously too uncomfortable or too difficult to examine. In sum, Shapiro et al. (2006) outlined a theory of the putative mechanisms of mindfulness in which the three fundamental components include intention, attention, and attitude, which leads to reperceiving. Reperceiving is thought to impact self-regulation and self-management as the shift in perspective increases the ability to stand back and witness emotional states, thus increasing individual degrees of freedom to effectively increase the number of behavioral patterns available.

Mindfulness and Attention

As previously mentioned, the operational definition of mindfulness outlined by Bishop et al. (2004) includes a component focusing on the self-regulation of attention. Shapiro et al. (2006) have also discussed the critical relation between attention and mindfulness by outlining that attention is one of the critical mechanisms to promote change in the IAA model. Put another way, attention was described as inherent to the understanding of mindfulness in general. Indeed, Bishop and colleagues (2004) discuss that the very basis of mindfulness is rooted in the regulation of attention, as there is an emphasis on bringing awareness to the moment-to-moment experiences. Specifically, the authors hypothesize that sustained attention is required to maintain an awareness of the current experiences. Put another way, sustained attention is related to mindfulness, as there is an element, which requires a state of vigilance to keep attention anchored in the moment-to-moment experiences so that thoughts, feelings, and sensations can be detected from the stream of consciousness. In addition to sustained attention, Bishop et al. (2004) identify skills in switching attention or executive attention as an integral component of mindfulness. Executive attention is a necessary component of mindfulness as it is common for an individual engaging in mindfulness practices to notice that attention had wandered from the target stimuli (e.g., somatic sensations of breathing), and thus need the skill to be able to redirect attention back to the target once a thought, feeling, or sensation has been acknowledged. In sum, Bishop et al. (2004) and Shapiro et al. (2006) have identified sustained and executive attention as core components of the self-regulation of attention, which are the roots of mindfulness meditations.

In 2011, Chiesa and colleagues completed a systematic review of research pertaining to previous empirical studies that have examined if mindfulness meditation practices (MMPs) can improve cognitive abilities such as attention, memory, executive functions, as well as other miscellaneous measures of cognition. The following sections of the literature review will explore literature discussed in Chiesa et al. (2011) to examine mindfulness practices impact on Posner and Petersen's (1990) tripartite attentional networks.

Mindfulness and the Alerting Network

Chiesa et al. (2011) outlined ten studies, which evaluated the effects of mindfulness meditation practices on sustained attention (i.e., alerting network). Seven of these studies included controlled or randomized trials, and the remaining three investigations were case-control studies. Of the seven controlled or randomized trials, only two studies observed significant improvements in sustained attention scores in mindfulness groups as compared with control groups (Chiesa et al., 2011).

Chambers, Lo, and Allen (2008) observed significant improvements on a measure of sustained attention among the mindfulness group who participated in an intensive 10-day Vipassana retreat, as compared to a waitlist control group. Sustained attention was measured via the Internal Switching Task (IST; Chambers et al., 2008), which provides a measure of reaction time and participants' capacity for sustained attention and switching effects. Specifically, participants were shown a single word stemming from two categories (e.g., food and household items), and were instructed to conduct a silent mental count for how many words were shown per category. This task was administered with neutral words as well as affective (i.e., positive and negatively charged words), both pre- and post-retreat for the mindfulness and control groups. Results indicated that the mindfulness group's overall reaction times in the affective condition of the internal switch task significantly improved from time one to time two, while the control group's reaction times did not significantly differ over time. In addition, mindfulness condition participants reported significant improvements in self-reported levels of mindfulness, depressive symptoms, rumination, and performances of working memory relative to the comparison group. In sum, Chambers et al. (2008) demonstrated that an intensive mindfulness retreat may significantly affect participant's sustained attention abilities as evidenced by the Internal Switching Task reaction times.

Jha et al. (2007) provide further insight into the impact that mindfulness meditation practices can have on the sustained attention network. Specifically, this study compared participants with no prior mindfulness meditation experience assigned to either an 8-week MBSR course or a waitlist control group, with mindfulness meditation experts who completed an intensive 1-month meditation retreat. Sustained attention was measured via the attentional network test (ANT; Fan et al., 2002) both pre- and post-mindfulness trainings. Results indicated that there were not significant differences between the novice groups on measures of sustained attention. However, a significant reduction in reaction times was observed in the intensive retreat expert group as compared with the mindfulness-based stress reduction group and waitlist control novices, suggesting that the sustained attention abilities of the expert group were significantly higher than both novice groups post mindfulness training (Jha et al., 2007). Overall, the results of Jha et al. (2007) and Chambers et al. (2008) suggest that mindfulness practices may be a useful strategy for increasing sustained attention abilities. However, it is important to note that both of these empirical studies are limited by non-randomized designs, and a lack of active control groups, which could potentially introduce some biases such as undetected differences across groups (Chiesa et al., 2011).

Further research has observed no significant differences between meditators and control groups across measures of sustained attention (Mcmillan, Robertson, Brock & Chorlton, 2002; Polak, 2009; Tang et al., 2007). It is important to note that these studies evaluated the effects of mindfulness training among novices after very short periods of mindfulness meditation practices. For example, Tang et al. (2007) measured sustained attention after just a 5-day retreat, and Polak (2009) after a 2-session mindfulness meditation practices. Further, Mcmillan et al. (2002) utilized a sample of participants with traumatic brain injuries (TBI), which may have affected the generalizability of observed results. Therefore, it is plausible that brief mindfulness trainings may not be an effective strategy for increasing sustained attention abilities, however intensive practice similar to Jha et al. (2007) may produce significant improvements in the sustained attention network. In sum, Chiesa and colleagues (2011) highlight previous empirical investigations of the impact that mindfulness may have on sustained attention and conclude that the availability of research at this time makes it impractical to ascertain a causal relation.

Mindfulness and the Orienting Network

Chiesa et al. (2011) outlined eight studies, which evaluated the effects of mindfulness meditation practices on selective attention (i.e., orienting network). Four of the included studies were prospective, and the remaining four were case-control investigations. The only non-randomized control trial (Jha et al., 2007) of the prospective studies was the single investigation that observed significant changes in selective attention following mindfulness training. In addition to the previously mentioned sustained attention investigations, Jha et al. (2007) also explored the effects of mindfulness meditation practices on selective attention as measured by the Attention Network Test. Novice meditators who were assigned to the mindfulness-based stress reduction group demonstrated significant improvements in selective attention when compared to the experts who completed the intensive month-long retreat, and the novice control group. The results suggest that novices who are in the early stages of meditation practice are able to enhance their ability to direct and limit attention to a subset of potential inputs following the beginning stages of practice (Chiesa et al., 2011; Jha et al., 2007). Jha and colleagues (2007) postulated that the expert mindfulness group may not have demonstrated significant changes as their meditation practices were focused on open monitoring faculty, which is hypothesized to impact sustained attention (see previous section).

The remaining prospective studies (Polak, 2009; Tang et al., 2007; Mcmillan et al., 2002) did not observe significant changes in levels of selective attention following mindfulness training. As previously mentioned, the relatively brief mindfulness training may be related to the insignificant findings of Polak (2009) and Tang et al. (2007), and the clinical population of participants with TBI in Mcmillan et al. (2002). While Polak (2009) did not observe a significant difference in selective attention between groups, results did indicate a significant positive relation between increases in selective attention and self-reported mindfulness levels (Chiesa et al., 2011). This may indicate a dosage effect in which the participants who regularly and consistently practice mindfulness meditation were among the participants who increased selective attention abilities.

Although there were specific differences across studies, all four of the case-controlled investigations reported significantly higher scores of selective attention among long-term or expert meditators as compared to novice controls (Chiesa et al., 2011). For example, Chan and Woollacott (2007) measured selective attention with the Global Local Letters task among 50 meditators and 10 control subjects. The Global Local Letter task (Chan & Wollacott, 2007) requires participants to read letters that consist of many tiny letters, and then are asked to process either the large letter or the smaller letter that makes up the larger letter (Chiesa et al., 2011). Results indicated no significant correlations between the congruency effect score and meditation practice, however meditation experience (e.g., meditation minutes/day) was associated with significantly faster response times in the global condition. These results suggest that meditation experience may enhance one's general performance on selective attention tasks (Chiesa et al., 2011; Chan & Woollacott, 2007).

Hodgins and Adair (2010) provide further evidence of the impact that mindfulness may have on selective attention. The authors measured selective attention through a cued-response task among regular adult meditators and age-matched controls. The cued-response task in this study required participants to quickly categorize the letters "M" and "W", while valid, invalid, and neutral cues were presented. Results indicated that both meditators and non-meditators had shorter response times across valid cue trials compared to invalid cue trials. However, the meditator condition demonstrated an increased ability to disengage more quickly from the incorrectly cued visual information, and re-direct attention towards new information. These results are further supported by van den Hurk et al. (2010) who observed that meditators had significantly smaller orienting network effects across response time data on the Attention Network Test than did novice controls, and Moore and Malinowski (2009) who observed a significant correlation between meditation experience and selective attention abilities using a comparable task of attention.

Taken together, previous prospective and case-controlled studies have provided some evidence to suggest that mindfulness practice may affect selective attention abilities. Chiesa et al. (2011) highlight that the previous research does not allow for any causal relations between mindfulness and selective attention to be inferred; however, there is preliminary evidence that meditation experiences are related to enhanced selective attention abilities. Further research into this area is needed to better understand the influence mindfulness may propose to selective attention.

Mindfulness and Executive Attention

Chiesa et al. (2011) outlined nine studies, which evaluated the effects of mindfulness practices on executive attention. Five of the included studies were prospective, while the remaining four were case-controlled investigations. Two of the prospective studies (Tang et al., 2007; Wenk-Sormaz, 2005) reported significant improvements in executive attention across separate measures.

Wenk-Sormaz (2005) explored if mindfulness can be used as an effective strategy to reduce habitual responding, or in other words, increase executive functioning. Participants were randomly assigned to an attention category including; mindfulness, learning, or rest condition, and were administered the Stroop Task (Stroop, 1935) both pre- and post-attention task. The mindfulness condition participants listened to a 20-minute guided breathing meditation, which asked subjects to focus on the somatic sensations of breathing. The Stroop Task (Stroop, 1935) provided a measure of executive attentional functioning by asking the subjects to ignore the habitual and automatized process of word reading, and instead attend to the less typical task of stating the color the word is printed (Chiesa et al., 2011). Results indicated that there were no significant differences between groups prior to the attention training; however, the mindfulness condition produced significantly lower levels of interference errors than both control groups post mindfulness training (Wenk-Sormaz, 2005). These results suggest that a relatively brief mindfulness meditation may impact executive attention abilities in terms of accuracy.

As previously reported, Tang et al. (2007) did not observe significant differences between the mindfulness condition and the control group among measures of sustained and selective attention. It is postulated that the relatively short mindfulness training of 5 days of 20-minute sessions was not sufficient to induce significant changes across sustained and selective attention as measured by the attention network test (Chiesa et al., 2011). Tang and colleagues (2007) also measured executive attention via the Attention Network Test and observed that the mindfulness group exhibited greater improvements in conflict scores. Put another way, results indicated that the mindfulness group's executive attention scores on the attention network test were significantly more efficient than the control group's scores, and these differences were not observed prior to the mindfulness training (Tang et al., 2007). These results further suggest that brief mindfulness interventions may impact the executive attention network in terms of increased efficiency of information that can be prioritized or managed.

In addition to investigations of sustained and selective attention previously mentioned, Jha et al. (2007) also measured executive attention as measured by the Attention Network Test. During baseline assessments, results indicated that the expert meditators displayed improved executive attention abilities compared to both groups of novices (e.g., the mindfulness-based stress reduction condition and the waitlist control). However, no significant differences were observed post training, which included an intensive 1-month retreat for the expert meditators, and an 8-week mindfulness-based stress reduction course for one condition of the novices. The authors postulate that these findings may have been related to an improvement of the waitlist control group's performance, which may have been related to increased task exposure effects or related to potential floor effects in response time performance across the Attention Network Test (Jha et al., 2007; Chiesa et al., 2011). Polak (2009) and Anderson et al. (2007), obtained similar results. However, as previously stated, Polak's (2009) results may have been related to the short mindfulness training of only two sessions (i.e., the intervention was not successful in promoting increased mindfulness levels). The results pertaining Anderson et al. (2007) may have been related to the participants practicing a ten-minute mindfulness prime prior to the attentional measures, however the authors discuss that this is unlikely, and the reason for insignificant findings is unclear.

Chiesa et al. (2011) highlight three case-controlled studies that evaluated the relation between executive attention and mindfulness among mediators and control groups. Generally, significant differences were observed using the Stroop Task as a measure of executive functioning. For example, Chan and Woollacott (2007) observed that meditation experience as measured by minutes of meditation a day was negatively correlated with Stroop interference. These results suggest that the more an individual meditates a day is related to increased executive attention skills. Moore and Malinowski (2009) demonstrated congruent results in which positive correlations were observed between mindfulness practice and better Stroop Task performances. Using the Attention Network Test to measure executive attention, van Den Hurk et al. (2010) observed a marginally statically significant relation between meditation practice and error scores, while Josefsson and Broberg (2011) did not observe significant differences between meditators and non-meditators using the Stroop Task. Chiesa and colleagues (2011) outlined a possible explanation for the results of Josefsson and Broberg (2011) is related to the meditators that participated in the study had generally less meditation experience and other case-controlled studies discussed.

Taken together, previous prospective and case-controlled studies have provided some evidence to suggest that mindfulness meditation practice may affect executive attention abilities. Chiesa et al. (2011) highlighted both prospective and case-controlled studies that found significant improvements of the executive attention networks across multiple methods of assessments including the Attention Network Test and Stroop Task. However, there have been previous investigations into the relation between mindfulness meditation and executive attention that was either approaching significance (van den Hurk et al., 2010), or non-significant (Josefsson & Broberg, 2011). In sum, it appears that mindfulness practices may affect the executive attention network following brief interventions; however, further research is required to better understand the relation and the mechanism underlying.

Mindfulness and Reading

This portion of the literature review will review the limited research that has previously examined the relations between mindfulness and reading.

While focusing on the existing knowledge concerning the role of attention during reading, and past observations that mindfulness practices may strengthen attentional networks, it has been hypothesized that mindfulness interventions may be a viable strategy to improve reading skills and performances (Tarrasch et al., 2016). Mindfulness interventions designed to increase reading skills as predicted through changes in attentional networks is a relatively new scientific inquiry and has been only been explored empirically by a few researchers. Recent research (Tarrasch et al., 2016; Mrazek et al., 2013; & Thierry et al., 2016) has provided some preliminary evidence to suggest that mindfulness practices are a successful strategy to increase reading skills among individuals, while other studies have reported conflicting evidence (Idler, Mercer, Starosta, & Bartfai, 2017). Figure 1 outlines a visual model of the various process involved in reading and mindfulness.

Idler et al. (2017) utilized a restricted alternating treatment design among four students in grades 3 through 5 to evaluate if a brief mindfulness-based intervention was successful in increasing student reading performances. Specifically, treatment conditions were alternated between reading fluency and reading fluency combined with mindful breathing. Four students were referred by teachers for deficits in reading and attention skills as compared to same age peers. The authors added a brief mindful breathing exercise to evidence-based reading fluency interventions to examine if the intervention with the mindfulness component was more effective in terms of increasing student reading and attention skills, as well as decreasing stress. Dependent measures included the Verbal Knowledge and Matrices subtests from the Kaufman Brief Intelligence Test, Second Edition (KBIT-2; Kaufman & Kaufman, 2004) to obtain measures of cognitive functioning. Reading fluency was measured via the Oral Reading Fluency (ORF) probes from the Dynamic Indicators of Basic Early Literacy Skills, 7^{th} edition (DIBELS; Good & Kaminski, 2011). Student attention and stress were self-reported prior to intervention sessions by students indicating on a 0 to 100% scale how well they can currently pay attention, and how stressed they were in the moment.

Intervention sessions occurred twice a week for a period of six weeks, for a total of twelve sessions.

The reading fluency only (RF) intervention sessions lasted 12 minutes, and the mindfulness and reading fluency intervention (MB+RF) lasted 15 minutes. During the RF intervention sessions, instructional strategies included time repeated readings, modeling, and phase-drill error correction. The MB+RF condition included the same reading fluency interventions but required students to complete a 3-minute mindful breathing exercise prior to instructional strategies. Results indicated that there were no consistent differences in within-sessions gains in oral reading fluency between conditions within or across all students. Bayesian analyses revealed that only one student demonstrated a large effect size on measures of self-reported state attention and stress after the completion of mindfulness practices (Idler et al., 2017). Overall, these results suggest that a brief mindfulness practice may not be more effective than more traditional reading fluency interventions to impact oral reading fluency. However, it should be noted that two of the students possessed instructional level reading abilities prior to the intervention, and the other two students were one level below grade level. These ceiling effects and the relatively short mindfulness intervention may have led to the observed results.

Using a randomized controlled study, Mrazek et al. (2013) examined if a two-week mindfulness course would be effective in decreasing mind wandering and improving working memory capacity and reading comprehension. A total of 48 undergraduate students were randomly assigned to either a mindfulness or active control condition. The mindfulness group met for 45 minutes, four times a week for two weeks. Topics discussed and practiced in the mindfulness group included instructions about posture; increasing awareness of thoughts; staying present in the moment; focusing on the somatic sensation of breathing; and using the breath as an anchor while meditating. The mindfulness condition was asked to complete 10 minutes of mindfulness practice outside of class. During the active control nutrition condition, participants learned about nutrition science and applied strategies for healthy eating. Participants in this group were asked to complete a daily log of food intake to match the out-of-class requirements of the mindfulness condition.

A mixed factorial pretest-posttest design was utilized in which participants completed Graduate Record Examination (GRE) verbal-reasoning questions, the operation span task (OSPAN), and mind-wandering probes both before, and after the intervention sessions. Reading comprehension was specifically measured via GRE verbal-reasoning questions, excluding vocabulary-focused questions. The proportion of total questions answered correctly operationalized accuracy on the GRE questions. The operation span task was utilized to measure working memory capacity. During the operation span task, subjects were presented to-be-remembered stimuli with alternated unrelated processing tasks and asked to choose the sets of 3 to 7 to-be-remembered letters from a pool of 12 letters. Mind wandering was assessed once students completed the operation span task by having students indicate on a 5-point Likert scale how on on-task or off-task they were during the activity. Mind wandering was measured during the GRE questions by presenting mind wandering probes at unpredictable quasi-random intervals which asked subjects where their attention was previously located, and have participants keep a tally of the number of self-caught mind wandering instances.

Results demonstrated a significant condition-by-session interaction for each of the dependent variables. Specifically, relative to the nutrition condition, the mindfulness condition demonstrated significantly improved GRE reading comprehension scores, operation span task scores, less probe-caught mind wandering, and self-caught mind wandering. Additionally, a test of moderated mediation indicated that changes in mind wandering significantly mediated the effect of mindfulness training on dependent variables among participants who exhibited higher rates of mind wandering at pretest (Mrazek et al., 2013). Taken together, these results suggest that mindfulness practices may be a successful strategy for increasing student reading comprehension skills. It is important to note that this study did not directly measure attention in terms of the alerting, orientating, or executive network. However, it may be possible that the changes in mind wandering were associated with increases in executive attention skills.

Further evidence that mindfulness-based interventions may be useful to increase student reading performances was provided from Thierry and colleagues (2016). This study implemented a quasi-experimental design in which one cohort of students (n = 23) received the MindUp (Hawn Foundation, 2011) mindfulness curriculum during prekindergarten and kindergarten years, and the control group (n = 24) cohort received typical educational programming during the prekindergarten and kindergarten years. The MindUp (Hawn Foundation, 2011) curriculum was delivered across the entire school year for the intervention classrooms during both the prekindergarten and kindergarten years. Lessons focused on building student's self-regulation and self-awareness skills, and students were asked to engage in a mindfulness breathing exercise three times a day during prekindergarten. During kindergarten, the students continued practicing daily mindfulness breathing exercises. The active control classrooms received typical educational programming that included an organized classroom, rules and routines, and proactive management of behavior. In other words, the only difference between conditions was the inclusion of the MindUp curriculum in the intervention classrooms. Experimental measures administered at the beginning and end of prekindergarten for both cohorts included BRIEF-P for Preschoolers (BRIEF-P; Gioia, Espy, & Isquith, 2002) completed by teachers and parents. The BRIEF-P is a normative assessment of executive functioning skills that produces five scales; inhibit; emotional control; shift; working memory; and planning/organizing. The Peabody Picture Vocabulary Test – Fourth Edition (PPVT-4; Dunn & Dunn, 2007) was also administered at the beginning and end of prekindergarten to obtain a measure of English receptive vocabulary. At the end of kindergarten, students were administered the ISIP Early Reading Assessment (Mathes, Torgeson, & Herron, 2011) to obtain a measure of vocabulary, phonemic awareness, letter knowledge, alphabetic decoding, and listening comprehension.

Results indicated no preexisting differences at beginning-of-the-year scores across teacher and parent BRIEF-P reports and PPVT-4 scores. Teacher BRIEF-P reports indicated that children who received the MindUp curriculum showed improvements in executive functioning skills, specifically related to working memory and planning/organizing at the end of the first school year. Further, results indicated that there were not significant differences among the two conditions end-of-the-year PPVT-4 scores. However, total scores on the end-of-the-year ISIP scores when the children were in kindergarten indicated that the MindUp condition possessed significantly higher performances. ISIP vocabulary scores were also significantly higher for students in the intervention condition as compared to the active control cohort (Thierry et al., 2016). Taken together, this study suggests that a yearlong mindfulness intervention may be a viable strategy to increase student vocabulary and reading skills.

The strongest evidence of the role of attention in the relation between mindfulness and reading has been provided by Tarrasch et al. (2016). This empirical research investigated the effects of a mindfulness-based stress reduction training on adult participant reading and attention skills. Participants had been identified with Attention-Deficit/Hyperactivity Disorder (ADHD) (n = 13), dyslexia (n = 12), or both ADHD and dyslexia (n = 6). Dyslexia was identified using the TILTAN screening test (Friedmann & Gvion, 2003), which requires students to orally read 128 single words including word pairs and non-words. The specific dyslexia diagnosis guided the additional reading tests that were administered to each participant (e.g., diagnosis of surface dyslexia resulted in the continuation of surface dyslexia assessments). Performances on this screener were compared to 372 same-aged control students to determine the specific type of dyslexia among participants. Specifically, subjects were identified as demonstrating subtypes of dyslexia that include letter position, attentional, surface, vowel, or phonological dyslexia.

Sustained attention was measured using the Continuous Performance Test (CPT) reaction times. Selective attention was measured using a conjunctive search task (Tsal et al., 2005) in which participants were asked to search for a target stimulus immersed in distracters. Performance on this task was measured by response times, and the search slope which reflects the efficiency of the search process. Orientation of attention was measured via a cost-benefit paradigm with peripheral cueing with an exogenous cue (Posner, Snyder, & Davidson, 1980). This task required subjects to discriminate a stimulus that was preceded by an abrupt onset of a cue at the target's expected location, or the opposite side of fixation. Executive attention was assessed using a Location-Direction Stroop like task (Stroop, 1935). This task asked subjects to respond to the location or the direction of an arrow appearing on a screen, while also ignoring other irrelevant dimensions. Performances on this measure was assessed specifically by the mean response times and accuracy rates by subtracting congruent response times divided by the accuracy rates. This provided a measure of an interference effect for this task, which indicates the extent to which individuals were able to suppress conflicting or irrelevant information.

The mindfulness workshop included eight weekly 2.5-hour classes, a half-day retreat with intensive practices during the sixth week and asking participants to complete home practice for 45 minutes per day. The mindfulness curriculum was standard in which activities included body scan meditation, increasing awareness of thoughts and cognitions, noticing the transient nature of thoughts, and brief yoga exercises. Results indicated that most of the subjects with dyslexia (10 out of 12) committed fewer reading errors following the workshop. The average rate of reading errors decreased significantly from 12.7% (*SD* = 6.4%) prior to the mindfulness-based stress reduction clinic, to 9.7% (*SD* = 4.5%) post mindfulness training. Interestingly, it was also observed that reading surface errors significantly decreased post-mindfulness training. This suggests that more students read words more consistently via the lexical route as surface errors result from incorrect grapheme-to-phoneme translations. Results of attentional measures indicated that participants demonstrated significantly improved performances across sustained, selective, orientating, and executive attention measures. Specifically, results indicated a significant reduction in reaction times and fewer errors on all three subordinate attentional networks as measured by the attention network test. Overall, the recent results obtained from Tarrasch et al. (2016) shed insight into the possibility that mindfulness interventions may be a useful tool to impact reading deficits, and this mechanism is related to changes in attentional networks.

Aims of the Current Study

The purpose of the current research was to examine if a brief mindfulness-based intervention (MBI) was successful in increasing 7th grade student reading performance as compared to an active control condition. Further, the current study aimed to evaluate if potential changes in reading performances among students in the mindfulness condition were mediated through changes in executive attention. The executive attention network was chosen for the current research due to the previous literature concerning the relation between attention and reading, and attention and mindfulness. Specifically, previous research has demonstrated that selective attention is related to the development of early literacy skills (Vidyasagar & Pammer, 2010; Stevens et al., 2013; Casco et al., 1998), while sustained and executive attention are related to reading skills such as comprehension and vocabulary (Lam & Beale, 1991; Stern & Shalev, 2013; McVay & Kane, 2012). Further, previous evaluations of the relation between mindfulness and attention suggests that relatively brief mindfulness interventions may be a viable strategy to increase executive attention related skills (Jha et al., 2007; Wenk-Sormaz, 2005). The current research employed a relatively brief mindfulness intervention among 7th grade students, thus the executive attention network was the most viable attentional network to experimentally measure.

Aim 1: The present study first needed to determine if a relatively brief mindfulness-based intervention was successful in increasing both state and trait levels of mindfulness for students in the experimental condition. It was hypothesized that students who received the brief mindfulness-based intervention would demonstrate higher scores across both state (e.g., MAAS) and trait (e.g., CHIME-A) levels of mindfulness over the course of three measurements, and the students in the control condition would not display changes across these measures.

Aim 2: The current research examined if the brief mindfulness-based intervention was an effective strategy to increase student reading comprehension. Specifically, the participating English-Language Arts teachers indicated at the beginning of the study that the middle school completes STAR Lexile testing across three occasions. However, the participating middle school communicated that it was planning to discontinue STAR Lexile testing after the time 1 data collection period and prior to the time 2 data collection period. For this reason, students were administered AIMSweb Maze reading comprehension probes during time 2 and time 3 data collection periods. It is important to note that the participating school did ultimately administer three STAR Lexile tests throughout the school year (contrary to the earlier noted communications), and subsequently the current research obtained three STAR Lexile scores for each student, and two AIMSWeb Maze scores for each student. It was hypothesized that students in the mindfulness condition will demonstrate significantly higher gains on an experimentally administered measure of reading comprehension (e.g., MAZE), and school-based measures of reading comprehension (e.g., Lexile) as compared to students assigned to the active control condition.

Aim 3: The present study aimed to evaluate if changes in reading performance for students in the mindfulness condition were mediated through changes to executive attention skills as self-reported levels of mindfulness, reading, and measures of executive attention were administered three times across the school year. Specifically, this research intended to elucidate the mechanistic relations between mindfulness-based intervention and reading, and it was postulated that changes in executive attention would account for portions of the variance in reading outcomes in a mediational framework. It was hypothesized that students who received the brief mindfulness-based intervention would demonstrate significantly increased reading performances than students in the control condition, and that these changes would be partially mediated through increased executive attention skills.

Methods

Participants

According to the New York State Education Department, the participating school had 375 students across 6th, 7th, and 8th grade during the 2016-2017 school year. The middle school possessed a majority of male students (56%). Further, the participating school possessed a majority of Black or African American students (72%), followed by white (12%), Hispanic or Latino (7%), and multiracial (6%). The majority of the school was considered economically disadvantaged (84%), and 30% of the student population had an identified disability (New York State Education Department, 2018).

Eligibility criteria for this study included students being enrolled in a 7th grade English and Language (ELA) general education class and the ability to speak and comprehend English. All 7th grade students enrolled in ELA classes were recruited for participation in this study (5 classrooms; n = 96). Parents were approached for participation in this research via a recruitment letter and consent form brought to them by their child from school. The majority of the obtained sample (*n* = 56) was African American (n = 44), followed by White (n = 9), Asian (n = 2), and American Indian or Alaskan Native (n = 1). The sample included equal representations of males (n = 28) and females (n = 28). Ten of the students had an Individualized Education Program (IEP), and 80% of the sample qualified for free-or-reduced lunch (n = 45). Table 1 details the demographic characteristics of the students in each study condition. In sum, the obtained sample in the current research is representative of the participating school population as a whole.

Setting

The current study took place at a participating middle school that is located within an urban school district in a small city in New York State. The 7th grade students were selected for the current research via convenience sampling. Put another way, one of the two participating 7th grade teachers reached out to the researchers to express interest in conducting a mindfulness-based research project in the Spring of 2017. It is important to note that the students remained in their classroom assignment for the entire school year. In other words, students remained in the same English-Language Arts class and thus assigned the condition for the entirety of the current research project.

Myself and my academic advisor, Dr. Joshua Felver, met with teachers and administrators of the participating middle school to outline the current research, and consent was obtained both from the Syracuse University Institutional Review Board and from the participating school district. Written approval for the study was also obtained from the principal and two 7th grade English-Language Arts teachers. The present research was implemented in two participating 7th grade teacher's English-Language Arts classrooms. There was a total of five classrooms taught by both of the two English-Language Arts teachers, and approximately 120 students that were asked for assent and legal guardian consent to participate in the research project.

Legal guardians of students from these five classrooms were approached for consent via the students bringing home printed consent forms. Students were provided with a physical copy of the parental consent document to bring home during the first week of school. After obtaining legal guardian consent, students were asked for their assent. If students did not provide assent or if consent was not obtained, they were not administered the data collection measures as outlined in the following sections.

Measures

The current research included school measures as well as experimental measures. School measures included data that the middle school already collects, and experimental measures were collected on three occasions during a single class period in September, January, and May. Specifically, the experimental measures were collected in the week prior to the beginning of the mindfulness audio tracks being played in English-Language Arts classrooms (i.e., baseline or Time 1), during a school day January which marked the half-way point in the study (i.e., Time 2), and one week after the audio tracks had terminated in May (post-intervention or Time 3).

School measures. The measure and data described below were administered and scored by the participating middle school.

STAR Lexile Scores. The present research utilized STAR Lexile scores that were gathered at the participating school at three time points (e.g., September, January, & May). STAR Lexile reading assessment is a computer-adaptive, norm-referenced reading test in which students are required to choose the best word to complete a sentence (Bess, 2012). In other words, the STAR Lexile reading assessment is an adaptive measure used for achievement-level progress monitoring assessments to provide teachers with accurate reading scores for students in 1st through 12th grade (Adair, 2010).

To begin a STAR Lexile reading assessment, students are first presented with a grade appropriate passage that is intended to be read silently. The STAR Lexile reading assessment will then administer 25 items that are selected from a database of more than 1,200 multiple-choice questions that are developmentally appropriate for grades 1 through 12. The items are presented across two different formats that include vocabulary-in-context, and authentic-text passage. STAR reading assessments for students in 3rd grade or higher are presented 20 vocabulary-in-context items, followed by 5 authentic-text passages. The STAR Lexile reading assessments are not timed in the sense that student scores are not affected by how quickly she or he responds to an item. However, there are item time limits to ensure that the test continues to move smoothly, as well as supporting test security (i.e., in case a student left the computer station with the assessment open) (Adair, 2010; Renaissance Learning, Inc., 2015). The STAR Lexile reading assessment norms were recently updated in 2014 with over 1 million students in grades 1 through 12. The sample was deemed representative of the United States population in terms of geographic location, gender, race/ethnicity, socioeconomic status, and type of school (e.g., public and private). The STAR reading assessment for 7^{th} grade was reported to possess a 0.90 split-half reliability coefficient, and a 0.83 test-retest reliability coefficient (Renaissance Learning, Inc., 2015).

The STAR reading assessment outlined in the previous paragraphs produces a Lexile score, which is used to interpret student reading comprehension skills at the participating school. Lexile scores range from BR400L to 1825L, whereas the "BR" indicates a beginning reader score, and the "L" represents the Lexile measure. The Lexile score is a common scale for both text measure in terms of readability or text difficulty, and reader measure in terms of reading achievement (Renaissance Learning, Inc., 2015). A higher Lexile score represents a higher level of reading ability. Lexile scores are derived from having students complete a test of reading comprehension following reading a brief passage, and the score represents a prediction how well a reader will likely comprehend a text at a specific Lexile level. For instance, a student with a Lexile score of 1000L who reads a text with the same Lexile measure of 1000L will be expected to comprehend 75% of the text if read independently. The 75% comprehension rate has been determined as the target range as the student will likely comprehend enough information to understand the text but will provide optimal difficulty to keep the reader engaged (MetaMetrics, 2011).

The participating school administered the STAR Lexile assessment as a group to one entire classroom at a time. More specifically, the STAR Lexile assessment was administered by the participating school to classrooms of approximately 20 to 25 students, and administration occurred in the school library. Students completed the STAR Lexile assessment using computers in the library, and the assessment procedure was delivered by a reading specialist at the participating school.

Experimental measures. The measures described below were administered and scored by the first author and a research team at Syracuse University comprised of trained doctoral students and undergraduate students.

As previously mentioned, experimental measures were administered across three time points during a single class period to those students who were enrolled in the current research. Data were collected using tablet computers (iPad) that were provided. A portion of the experimental measures were administered through the Assessment of Neurological and Behavioral Function (NIH Toolbox) iPad application. The NIH Toolbox application is a collection of brief standardized batteries designed to measure neurological and behavioral indicators of cognitive, motor, emotional, and sensory health from individuals aged 3 to 85. The NIH Toolbox was normed using a large sample of 4,859 participants aged 3 to 85. The participants included were representative of the United States population, and English and Spanish speakers were a part of the normative sample. NIH Toolbox normative scores are available for each year of age between 3 and 17, as well as age ranges of 18-29, 30-39, 40-49, 50-59, 60-69, 70-79, and 80-85 (Health Measures, 2017).

NIH Toolbox Flanker Inhibitory Control and Attention Task. The NIH Toolbox iPad application includes a version of the Eriksen flanker task (Eriksen & Eriksen, 1974) that has previously been adapted by the Attention Network Test. The flanker task is a measure of executive attention in which participants are required to prioritize attentional resources among competing responses. During the flanker task participants are required to indicate the left-right orientation of a centrally presented stimulus while demonstrating inhibiting attention to possible incongruent stimuli on both sides of the central target (e.g., arrows on both side of a central picture such as a fish). During a portion of the trials the orientation of the flanking stimuli is congruent with the orientation of the central target arrow, while on other trials the flanking stimuli are incongruent (e.g., the arrows are pointing in opposite directions of the target).

The NIH Toolbox Flanker task scoring is based on a combination of accuracy and reaction times. Specifically, a 2-vector scoring method is utilized which uses accuracy and reaction times. This results in a computed score in which each vector score (e.g., accuracy and reaction time) is combined, resulting in scores that range in value from 0 to 10. It is important to note that accuracy is considered first for each individual. For instance, if accuracy levels of a participant are less than 80%, the final computed score is equal to the accuracy score. On the other hand, if the accuracy score is greater than 80%, the accuracy and reaction time scores are combined. As previously mentioned, accuracy scores range from 0 to 5 points, and participants are awarded 0.125 points for each correct response. In other words, the accuracy score is calculated by providing 0.125 points per correct response, or 0.125 multiplied by the number of correct responses (NIH Toolbox Scoring and Interpretation Guide for the iPad, 2016).

Reaction time scores are produced using each participant's raw, incongruent median reaction time score from the Flanker task. The median reaction time values are generated using only trials with correct responses, while reaction times greater than or less than to 100 milliseconds and reaction times no larger than 3 standard deviations from the individual mean are not included (i.e., scores capitated at +/- 3 standard deviations). Identical to the accuracy scores, reaction time scores range from 0 to 5 points. It is important to note that reaction time scores tend to be positively skewed, and therefore a log (Base 10) transformation is applied to each participant's median reaction time score. This results in a normal distribution of reaction time scores. Once the reaction time scores are calculated, they are added to the accuracy scores for each participant who achieved the accuracy criterion of better than 80%. If participants do not meet the 80% accuracy criterion, only accuracy scores are utilized. This combination of accuracy and reaction time scores are then converted to normative scores (NIH Toolbox Scoring and Interpretation Guide for the iPad, 2016). Overall, computed NIH Flanker scores can range from 0 to 10 via the 2-vector (i.e., accuracy and reaction time) scoring procedures, with high scores indicating stronger executive attention abilities.

Validation of the NIH Toolbox flanker task has previously been assessed using convergent and discriminant validity measures (Zelazo et al., 2013). Convergent validity has been assessed for participants aged 3 to 6 using the Block Design subtest from the Wechsler Preschool and Primary Scale of Intelligence, 3rd Edition (WPPSI-III; Wechsler, 2002). The Delis-Kaplan Executive Function Scales (D-KEFS; Delis, Kaplan, & Kramer,

2001) Color-Word Interference Inhibition raw score has been used for the convergent validity measures for participant ages 8 to 15. The NIH Toolbox flanker task was assessed to be positively correlated with WPPSI-III Block Design, r (81) = 0.60, $p <$ .0001, and with D-KEFS Inhibition raw scores, r (81) = 0.34, p = .002. Overall, the NIH Toolbox flanker task has previously demonstrated excellent test-retest reliability and adequate convergent validity.

The NIH Flanker task was administered in a group setting to whole classes by the first author and a team of Syracuse University doctoral and undergraduate students. More specifically, participating students were administered the NIH Flanker task using tablet computers that the first author provided for data collection. Each student sat at a desk with a divider set up to minimize visual distractions, and students were provided with headphones in which they were asked to listen to audio instructions that were outlined during the NIH Flanker task. Group administration of the NIH Flanker task occurred in the students' ELA classrooms with approximately 20 to 25 students present, and were delivered and proctored by the first author and trained Syracuse University doctoral and undergraduate students.

Comprehensive Inventory of Mindfulness Experiences – Adolescents **(**CHIME-A; Johnson et al., 2016). The CHIME-A was used to measure student's trait levels of mindfulness. Specifically, the CHIME-A is a 25-item scale that provides a measure of trait mindfulness across 8 factors that include awareness of internal experiences, awareness of external experiences, acting with awareness, accepting and nonjudgmental orientation, decentering and nonreactivity, openness to experience, relativity of thoughts, and insightful understanding. During the CHIME-A, participants are asked to answer 25 items with 6 Likert-style response items that range from “Almost Never” to “Almost Always”. The CHIME-A has recently been developed using the 37-item adult CHIME scale. Across five studies and four early adolescent samples, Johnson et al. (2016) have indicated that the CHIME-A has sound internal consistency and excellent model fit indices for each of the eight aforementioned subscales. The total score generated via the CHIME-A has demonstrated poor internal consistency, which may be linked to ongoing cognitive maturation during adolescence (Johnson et al., 2016). At the subscale level, the CHIME-A has demonstrated adequate internal consistency (α = 0.65 - 0.77) to assess student trait mindfulness levels. Additionally, the CHIME-A test-retest reliability measures for each subscale have been determined to range from r = 0.56 to r = 0.79. Johnson et al. (2016) discuss that the test-retest reliability of the CHIME-A is similar to psychometric properties of adolescent well-being scales that are often employed with adolescent samples. In the current research, the internal consistency was evaluated for the total score. The total score internal consistency was found to be adequate (see results sections), thus the CHIME-A was analyzed using the total score in the present study Finally, the CHIME-A has been correlated with other self-report mindfulness measures such as the Child and Adolescent Mindfulness Measure (CAMM; Greco et al., 2011), suggesting adequate construct validity (Johnson et al., 2016). Higher CHIME-A total scores represent higher levels of trait-level mindfulness.

The CHIME-A was administered to students electronically using tablet computers. More specifically, the first author and trained Syracuse University doctoral and undergraduate students administered the CHIME-A to the participating students using the Qualtrics application for tablet computers. Administration of the CHIME-A occurred in the participating students' ELA classroom with approximately 20 to 25 students present.

Mindful Attention Awareness Scale – state version (MAAS; Brown & Ryan, 2003). The MAAS was implemented to assess the short-term core characteristic of mindfulness (i.e., state mindfulness levels). During the MAAS, participants are asked to respond using Likert-style response options ranging from "Not at all" to "Very much". Specifically, the 5-item measure asked students about a receptive state of mind in which attention is informed by a sensitive awareness of what is occurring in the present moment (Brown & Ryan, 2003). The 5-item version of the MAAS has been reported to predict dispositional mindfulness, and to possess good internal consistency (α= .86 - .92). Additionally, the test-retest reliability of the measure has previously been determined as adequate as the intraclass correlation has been reported as 0.81 (p < .001), and the measure has been observed to possess no significant differences across a 4-week time frame without ongoing mindfulness intervention (Brown & Ryan, 2003; Pepping, Davis, & O'Donovan, 2015). Construct and content validity has been found to be adequate cross-culturally in the United States, The Netherlands, and China, as well with clinical samples (Johnson, Burke, Brinkman, & Wade, 2017). Overall, higher scores on the MAAS indicate higher levels of state-mindfulness.

The MAAS was administered to students electronically using tablet computers. More specifically, the first author and trained Syracuse University doctoral and undergraduate students administered the MAAS to the participating students using the

Qualtrics application for tablet computers. Administration of the MAAS occurred in the participating students' ELA classroom with approximately 20 to 25 students present.

Behavior Observation System for Students (BOSS; Shapiro, 2011). The BOSS modified observations were conducted for each mindfulness classroom during two time points (April & June) to collect data on student behavior while the mindfulness audio tracks were being played. Using 10-second observation intervals, a momentary time sampling procedure was used to categorize the student's engagement as either on-task (e.g., students were sitting quietly with eyes closed and appeared to be following along with the audiotrack). Student off-task (e.g., students talking to each other or using their cellular phone) behavior was categorized on a partial interval basis as off-task motor (e.g., walking around the classroom), off-task passive (e.g., completing an activity not related to the audiotrack), or off-task verbal (e.g., communicating while audio track was being played). For purposed of this research, the three off-task categories were combined for a total off-task percentage score. In addition, BOSS observations were conducted for the whole class. In other words, there was not one single target student for the observation, rather the observer would rotate the target child under observation throughout the entire observation period, changing a to a new child during each 10-s interval. The final product of this method was a composite student made up of all students in the classroom, representing the classroom's behavior during the observation period. This data was used as an index as to the extent to which the students were on- or off-task while the mindfulness audio tracks were being played in the intervention classrooms. Finally, the first author conducted these BOSS observations for each intervention classroom, and therefore was not blind to the experimental design and hypotheses. It is important to highlight that the BOSS observation procedure deviates from the standardized methodology for the BOSS observation, but the current research was not interested in obtaining on- and off-task rates of behaviors for a single student, but instead on- and off-task rates of behavior for an entire class while the mindfulness audio tracks were played in the intervention classrooms.

AIMSweb Maze (Shinn & Shinn, 2002) is a norm-referenced, standardized curriculum-based measurement tool used to assess reading comprehension skills of students in grades 1 through 12. The AIMSweb Maze is a three-minute group administered reading comprehension assessment of fluency and comprehension. Each Maze passage is 150 to 400 words in length, and the raw score is the number of targets correctly identified within the three-minute time limit (Vaugh et al., 2010). AIMSweb Maze passages include both narrative and expository text, and students are presented with a reading passage in which every seventh word is missing and instead replaced by three words. The student is required to select one of the three words that best completes the sentence. The AIMSweb Maze Manual (Shinn & Shinn, 2002) indicates that the standardized scoring procedure is to count the number of correct responses for each student at the end of the three-minute assessment period (Cullen, Alber-Morgan, Schnell, & Wheaton, 2014).

The AIMSweb Maze test has previously been shown to demonstrate moderate to high reliability estimates across grades. Alternate form reliability estimates among middle school students range from 0.27 to 0.91, but most pairwise comparisons range from 0.70 to 0.91. Tolar et al. (2012) have indicated that the alternate form reliability coefficient of 0.27 is due to a specific passage and does not reflect the general reliability of the Maze test. Further, the Maze assessment tool validity coefficients (i.e., correlations with other measures of reading comprehension) range from 0.51 to 0.72. In sum, the AIMSweb Maze assessment is generally considered both a valid and reliable tool to measure 7th grade students' reading comprehension, but there has been variability in reliability and validity coefficients that is likely due to studies including middle school samples tend to possess smaller sample sizes than elementary or high school research projects (Tolar et al., 2012).

AIMSweb Maze assessments were administered in a group setting that occurred in the students' ELA classrooms with approximately 20-25 students present. More specifically, the first author read the AIMSweb Maze instructions aloud to the participating students, and then the students were asked to complete two Maze probes. The first probe was not scored as it was designed to be a practice trial for the students. After the practice trial, the examiner asked if any students had questions, and then the students proceeded to complete the second Maze probe in a group setting. The Maze probes were completed using paper-and-pencil packets that were a part of the AIMSweb materials.

Kids Intervention Profile (KIP; Eckert, Hier, Hamsho, & Malandrino, 2017) was utilized during the time 3 data collection period to obtain a measure of intervention acceptability among the students who received the mindfulness intervention. The KIP is an 8-item measure designed to assess students' perceptions of academic interventions. Further, the scale includes a 5-point anchored scale that ranges from *not at all*, to *very, very, much*. Instead of using a traditional Likert-type scale, the KIP includes boxes of increasing sizes to provide students with a more developmentally appropriate indicator regarding the relative strength of their Likert scale responses. Higher scores on the KIP indicate greater intervention acceptability levels with possible total score range from 8 to 50. In general, a total score greater than 24 represents an acceptable intervention rating. Previous research indicates that the KIP possesses adequate internal consistency, test-retest reliability, and construct validity (Eckert et al., 2017)

The KIP was administered to the students in the mindfulness condition at Time 3 (i.e., post-intervention) as a group in the students' ELA classroom. More specifically, the students completed paper-and-pencil forms of the KIP and this procedure was proctored by the first author and a team of Syracuse University doctoral and undergraduate students. Approximately 20 to 25 students were in the classrooms when students completed the KIP.

Children's Intervention Rating Profile (CIRP; Witt & Elliott, 1985) was administered to the students in the mindfulness classrooms to gather a measure of student social validity. The CIRP is a seven-item measure that uses a six-point Likert-type scale in which students indicate how much they agree or disagree with statements about the fairness, acceptability, and potential side effects of a classroom-based intervention (i.e., the mindfulness audio tracks). Total scores across the CIRP can range from 7 to 42, with higher scores indicating increased levels of intervention acceptability. Previous research has demonstrated that the CIRP has adequate internal consistency reliability estimates ranging from 0.75 to 0.89 (Witt & Elliott, 1985; Felver et al., 2017).

The CIRP was administered to the students in the mindfulness condition at Time 3 (i.e., post-intervention) as a group in the students' ELA classroom. More specifically, the students completed paper-and-pencil forms of the CIRP and this procedure was proctored by the first author and a team of Syracuse University doctoral and undergraduate students. Approximately 20 to 25 students were in the classrooms when students completed the CIRP.

Intervention Fidelity was measured by having the participating ELA teachers completing a self-report log to indicate which school days they administered the MBI to the assigned classrooms. More specifically, both teachers were provided a binder and were asked to indicate if they administered the mindfulness intervention each school day throughout the duration of the study.

Procedure

English-Language Arts classrooms (*n* = 5) were randomly assigned to either the mindfulness intervention condition, or the active control condition. Specifically, classes were randomized via flipping a coin (i.e., heads meant the classroom would receive the intervention and tails would mean the classroom would be an active control). The intervention condition began each 7th grade English-Language Arts class with one of four mindfulness audio tracks. These mindfulness recordings were taken from the Learning TO BREATHE (L2B; Broderick, 2013) school-based mindfulness intervention curriculum, and are approximately 5 minutes in duration. Transcripts of the audio recordings can be found in Appendix A. The intervention classrooms received daily mindfulness audio tracks from September 2017, to May 2018. During these months, the control condition completed English-Language Arts “Do Now” programming tasks at the beginning of each English-Language Arts class that are discussed below.

The classrooms that completed the “Do Now” activities were considered an active control group rather than a treatment-as-usual (TAU) group for three primary reasons. First, the “Do Now” classrooms completed activities at the start of English-Language Arts class that were designed to be comparable to the experimental classroom mindfulness activities. Specifically, the “Do Now” activities were approximately 5 minutes in duration, identical to the mindfulness audio tracks that the experimental classrooms completed at the beginning of each class. Second, the “Do Now” activities were designed to increase student reading related skills, just as the current research evaluated if the mindfulness audio tracks were successful in increasing student reading comprehension skills. Finally, the “Do Now” activities are simply not TAU, and the participating teachers identified that the “Do Now” activities had previously been implemented on an inconsistent schedule. For the 2017-2018 school year, the active control classrooms completed the “Do Now” activities at the start of each English-Language Arts classroom, for the basis of comparing the effectiveness of the “Do Now” activities to the mindfulness audio tracks in terms of student reading skills.

The mindfulness audio tracks that were administered to the intervention classrooms across the 2017-2018 school year were components from the Learning to BREATHE (L2B; Broderick, 2013) standardized intervention. Learning to BREATHE is a mindfulness training and universal prevention program that is designed for integration into secondary education settings. The intervention uses concepts from Kabat-Zinn’s (1990) mindfulness-based stress reduction program, and aims to increase student levels of emotion regulation, stress management, compassion, and executive functioning abilities. (Broderick, 2013; Schoner-Reichl & Roeser, 2016). Previous empirical applications of the Learning to BREATHE intervention suggest that the curriculum may reduce levels of student stress, tiredness, psychosomatic complaints, and depressive symptoms, while also increasing levels of efficacy in affective regulation (Metz et al., 2013; Broderick & Metz, 2009; Bluth et al., 2016). The Learning to BREATHE intervention includes four mindfulness audio tracks that have been reduced from their original length of ~10 minutes to ~5 minutes in length. The four tapes are guided meditations that include the topics of body scan, awareness of feelings, practicing kindness towards self and others, and awareness of thoughts (Broderick, 2013). Each of these audio tracks align with the previously mentioned IAA theory (Shapiro et al., 2006) of the mechanistic underpinnings of mindfulness as each of the audio tracks ask students to intentionally pay attention to different variables (e.g., body, thoughts, feelings) with an attitude of non-judgment. Audio tracks were played daily at the beginning of each English-Language Arts class. It is important to note that both participating 7th grade teachers had concerns about the developmental level of their students, indicating that the audio tracks may be difficult for the students to comprehend. It was decided to use the original Learning to BREATHE audio tracks and not modify the tracks in any manner in part due to previous research which has implemented the Learning to BREATHE intervention with 7th and 8th grade ethnically diverse students (Fung, Guo, Jin, Bear, & Lau, 2016).

In addition to the daily mindfulness audio tracks, the intervention classrooms received three brief (approximately 5-10 minutes) mindfulness trainings throughout the year. The first training which occurred in September involved one of the researchers attending each of the intervention classrooms to explain what mindfulness is and answer any potential student questions. The second student training occurred in December in which the students completed a brief mindful listening activity. Specifically, one of the authors brought a bowl to each of the mindfulness classrooms. The bowl is hit with a small wooden stick which produces an auditory tone. The purpose of the activity was for the students to see how long they can hear the sound of the bowl, thus focusing ones' attention. The third training which occurred in April included a brief demonstration of mindful eating. In particular, the students were presented with doughnuts, and completed a brief mindfulness demonstration in which the students practiced paying attention to different sensory elements involved with eating.

Both participating teachers received a brief training concerning the implementation of the audio tracks prior to the beginning of the intervention. Specifically, both teachers were provided digital versions the four mindfulness audio tracks in which the files were transferred to the classroom computer. The teachers were instructed on how to play each audio file (i.e., where the audio track is digitally stored on the computer & how to adjust the speaker volume). In addition, both teachers were provided with identical manuals that stated which mindfulness audio track (e.g., tracks 1 through 4) should be played on each school day.

During the months of September to May, the control classrooms completed the "Do Now" activities daily during the beginning of English-Language Arts classes. The "Do Now" activities are typical reading requirements that occur at participating middle school. The "Do Now" activities are brief, 5-minute tasks that typically require students to answer a question pertaining a novel that is being read in class, or practice using vocabulary or literacy terms that a part of the 7th grade English-Language Arts curriculum. An example of a “Do Now” activity would be for students to answer questions on a worksheet that asks who the primary characters of a novel that is a part of the English-Language Arts curriculum or define vocabulary words from the previous days lecture.

It is important to note that the participating teacher’s role across both conditions was equally passive. For instance, in the mindfulness condition, the teachers were simply instructed to press play on the audio track and observe the students practicing mindfulness. Similarly, in the active control condition the teachers would hand out the “Do Now” activity and observe the students complete the brief assignment. In sum, the teachers employed a passive role during the five-minute period of both the mindfulness and control conditions.

Experimental measures were administered to students enrolled in the research during a single class period across three time points. The participating teachers agreed to use English-Language Arts class time to administer experimental measures during all three time points. Time one data was collected during an English-Language Arts class period in September in the week prior to the mindfulness audio tracks beginning. Time two data was collected during a school day in January which roughly marked the half-way point in the current study. Time three data was collected during an English-Language Arts class in May after the mindfulness tracks had terminated. As previously mentioned, data collection occurred via the students using the NIH Toolbox application and online questionnaires on tablet computers that the authors provided. During data collection time points, trained research assistants who are a part of Dr. Joshua Felver’s Mind Body Laboratory assisted the students with using the NIH Toolbox applications and tablet computers. In addition, I was present during data collection time points to assist with any student questions or concerns that arose.

Data Analysis Strategy

Aim 1

In order to explore if the brief mindfulness-based intervention was an effective strategy to increase student state and trait levels of mindfulness, a two-way repeated measures analysis of variance (ANOVA) was utilized. A two-way repeated measures ANOVA is advantageous as it allows for interaction effect analyses between the two factors (e.g., time and condition) on the dependent variables. A two-way repeated measures ANOVA was conducted for two different dependent variables, namely the CHIME-A total score, and the MAAS total score. The present study did not adjust for alpha for multiple comparisons as the two dependent variables measure different components of mindfulness. In particular, the CHIME-A provides an index of trait level mindfulness, whereas the MASS will provide an index of state level mindfulness.

For analyses of both the CHIME-A and MAAS, the between-subjects factor was the group assignment (e.g., mindfulness or active control). For one analysis, the within-subjects factor was the CHIME-A scores for time 1, time 2, and time 3. For the other analysis, the within-subjects factor was the MASS scores for time 1, time 2, and time 3. Prior to the two-way repeated measures ANOVA analyses, assumptions of this statistical test were conducted. First, there was an evaluation to determine if significant outliers exist in the data. Second, the normality of the distribution of both dependent variables was assessed using the Shapiro-Wilk test and visual inspection of score distribution obtained from a histogram. Next, the sphericity was assessed to ensure the variances of the differences between all combinations of related groups are equal. To assess this assumption, a Mauchly's Test of Sphericity was completed. Finally, the current study had 5 main analyses planned due to the 5 main dependent variables (e.g., CHIME-A, MAAS, STAR Lexile, AIMSweb Maze, & NIH Flanker scores). For this reason a Bonferroni correction was used to lower the alpha level from 0.05 to 0.01 (0.05 / 5 = 0.01) for analyses in Aim 1 and Aim 2.

Finally, two-way repeated measures ANOVAs were completed using only Time 1 and Time 2 CHIME-A and MAAS total scores as the dependent variables. The rationale for conducting these analyses was to explore if differences exist between Time 1 and Time 2, as the initial hypothesis predicted differences from Time 1 to Time 3. These analyses were completed in addition to the aforementioned tests using Time 1, Time 2, and Time 3 values as the dependent variables to explore if there were significant differences on self-reported levels of mindfulness between the intervention and control classrooms from September, January, and May. In other words, a final set of two-way repeated measures ANOVAs were completed using only the September (e.g., Time 1) and January (e.g., Time 2) data.

Aim 2

In order to explore if the brief MBI was an effective strategy to increase student reading performances, a two-way repeated measures ANOVA was conducted similarly to the steps outlined in Aim 1. A two-way repeated measures ANOVA was conducted for the dependent variable, namely the AIMSweb MAZE and STAR Lexile reading comprehension scores. For one analysis, the between-subjects factor was the group assignment (e.g., mindfulness or active control) and, the within-subjects factor was the AIMSweb MAZE reading comprehension scores for time 2, and time 3. For the second analysis, the between-subjects factor was the group assignment, and the within-subjects factor was the STAR Lexile scores for Time 1, Time 2, and Time 3. Prior to the two-way repeated measures ANOVA analysis, outliers, normality, and sphericity were assessed using the previously described methods. If a statistically significant interaction was observed, a post hoc test was employed. A statistically significant interaction would indicate that the relationship between a factor (e.g., condition assignment) differs by the level of the other factor (e.g., AIMSweb MAZE reading comprehension scores across 2 time points). Finally, the current study had 5 main analyses planned due to the 5 main dependent variables (e.g., CHIME-A, MAAS, STAR Lexile, AIMSweb Maze, & NIH Flanker scores). For this reason a Bonferroni correction was used to lower the alpha level from 0.05 to 0.01 (5 / 0.05 = 0.01) for analyses in Aim 1 and Aim 2.

It is important to note that *a priori* power analyses were not conducted for Aim 1 or Aim 2 of the current research. While an *a priori* power analysis for Aims 1 and 2 would have yielded important information concerning rates of Type I and Type II error rates, the current study was limited in the maximum number of participants. Namely, the current research was conducted with five 7th grade ELA classes, and attempts were made by the research to obtain informed consent and assent for all of the students within these classes. Further, the current research was novel in that this project was the first empirical evaluation to examine the effectiveness of a brief mindfulness-based intervention on positively impacting student reading comprehension and executive attention performances. Due to the restrictions on the maximum number of participants and the lack of previous studies that conducted a similar intervention with middle school students, a power analysis was not conducted. Put another way, there is no representative existing study to base a power analysis off of for the current research.

Sex was included as a covariate in the repeated measures ANOVA evaluating the relation between condition assignment and reading comprehension scores (e.g., STAR Lexile & AIMSweb Maze). Sex was included as a covariate variable in these analyses as previous literature generally indicates that females outperform males on measures of verbal and language abilities and reading achievement with small to moderate effect size estimates (Reilly, Neumann, & Andrews, 2018; Lynn & Mikk, 2009).

Finally, a two-way repeated measures ANOVA was completed using only Time 1 and Time 2 STAR Lexile scores as the dependent variables. These analyses were completed in addition to the aforementioned tests using Time 1, Time 2, and Time 3 STAR Lexile values as the dependent variables. In other words, a final set of two-way repeated measures ANOVAs were completed using only the September (e.g., Time 1) and January (e.g., Time 2) data. It is important to note that there was AIMSweb Maze data only from Time 2 and Time 3, and therefore it was not possible to complete analyses using only Time 1 and Time 2 data for that variable

Aim 3

Mediation analyses were conducted to explore if potential changes in reading performances are partially mediated by changes in executive attention skills. Specifically, path analyses were completed to explore the indirect effects of group assignment mediated through changes to executive attention using AIMSweb MAZE reading scores as the dependent outcome. The current research utilized path analytics strategies rather than regression analyses for multiple reasons (Kline, 2016). First, path analyses allow for variables to correlate whereas regression analyses merely adjust for other variables outlined within a specific model. Second, path analyses account for measurement error whereas regression analyses assume perfect measurement of variables. Finally, path analytic techniques allow for the examination of mediated effects simultaneously, whereas regression analyses require multiple steps. The dependent variable in these analyses were the AIMSweb MAZE reading comprehensions scores at post-intervention (Time 3).

Prior to the path analyses, assumptions of this statistical method were evaluated. First, the data were evaluated to determine if the assumption of multivariate normal distribution has been satisfied. For instance, the skew index measure, which produces a score of symmetrically distributed data, was calculated for all continuous variables within the model (e.g., executive attention & STAR Lexile reading scores) (Kline, 2016). Second, bivariate scatterplots were created for continuous variables to ensure the data meets the assumption of linearity. Bivariate scatterplots were utilized as per recommendations by Kline (2016), due to the ease of detecting curvilinear relations from the associated graphs. Third, the data were examined to determine if univariate and/or multivariate outliers exist in the data. Kline (2016) has discussed the lack of a definitive definition of a univariate outlier but suggests that an outlier is data point is more than three standard deviations beyond the mean.

Multivariate outliers exist when a participant has two or more extreme scores or an unusual configuration of scores (Weston & Gore Jr, 2006). Following the recommendations of DeCoster and colleagues (2009) and Ruppert (1988), significant outliers were winsorized to the values associated with the 5^{th} or 95^{th} percentile. Fourth, the data was examined to search for missing data. Finally, the current research aimed to have an adequate sample size to ensure there is stability of the parameter estimates. Schreiber et al. (2006) have identified that there is no exact rule for the number of participants needed for path analysis analyses, but 10 participants per estimated parameter is the general consensus. This study includes 11 variance paths, 4 covariance paths, and 3 residual or error terms, for a total of 18 free parameters in the saturated model. Further, the current research has a sample of 56 students. Therefore, the current research will have a ratio of estimated parameters and participants that is lower than 10, thus considered underpowered. While underpowered, the present research will continue to conduct path analysis analyses to explore if potential changes in AIMSweb MAZE reading comprehension scores were mediated by changes in executive attention scores.

The current research was required to longitudinally adapt the classic model of mediation proposed by Baron and Kenny (1986), displayed in Figure 2. The classic model of mediation demonstrates a direct effect of the independent variable on the outcome or dependent variable (path “C’”). This model also includes indirect effects related to the mediator. Path “A” represents the indirect relationship between the independent variable and the mediator, while path “B” indicates the indirect effect of the mediator on the outcome or dependent variable. To test for mediation in this model, first a relation between the independent and outcome variable is established (e.g., path “C’”). Next, the relation between the independent and mediating variable is established (e.g., path “A”), and then the relation between the mediator and the outcome variable (e.g., “path B”). Finally, path “C’” is determined again while controlling for the indirect effect of the mediating variable.

The present research included data collection across three time points, and therefore needed to perform a longitudinal adaptation of the Baron and Kenny (1986) model presented in Figure 1. The current research tested a model in which the total effects of the independent variable (e.g., group assignment) on the dependent variable (e.g., AIMSweb MAZE scores) is represented as the direct effect of path “C”. The indirect effect (path “A” multiplied by path “B”) represents the proportion of the total effect of group assignment to the mindfulness or active control group on AIMSweb Maze reading scores that can be attributed to executive attention (i.e., mediator variable). The current study controled for scores across the dependent and moderator variable during the pre-intervention time point to account for changes occurring to participants over time that are not directly related to the independent variable. Figure 3 is a graphical representation of the theoretical mediaton model of Aim 3.

Results

Data Preparation

Data input and consistency checks. Highly trained doctoral psychology students, along with trained undergraduate research assistants were responsible for entering Maze reading comprehension data into a Microsoft Excel file. An additional researcher double-checked all imputed data to ensure accuracy and agreement, which was assessed to be 100%. The remaining data (e.g., NIH Flanker task, CHIME-A, &

MAAS scores) were extracted directly from the tablet computers into a Microsoft Excel file. Put another way, the data was taken from the tablet computer, and was automatically transformed into a Microsoft Excel file. At this point, data were transferred from Microsoft Excel to SPSS 24.0 (IBM Corp, 2013) SPSS version 24 was used to perform descriptive statistics as well as statistical analyses of Aim 1 and Aim 2.

As previously mentioned, the internal reliability of the CHIME-A total score was observed to be poor in the initial development and validation of the measure (Johnson et al., 2016). However, the CHIME-A baseline (i.e., Time 1) scores were analyzed using the total score in the current research as the reliability estimate of all 25 items ($\alpha = 0.82$) was considered to be adequate (George & Mallery, 2003). Further, the current research observed an adequate reliability estimate of all 5 items on the MAAS ($\alpha = 0.83$).

Data Screening

The first step in data analysis included the examination of normality and identification of outliers. The majority of the variables included in the subsequent analysis were found to be normally distributed, and data that was found to be skewed is described below. Variables in which the assumption of normality was violated are explained in the specific analyses with these variables. Additionally, there were outliers identified in the CHIME-A Time 2 and Time 3 data, NIH Flanker Time 2 and Time 3 data, Fall, Winter, and Spring Lexile data, as well as the Time 2 Maze Reading Comprehension and Maze Change Score variables. Following the recommendations of DeCoster and colleagues (2009) and Ruppert (1988), significant outliers were winsorized to the values associated with the 5^{th} or 95^{th} percentile.

Once normality and outliers were examined, missing data for all outcome variables were explored. Table 2 depicts the percentage of missing data for each variable at the three different time points in the original data set. Overall, the majority of dependent variables possessed more than 10% of missing data (range = 1.8% - 48.2%). Due to the vast amounts of data missing across the three time points, it was necessary to examine if the data was missing at random or due to systematic patterns. Little's missing completely at random (MCAR) test indicated that the data were missing at random, $\chi2$ (326, n = 29) 346.14, p = 0.212. Figure 4 is a graphical depiction of the flow of participants from informed consent to data collection at Time 3.

Once the data were assessed to be missing at random, multiple imputation methods were employed to address the missing values as almost all of the variables had more than the recommended 10% percentage of missing data (Clearinghouse, 2017). In broad terms, multiple imputation methods were utilized to complete simulations on the missing data relative to the observed data in an attempt to replace the missing values with data that is most likely similar to the observed data. Five imputation models were completed with all of the predictor and outcome variables, and the pooled mean for each variable was inputted as the missing value. In sum, the percentage of missing data in the current research required us to adhere to intention-to-treat principles (Milgrom, Negri, Gemmill, McNeil, & Martin, 2005). First, analyses were conducted using only observed cases (i.e., original data set with missing values). Next, analyses were executed once using the multiple imputation data under multivariate normal assumptions using procedures provided by Schaffer (1997), in which available demographic and dependent variable data was employed. Table 4 outlines the pooled mean that was inputted for each variable following the multiple imputation simulations.

Descriptive Statistics

The current research obtained signed parental consent and student assent from 56 total students. Across the three mindfulness classrooms there were 36 total students, and 20 students from the assigned control classrooms. More specifically, there were 13 students from Teacher B's 1st period class (mindfulness condition), 8 students from Teacher B's 10th period class (control condition), 8 students from Teacher A's 1st period class (mindfulness condition), 15 from Teacher A's 2nd period class (mindfulness condition), and 12 students from Teacher A's 5th period class (control condition). The majority of the sample was African American (n = 44), followed by White (n = 9), Asian (n = 2), and American Indian or Alaskan Native (n = 1). The sample included equal representations of males (n = 28) and females (n = 28). Finally, most of the students (n = 46) did not have an Individualized Education Program (IEP), and 80% of the sample qualified for free-or-reduced lunch (n = 45). There were a total of 10 students with an IEP included in the current research, 5 students in the control condition (Teacher B's 10th period class) and 5 students in the mindfulness condition (Teacher A's 1st period class).

As previously mentioned, the current study obtained parental consent and student assent from a total of 56 participants across the 5 participating classrooms. A total of 36 students were in classrooms that were assigned to the mindfulness condition and 20 students were in classrooms assigned to the active control classroom. At baseline, 28 students from the mindfulness classrooms completed the surveys and 16 students from the control classroom. Further, 35 students completed baseline STAR Lexile testing from the mindfulness classrooms and 19 students from the control classrooms. At Time 2, 18 students from the mindfulness classrooms completed the surveys and 28 completed the Maze assessment. A total of 24 students from the mindfulness classrooms completed the STAR Lexile at Time 2, and a total of 17 students from the control classrooms. During Time 2 data collection 15 students from the control classrooms completed the surveys and 20 completed the Maze assessment. During the post-intervention data collection period 21 students from the mindfulness classrooms completed the surveys and 27 students completed the Maze assessment. Further, 20 students from the control classrooms completed the surveys and Maze assessment. At post-intervention, a total of 29 students completed the STAR Lexile assessment from the mindfulness classrooms and 16 students from the control classrooms. Figure 3 is a visual depiction outlining the flow of participants throughout the study.

Descriptive statistics for pre-intervention measures (i.e., Time 1 data collection period) were analyzed using independent sample *t*-tests or one-way analysis of variances (ANOVA), depending on the number of levels of the independent variable (i.e., condition had 2 levels while class assignment had 5 levels). On the self-reported mindfulness levels (e.g., CHIME-A & MAAS), *t*-tests revealed no statistically significant differences between condition assignment (e.g., mindfulness or control), or between sex (e.g., female or male). Further, *t*-tests revealed that there were no differences in IEP status on CHIME-A at baseline, but there were significant differences between students with and without an IEP on the MAAS. Specifically, students without an IEP (M = 19.73;

SD = 6.74) had marginally significant higher MAAS scores at baseline than students with an IEP (*M* = 14.65, *SD* = 5.15), t (54) = 2.24, p = 0.029. One-way ANOVA analyses revealed that there were no significant differences on ethnicity on the CHIME-A and MAAS scores at baseline. Finally, one-way analyses suggest that there were not significant differences of class assignment on baseline CHIME-A scores, but there were marginally significant differences between class assignment on MAAS scores, F, (4, 51) = 2.92, p = 0.030. In particularly, post-hoc Tukey HSD tests indicate that Teacher A's 1st period class (*M* = 17.52, *SD* = 6.47) had significantly lower MAAS scores at baseline than Teacher A's 2nd period class (*M* = 20.83, *SD* = 6.41), and Teacher A's 5th period class (*M* = 21.12, *SD* = 7.16). Analyses with the original data set (i.e., the data with high rates of missing values) produced identical results as the aforementioned analyses with the multiple imputation data.

On the NIH Toolbox Flanker task, there were no significant differences between condition, sex, IEP status, class assignment, or ethnicity. Similarly, using the original (i.e., data with miss values) data set, identical results were obtained.

At baseline, there were no significant differences on Fall Lexile scores between conditions, sex, or by ethnicity. However, there were significant differences based on IEP status, and class assignment. For instance, students without an IEP (*M* = 638.11, *SD* = 245.46) were found to have marginally significant higher Fall Lexile Scores than students with an IEP (*M* = 437.25, *SD* = 232.34), t (54) = 2.37, p = 0.022). Further, there were significant differences between class assignment and Fall Lexile scores, F, (2,51) = 6.64, p = <0.001. Post-hoc Tukey HSD tests suggest that Teacher A's 2nd period class (*M* = 803.40, *SD* = 167.84) had significantly higher scores than Teacher B's 1st period class (*M* = 533.85, *SD* = 285.58), and Teacher A's 1st period class (*M* = 343.48, *SD* = 196.03). The same analyses with the original data with high rates of missing data produced identical results as the aforementioned analyses

Finally, descriptive statistics for the Time 2 Maze reading comprehension scores were computed. While this data does not reflect a true baseline as the intervention had already been occurring in the classroom for approximately four months, Time 2 was the first instance in which the students completed the Maze reading comprehension task. At Time 2, there were no significant differences on Maze reading scores between condition, sex, or ethnicity. However, there were significant differences between students with and without an IEP. Students without an IEP (*M* = 18.42, *SD* = 6.05) had marginally significant higher Maze Reading Scores at Time 2 than students with an IEP (*M* = 12.82*, SD* = 6.97), *t* (54) = 2.59, *p* = 0.012. Further, there were significant differences on Time 2 MAZE reading comprehension scores on class assignment, *F,* (4,51) = 4.16, *p* = 0.005). Post-hoc Tukey HSD tests indicated that Teacher A's 2nd period class (*M* = 20.94, *SD* = 5.713) and Teacher A's 5th period class (*M* = 20.17, *SD* = 5.29) had significantly higher Maze scores than Teacher B's 10th period class (*M* = 12.50, *SD* = 5.53). Again, analyses using the original data (i.e., data with missing values) were in agreement with the previous results. Analyses using the original data produced identical results as the multiple imputation data.

Results – Aim 1 (Self-reported State and Trait Mindfulness)

A two-way repeated measures ANOVA was conducted that examined the effect of condition assignment on self-reported CHIME-A trait mindfulness scores across time (e.g., Time 1, Time 2, & Time 3). Sex was included in this analysis as a covariate variable to explore if self-reported trait mindfulness levels differed between males and females. Mauchly's Test of Sphericity indicated that the assumption of sphericity had been violated, χ^2 (2) = 8.01, *p* = 0.018. Therefore, Greenhouse-Geisser corrections are reported for these analyses (ε = 0.86).

There was not a significant main effect of time on the dependent variable of CHIME-A scores, *F,* (1.75, 92.76) = 2.43, *p* = 0.100. Further, there was not a significant interaction between time and condition, *F,* (1.75, 942.76) = 1.42, *p* = 0.247, or between time and sex, *F,* (1.75, 92.76) = 0.10, *p* = 0.883 Similar results using the multiple imputation data were obtained while including class assignment as a covariate. The Greenhouse-Geisser corrections (*ε* = 0.89) were used as Mauchly's Test of Sphericity indicated that the assumption of sphericity had been violated, χ^2 (2) = 7.21, *p* = 0.027. There was not a significant main effect of time, *F,* (1.77, 93.85) = 0.25, *p* = 0.757, no significant interaction between time and condition *F,* (1.77, 93.85) = 2.34, *p* = 0.104, or significant interaction between time and class assignment *F,* (1.77, 93.85) = 2.40, *p* = 0.102. The same analysis using the original data (i.e., the data with missing values) produced slightly different results with sex included as a covariate (results were identical with class assignment as a covariate). According to the original data, there was a main effect of time, *F,* (2, 34) = 6.67, *p* = 0.004, η_p^2 = 0.28, but not a significant interaction between time and condition, *F,* (2, 34) = 3.10, *p* = 0.058, or between time and sex, *F,* (2, 34) = 1.19, *p* = 0.317).Table 3 outlines the CHIME-A Total Score mean and standard deviations, and Figure 5 is a graphical representation of the CHIME-A two-way repeated measure ANOVA with sex included as a covariate using the multiple imputation data.

A two-way repeated measures ANOVA was conducted that examined the effect of condition assignment on self-reported MAAS state mindfulness scores across time (e.g., Time 1, Time 2, & Time 3). Sex was included in this analysis as a covariate variable to explore if self-reported state levels of mindfulness differed between females and males. There was not a significant effect of time, *F,* (2, 106) = 1.22, *p* = 0.300. Further, there was not a significant interaction between time and sex, *F,* (2, 106) = 2.13, *p* = 0.124. Results did indicate a marginally significant interaction between time and condition on MASS scores, *F,* (2, 106) = 4.26, *p* = 0.017, η_p^2 = 0.074. Post-hoc tests revealed that MAAS scores from Time 3 (*M* = 15.63, *SD* = 6.63) were significantly lower than MAAS scores at Time 1 (*M* = 18.82, *SD* =6.73) and Time 2 MAAS scores (*M* = 18.70, *SD* = 5.24). Finally, post-hoc tests indicated that overall the control classrooms (*M* = 18.67, *SD* = 6.67) had higher MAAS scores than the mindfulness classrooms (*M* = 17.19, *SD* = 5.81).

Post-hoc independent sample t-tests indicated that there were no significant differences between conditions on Time 3 MAAS scores and Time 1 or Time 2 MAAS scores. When class assignment was included as a covariate using the multiple imputation data, results suggest that there was a marginally significant interaction between time and condition, *F,* (2, 106) = 3.87, *p* = 0.024, η_p^2 = 0.068. However, there was not a significant main effect of time, *F,* (2, 106) = 5.92, *p* = 0.772, or interaction between time and class assignment, *F,* (2, 106) = 6.48, *p* = 0.753. Table 5 outlines the MAAS Total Score means and standard deviations, and Figure 6 is a graphical representation of the two-way repeated measures ANOVA with sex as a covariate using the multiple imputation data. Identical results were obtained using the original data with high rates of missing values.

Next, the multiple imputation data was used to test for significant differences between Time 1 and Time 2. A two-way repeated measures ANOVA using only the Time 1 and Time 2 CHIME-A total scores, while including sex as a covariate produced similar results. Results suggest that that was not a significant main effect of time, F, (1, 53) = 2.31, p = 0.135, no significant interaction between time and condition, F, (1, 53) = 0.02, p = 0.885, and no significant interaction between time and sex, F, (1, 53) = 0.21, p = 0.646. With regards to the Time 1 and Time 2 differences on MAAS total scores, similar results were obtained. A two-way repeated measures ANOVA with sex included as a covariate variable suggests that there was not a significant main effect of time, F, (1, 53) = 1.03, p = 0.314, and no significant interaction between time and sex, F, (1, 53) = 0.43, p = 0.516. However, there was a marginally significant interaction between time and condition, F, (1, 53) = 5.22, p = 0.026, η_p^2 = 0.09. Identical results were obtained using the original data set with high rates of missing values.

Overall, results from the current research suggest that the brief daily mindfulness intervention was not successful in significantly increasing the self-reported trait mindfulness levels of the students who received the intervention as compared to the active control classrooms. Further, unexpected results were obtained while evaluating the self-reported state mindfulness levels between the intervention and control classrooms. Specifically, results indicate that there were significant differences between the two conditions across the three time points, with the active control classrooms reporting to have higher state-level mindfulness scores.

Results – Aim 2 (STAR Lexile Reading Comprehension)

A two-way repeated measures ANOVA was conducted that examined the effect of condition assignment on STAR Lexile reading comprehension scores across time (e.g., Time 1, Time 2, & Time 3). Sex was included in this analysis as a covariate variable due to previous literature outlining sex differences on measures of reading achievement and language-based assessments (Reilly, Neumann, & Andrews, 2018; Lynn & Mikk, 2009). There was a significant main effect of time on STAR Lexile scores, *F,* (2, 106) = 9.62, *p* = <.001, η_p^2 = 0.154. There was not a significant interaction between time and condition, *F,* (2, 206) = 2.27, *p* = 0.108, or between time and sex, *F,* (2, 106) = 2.21, *p* = 0.115. Post-hoc analyses indicated that Time 1 (*M* = 602.24, *SD* = 253.28) and Time 3 Lexile scores (*M* = 629.20, *SD* = 313.21) were significantly higher than Time 2 Lexile Scores (*M* = 526.91, *SD* = 343.95). The same analyses using the original data (i.e., data with missing values) provided identical results.

Next, class assignment was included as a covariate using the multiple imputation data. Results suggest that there was a significant effect of time, *F,* (2, 106) = 5.86, *p* = 0.004, η_p^2 = 0.10, and a marginally significant interaction between time and class assignment, *F,* (2, 106) = 3.27, *p* = 0.042, η_p^2 = 0.058, and a significant interaction between time and condition, *F,* (2, 106) = 3.81, *p* = 0.025, η_p^2 = 0.067. Identical analyses were obtained using the original data set with high rates of missing values. Table 5 outlines the STAR Lexile means and standard deviations for each condition at all three time points, and Figure 7 depicts the two-way repeated measures ANOVA with sex as a covariate variable using the multiple imputation data.

As previously discussed in the descriptive statistics analysis, there were significant differences between classes on STAR Lexile Reading Comprehension scores at Time 1. Specifically, Teacher A’s 2nd period class (a mindfulness classroom) had significantly higher Lexile scores than Teacher B’s 1st period class (a mindfulness classroom) and Teacher A’s 1st period class (a mindfulness classroom).

A one-way analysis of variance (ANOVA) indicated that there were also significant differences between classes on STAR Lexile reading comprehension scores at Time 3, *F,* (4, 55) = 15.97, *p* = <.001. Post-hoc analyses demonstrated that Teacher A’s 2nd period class (a mindfulness classroom; *M* = 922.97, *SD* = 235.85, *n* = 15) had significantly higher Lexile scores at Time 3 than Teacher B’s 1st period class (a mindfulness classroom; *M* = 569.78, *SD* = 239.43, *n* = 13), Teacher B’s 10th period class (a control classroom; *M* = 457.72, *SD* = 167.24, *n* = 8), and Teacher A’s 1st period class (a mindfulness classroom; *M*= 220.01, *SD* = 254.01, *n* = 8). Further, Teacher A’s 5th period class (a control classroom; *M* = 713.49, *SD* = 159.81, *n* = 12) had significantly higher scores that Teacher A’s 1st period class (a mindfulness classroom). Similar results were obtained with the original data (i.e., the data with missing values) when evaluating for differences between classes on STAR Lexile scores, *F,* (4, 40) = 15.43, *p* = <.001. The only notable differences using the original data, Teacher A’s 5th period class (*M* = 701.36, *SD* = 161.71) demonstrated significantly higher Time 3 Lexile scores than Teacher A’s 1st period class (*M* = 130.50, *SD* = 325.22). Table 7 outlines the STAR Lexile score means and standard deviations by the five different classrooms.

Next, the multiple imputation data was used to test for significant differences between Time 1 (e.g., Fall) and Time 2 (e.g., Winter) STAR Lexile scores. Specifically, a two-way repeated measures ANOVA using only the Time 1 and Time 2 STAR Lexile scores, and including sex as a covariate variable was conducted. Results were identical to the aforementioned analyses using all three-time points.

Overall, the results from the current research suggest that there were not significant differences between the mindfulness and active control classrooms on STAR Lexile scores. However, there was a significant main effect of time, with STAR Lexile scores at Time 1 and Time 3 being higher than STAR Lexile scores at Time 2. Finally, the results obtained indicate that there were significant differences on STAR Lexile scores between classrooms at Time 1 and Time 3.

Results – Aim 2 (AIMSweb Maze Reading Comprehension)

A two-way repeated measure ANOVA was conducted that examined the effect of condition assignment on AIMSweb Maze reading comprehension scores across time (e.g., Time 2 and Time 3). Sex was included in this analysis as a covariate variable due to the previous literature outlining sex differences on measures of reading achievement and language-based assessments. Results indicate that there was a significant main effect of time, $F,$ (1, 53) = 7.90, p = 0.007, η_p^2 = 0.130. Further, there was a marginally statistically significant interaction between the effects of condition and Maze time point, $F,$ (1, 53) = 6.79, p= 0.012, η_p^2 = 0.114. Finally, there was not a statistically significant interaction between the effects of sex and Maze time point, $F,$ (1, 53) = 2.97, p = 0.091.

Similar results were obtained using the original data (i.e., data with missing values). For instance, a main effect of time on Maze scores was observed, and a significant interaction between time and condition. However, with the original data, a marginally significant interaction between time and sex was also observed, $F,$ (1, 43) =

6.49, p = 0.014. Post-hoc independent sample *t*-tests indicated that there were no significant differences between females (*M* = 19.08, *SD* = 7.67) and males (*M* = 15.27, *SD* = 6.33) on Time 2 Maze scores, or between females (*M* = 21.07, *SD* = 7.16) and males (*M* = 20.29, *SD* = 6.96) on Time 3 Maze scores. However, an independent sample *t*-test demonstrated that there were marginally significant differences between males and females on the Maze change variable, t (44) = -2.09, p = 0.043. Specifically, males (*M* = 5.16, *SD* = 4.64) had significantly higher Maze change scores than females (*M* = 2.36, *SD* = 4.43).

Finally, class assignment was included as a covariate in the multiple imputation data set. Results suggest there was not a significant main effect of time, *F,* (1, 53) = 3.83, p = 0.056, or a significant interaction between time and class assignment *F,* (1. 53) = 0.07, p = 0.800. However, there was a marginally significant interaction between time and condition, *F,* (1. 53) = 6.06, p = 0.017, η_p^2 = 0.138. Table 8 outlines the AIMSweb Maze correct response means and standard deviations, and Figure 8 depicts the AIMSweb Maze two-way repeated measures ANOVA.

Post-hoc independent sample *t*-tests were completed once significant interaction was observed. Independent sample *t*-tests were utilized because all variables included had two levels. Results indicated that the mindfulness group did not significantly differ from the control group in terms of Maze scores at Time 2, t (54) = 0.27, p = 0.786. However, the mindfulness group did marginally significantly differ from the control group on Maze scores at Time 3, t (54) = 2.05, p = 0.045. Analyses with the original data (i.e., data with missing values) produced identical results.

Next, analyses were completed using a dependent variable that examined the amount of change in the number of correct items from Maze time point 2 and Maze time point 3. Put another way, this dependent variable was the difference of a participant's Time 3 Maze correct responses and Time 2 Maze correct responses (i.e., change score). Independent sample t-tests demonstrated that there was a marginally significant effect of condition (mindfulness M = 4.46, SD = 4.57, n = 36; control M = 1.70, SD = 3.01, n = 20), t (54) = 2.43, p = 0.019). Identical results were obtained with the original data (i.e., data with missing values).

As previously discussed in the descriptive statistics analysis, there were significant differences between classes on Maze reading comprehension scores at Time 2. Qualitatively, both teachers reported that Teacher A's 2nd period class and Teacher B's 5th period class included the high achieving 7th grade students. Specifically, Teacher A's 2nd period class (a mindfulness classroom) had significantly higher Maze reading comprehension scores than Teacher B's 10st period class (a control classroom). A one-way analysis of variance (ANOVA) indicated that there were also significant differences between classes on Maze reading comprehension scores at Time 3, $F,$ (4, 55) = 9.44, p = <.001. Post-hoc analyses demonstrated that Teacher A's 2nd period class (M = 27.23, SD = 5.51) had significantly higher Maze reading comprehension scores than Teacher B's 1st period class (M = 19.99 , SD = 4.48), Teacher B's 10th period class (M = 15.11, SD = 54.83), Teacher A's 1st period class (M = 17.42, SD = 6.37), and Teacher B's 5th period class (M = 21.15, SD = 6.46). Table 9 details the Maze reading comprehension scores by classroom for both Time 2 and Time 3 data collection period. Similar results were obtained completing the same analysis with the original data (i.e., data with missing values), *F,* (4, 42) = 9.98, *p* = <0.001. However, post-hoc tests indicated that significant differences existed Teacher A's 2nd period class having higher scores than Teacher B's 10th period class and Teacher A's 1st period class.

Overall, results from using the multiple imputation data and original data suggest that there were significant differences between the mindfulness and active control classrooms on AIMSweb Maze reading comprehension scores at Time 3. Specifically, the mindfulness classrooms had significantly higher Maze scores than the active control classrooms. Further, the mindfulness classrooms had significantly higher Maze change scores than the active control classrooms. While using the original data (i.e., data with missing values), results suggest that students in the mindfulness classrooms had significantly higher Time 3 Maze scores than the students in the control classrooms, and males had significantly higher Maze change scores than females. Finally, results also indicated that there were classroom differences on Maze scores at both Time 2 and Time 3.

Exploratory Analyses – Aim 2 (AIMSweb Maze Reading Comprehension)

To evaluate the clinical significance of the results, students' categorical placements in percentile ranks were evaluated. Using the original data (i.e., data with missing values), the number of students who fell in the Tier 1 category (e.g., at or above the 45th percentile), Tier 2 category (e.g., between the 15th and 44th percentile), and Tier 3 category (at or below the 14th percentile) were explored. At Time 2 (i.e., Winter norms), there were 5 students in the mindfulness classrooms who were in Tier 1, and 2 students from control classrooms. For Tier 2, there were 8 students from mindfulness classrooms and 10 from control classrooms. For Tier 3, there were 15 students from the intervention classrooms and 8 from the control classrooms. At Time 3 (i.e., Spring norms), there were 6 students from the mindfulness classrooms who fell within Tier 1, and zero students from the control classrooms. Further, there were 13 students from mindfulness classrooms who fell within Tier 2, and 11 students from the control classrooms. Finally, there were 8 students from mindfulness classrooms who fell within Tier 3, and 9 students from control classrooms. These observations further suggest that the students in the mindfulness classrooms experienced greater clinically significant gains across the Maze reading achievement assessment as compared to the control classroom students (Education, P., 2011). Table 15 displays the number of students in each tier at Time 2 and Time 3 by the two conditions.

Aim 3

Prior to any tests of mediation, a two-way repeated measure ANOVA was conducted that examined the effect of condition assignment on NIH Flanker computed scores across time (e.g., Time 1, Time 2, & Time 3). Sex was included in the analysis as a covariate variable to explore if there were differences between females and males on measures of executive attention. Mauchly's Test of Sphericity indicated that the assumption of sphericity had been violated, χ^2 (2) = 6.83, p = 0.033. Therefore, Greenhouse-Geisser (ε = 0.89) corrections are reported for these analyses. Results indicate that there was not a significant main effect of time, F, (1.78, 94.38) = 2.60, p = 0.086. Further, there was no significant interaction among time and condition, F, (1.78, 94.38) = 0.36, p = 0.361. Additionally, there was no significant interaction between time and sex, *F,* (1.78, 9.38) = 0.27, *p* = 0.742. Identical results were obtained using the original data set with high rates of missing values.

. Finally, class assignment was included as a covariate using the multiple imputation data. Mauchly's Test of Sphericity indicated that the assumption of sphericity had been violated, χ^2 (2) = 6.85, *p* = 0.033. Therefore, Greenhouse-Geisser (ε = 0.89) corrections are reported for these analyses. Results indicate that there was not a significant main effect of time, *F,* (1.78, 94.46) = 6.49, *p* = 0.999 Further, there were no significant interactions between time and condition, *F,* (1.24, 94.46) = 1.32, *p* = 0.270, or between time and class assignment, *F,* (1.78, 94.46) = 0.72, *p* = 0.475 Table 10 outlines the NIH Flanker Task means and standard deviations, and Figure 9 depicts the NIH Flanker Task two-way repeated measures ANOVA with sex as a covariate.

Next, the multiple imputation data was used to test for significant differences between Time 1 and Time 2 NIH Flanker scores. A two-way repeated measures ANOVA using only the Time 1 and Time 2 NIH Flanker scores, while including sex as a covariate produced similar results. For instance, results suggest that there was not a significant main effect of time, *F,* (1, 53) = 3.28, *p* = 0.076, no significant interaction between time and condition, *F,* (1, 53) = 0.09, *p* = 0.930, and no significant interaction between time and sex, *F,* (1, 53) = 0.34, *p* = 0.560. Identical results were obtained using the original data set with high rates of missing values.

The purpose of Aim 3 was to examine the mediation (i.e., indirect) effects of executive attention at Time 2 (i.e., NIH Flanker) on a measure of reading comprehension at Time 3 (e.g. AIMSweb Maze), while controlling for condition assignment, Time 1 executive attention scores, and the reciprocal relations between

Time 2 executive attention and reading comprehension. As previously stated, the a priori hypothesis for Aim 3 predicted that executive attention scores at Time 2 would partially mediate reading comprehension scores at Time 3, while controlling for condition assignment. It is important to highlight that results from path analysis can be interpreted similarly to generalized liner modeling (e.g., regression analysis). However, an advantage of path analysis included the ability to estimate complex causal relationships among multiple predictors, mediators, and outcomes simultaneously in a single model. In sum, Aim 3 was designed to evaluate the role of a mediating variable, namely executive attention (e.g., NIH Flanker scores) at Time 2, and a dependent variable at Time 3 (e.g., AIMSweb Maze) in a longitudinal model. Due to the previous two-way repeated measures ANOVAs suggesting no significant changes between Time 1 and Time 2 on measures of reading comprehension (e.g., STAR Lexile) and executive attention (e.g., NIH Flanker scores), the path model only included Time 3 reading comprehension as the dependent variable.

Descriptive statistics of the included variables were discussed in the previous sections, and were obtained using *SPSS*, Version 24. Next, *Mplus* Version 8 (Muthen & Muthen, 1998-2017) was utilized to test path models designed to evaluate mediation effects. Specifically, a Sobel first-order test was conducted to test significance of the mediator using the model indirect command. As an effect size measure for the mediating effects, 95% confidence intervals from 10,000 bootstrapped samples were obtained.

Path analysis was completed using the previously discussed multiple imputation data set, which thus resulted in the data having zero missing values. It should be noted that one variable, namely, the executive attention (e.g., NIH Flanker) Time 1 variable was slightly negatively skewed (skewness = -0.91). All other variables included in the model were normally distributed (skewness = -0.01 – 0.41; kurtosis = -0.47 – 0.18). Most of the variables were weakly to moderately correlated with each other (r = <0.01 – 0.76). Finally, multicollinearity was assessed with variance inflation factor (VIF) scores ranging from 1.11 to 1.74. Tables 5, 6, and 9 display the descriptive statistics, and Table 11 outlines bivariate correlations between study variables.

Aim 3 specifically hypothesized about the mediation effect of executive attention at Time 2 on reading comprehension at Time 3. However, a saturated path analysis model was completed that evaluated all of the direct paths displayed in Figure 10. As anticipated by previous analyses, condition assignment was not significantly related to AIMSweb Maze Time 2 scores (b = 0.23, SE = 0.28, β = 0.23, p = 0.416) or NIH Flanker scores at Time 2 (b = 0.23, SE = 0.28, β = 0.23, p = 0.416). However, condition assignment was significantly related with AIMSweb Time 3 scores (b = -3.51, SE = 0.91, β = -0.55, p = <.001).

NIH Flanker scores at Time 1 were not significantly related to Flanker scores at Time 2 (b = 0.09, SE = 0.13, β = 0.10, p = 0.504), or AIMSweb Maze scores at Time 2 (b = 0.35, SE = 0.67, β = 0.07, p = 0.598). However, Flanker Time 1 scores were significantly related to AIMSweb Maze score at Time 3 (b = 0.76, SE = 0.35, β = 0.15, p = 0.030).

Fall Lexile scores were not significantly related to Flanker Time 2 scores (b = 0.01, SE = <0.01, β = 0.13, p = 0.311). However, Fall Lexile scores were significantly related to AIMSweb Maze Time 2 scores (*b* = 0.01, *SE* = <0.01, *β* = 0.51, *p* = <.001), and AIMSweb Maze Time 3 scores (*b* = <0.01, *SE* = <0.01, *β* = 0.21, *p* = 0.003).

Next, six indirect mediation paths were assessed. First, the indirect effect from condition assignment to Maze Time 3 scores via Time 2 Flanker scores as a mediator. Second, the indirect effect on Time 3 Maze scores via Time 2 Maze scores as a mediator. Third, the indirect effect from Fall Lexile scores on Maze Time 3 scores via Time 2 Flanker scores as a mediating variable. Fourth, the indirect effect from Fall Lexile scores on Time 3 Maze scores via Time 2 Maze scores as a mediator. Fifth, the indirect effect from Flanker Time 1 scores on Maze Time 3 scores with Time 2 Flanker scores as a mediating variable. Finally, the indirect effect from Flanker Time 1 scores on Time 3 Maze scores with Maze Time 2 scores as a mediator. The total indirect effect consists of all paths from the predictor variable to the dependent variable mediated by both mediating variables in the model (e.g., Time 2 NIH Flanker & Time 2 Maze scores). The specific indirect effects are estimations of the predictor variable on the dependent variable while selecting a single mediating variable (e.g., Time 2 NIH Flanker or Time 2 Maze scores).

Results suggest that the total indirect effect from condition assignment to Maze Time was not significant (*b* = -0.29, *SE* = 1.03, 95% bootstrapped CI [-5.42- -1.83]). Further, the specific indirect path from condition assignment to Time 3 Maze scores via Time 2 Flanker scores as a mediating variable were not significant (*b* = 0.04, *SE* = 0.15, 95% bootstrapped CI [-0.13 – 0.57]). Additionally, the specific indirect path from condition assignment to Time 3 Maze scores via Time 2 Maze scores as a mediating variable were not significant (*b* = -0.33, *SE* = 1.02, 95% bootstrapped CI [-2.43 – 1.60].

Further, results suggest that the total indirect effect from Fall Lexile scores on Maze Time 3 scores were significant (*b* = <0.01, *SE* = <0.001, 95% bootstrapped CI [0.002 - 0.009]). The specific indirect effect from Fall Lexile scores on Maze Time 3 scores with Time 2 Flanker scores as a mediator was not significant (*b* = <0.01, *SE* = <0.01, 95% bootstrapped CI [<0.01 – <0.01]. However, the specific indirect effect from Fall Lexile scores on Time 3 Maze scores with Time 2 Maze scores as a mediating variable was significant (*b* = 0.01, *SE* = 3.90, 95% bootstrapped CI [<0.01 – 0.01].

Finally, results suggest that the total indirect effect from Flanker Time 1 scores on Maze Time 3 scores was not significant (*b* = 0.22, *SE* = 0.46, 95% bootstrapped CI [0.13 – 1.5]). The specific indirect path from Flanker Time 1 scores to Maze Time 3 scores with Time 2 Flanker scores as a mediator was not significant (*b* = 0.02, *SE* = 0.23, 95% bootstrapped CI [-0.12 – 0.29]. Lastly, the specific indirect effect from Time 1 Flanker scores on Time 3 Maze scores with Time 2 Maze scores as a mediator was not significant (*b* = 0.21, *SE* = 0.41, 95% bootstrapped CI [-0.91 – 1.00].

Traditional model fit indices (e.g., Chi-Square Test of Model Fit, Root Mean Square Error of Approximation, etc.) were not calculated as this model was fully saturated. However, the Bayesian Information Criterion (BIC) value of model fit was 878.37, and the sample-size adjusted BIC value was 821.79. Also, the Akaike Information Criterion (AIC) value of model fit was 842.91.

As Figure 11 displays, a second path model was used to test Aim 3 with three total paths removed from the fully saturated model. Specifically, the following paths were removed in the analysis (1) the effect from Flanker Time 1 on Maze Time 2, (2) the effect of Fall Lexile scores on Flanker Time 2, and (3) the relationship between Flanker

Time 2 and Maze Time 2. These paths were dropped for two primary reasons. First, the results from the saturated model suggested these effects were non-significant. Second, these paths did not align with the aforementioned theoretical model because it was not predicted that baseline executive attention scores would be associated with Time 2 reading comprehension scores, or baseline reading comprehension scores would be related to Time 2 executive attention scores.

Similar to the saturated model, the results from the model with dropped paths suggest that there was not a significant relation between condition assignment on Time 2 Flanker scores (b = 0.22, SE = 0.28, β = 0.22, p = 0.429), or between condition assignment and Time 2 Maze score (b = -0.45, SE = 1.66, β = -0.07, p = 0.789). However, results did indicate a significant relation between condition assignment on Maze Time 3 scores, (b = -3.51, SE = 0.91, β = -0.56, p = <0.01). Further, NIH Flanker scores at Time 1 were not significantly related to NIH Flanker scores at Time 2 (b = 0.11, SE = 0.12, β = 0.13, p = 0.376). Fall Lexile scores were significantly related with Time 2 Maze scores (b = 0.01, SE = <0.01, β = 0.52, p = <0.01), and Time 3 Maze scores (b = <0.01, SE = <0.01, β = 0.21, p = 0.003). Results also suggest that Time 1 Flanker scores were significantly related to Time 3 Maze scores (b = 0.76, SE = 0.35, β = 0.15, p = 0.30). Time 2 Flanker scores were not significantly related to Time 3 Maze scores (b = 0.19, SE = 0.41, β = 0.03, p = 0.636). Finally, Time 3 Maze scores were significantly related to both Fall Lexile scores (b = <0.01, SE = <0.01, β = 0.21, p = 0.003), and Maze Time 2 scores (b = 0.60, SE = 0.07, β = 0.61, p = <0.001).

Next, four indirect mediation paths were assessed. First, the indirect effect from condition assignment to Maze Time 3 scores with Time 2 Flanker scores as a mediating variable. Second, the indirect effect of condition assignment on Time 3 Maze scores with Time 2 Maze scores as a mediator. Third, the indirect effect from Fall Lexile scores on Maze Time 3 scores. Fourth, the indirect effect from Flanker Time 1 scores on Maze Time 3 scores with Time 2 Flanker scores as a mediator.

Results suggest that the total indirect effect from condition assignment to Maze Time 3 scores was not significant (*b* = -0.23, *SE* = 1.00, 95% bootstrapped CI [-5.42 - -2.08]). The specific indirect path between condition assignment on Maze Time 3 scores with Flanker Time 2 scores as a mediator was not significant (*b* = 0.04, *SE* = 0.15, 95% bootstrapped CI [-0.12 – 0.45]. The specific indirect effect from condition assignment on Maze Time 3 scores with Time 2 Maze scores as a mediator was not significant (*b* = -0.27, *SE* = 0.99, 95% bootstrapped CI [-2.29 – 1.32].

Results suggest that the specific indirect effect from Fall Lexile scores on Maze Time 3 scores with Maze Time 2 scores as a mediator was significant (*b* = <0.01, *SE* = <0.01, 95% bootstrapped CI [<0.01 – 0.01]). Finally, results indicated that the specific indirect effect from Flanker Time 1 scores on Maze Time 3 scores with Flanker Time 2 scores as a mediator was not significant (*b* = 0.02, *SE* = 0.07, 95% bootstrapped CI [-0.06 – 0.24]).

Model fit indices were evaluated for the constrained path model used to test Aim 3. A Chi-Square Test of Model Fit ($\chi 2 = 3.29$, $p = 0.349$), suggests that the imposed constraints did not result in a significant decrement in model fit. Further, the RMSEA estimate of 0.04 falls below the ideal threshold of <0.06. The CFI estimate of 0.99 and TLI estimate of 0.99 is above the > 0.95 threshold. The SRMR value of 0.06 is equal to the generally accepted threshold of 0.06 (Hu & Bentler, 1999). Finally, the AIC estimate result was 839.20, the BIC estimate was 869.58, and the sample-size adjusted BIC estimate was 822.44. These results suggest that the constrained path model generally demonstrated adequate model fit. Further, the AIC and BIC estimates are slightly lower for the constrained model as compared to the saturated model, with the sample-size adjusted BIC value being slightly higher for the constrained path model.

The final step for the analyses of Aim 3 was to complete a Chi-Square difference test between the saturated path model and the constrained model. The Chi-Square difference from the saturated model to the constrained model was 3.29 with 3 degrees of freedom being present in the constrained model. Results from the Chi-Square difference test suggests that there were not significant differences in model fit from the saturated model to the constrained path model with three paths dropped ($p = 0.349$).

Taken together, the results from the saturated and constrained path model suggest that the current research failed to find supporting evidence of Aim 3. Put another way, results indicated that executive attention scores at Time 2 (e.g., NIH Flanker) did not partially mediate reading comprehension scores (e.g., Maze) at Time 3. However, results did indicate that condition assignment is significantly related to reading comprehension scores at Time 3 (consistent with results obtained in from analyses related to Aim 2) and Fall Lexile scores are significantly related to Time 2 and Time 3 reading comprehension scores.

Classroom Observations and Intervention Acceptability/Fidelity

BOSS Observations

As previously identified, all three mindfulness classrooms were observed while the mindfulness audio track was being played on two occasions. BOSS observations were conducted to obtain a measure of on-task and off-task behavior while the audio track was being played in the classroom. During the first observation in April, the on-task behavior ranged from 71% to 83% (*M* = 76%), and the off-task behavior ranged from 17% to 33% (*M* = 24%). During the second observation in June, the on-task behavior ranged from 42% to 92% (*M* = 61%), and the off-task behavior ranged from 21% to 58% (*M* = 43%). Overall, the results suggest that the students displayed lower on-task behavior (e.g., sitting quietly and following along) during the mindfulness audio track intervention as the school year progressed. Qualitatively, both participating teachers reported that the students demonstrated less engagement with the mindfulness audiotracks in the last month of the school year. Teachers reported that the students indicated that they were beginning to become frustrated that the same four audiotracks were played throughout the entire school year. Table 12 summarizes the BOSS observations for each classroom at both time points.

Kids Intervention Profile (KIP)

The KIP was administered to the students (*n* = 27) who received the mindfulness audio tracks to obtain a measure of intervention acceptability. As previously reported, higher scores on the KIP indicate greater intervention acceptability levels, and possible total scores range from 8 to 50. Further, a total score greater than 24 represents an acceptable intervention rating as this score would be equivalent to the lowest positive indicator of the Likert-type scale (e.g., *some*). The overall range across the three-mindfulness classroom was 11 to 39 (*M* = 23). For the students (*n* = 8) in Teacher A's classroom, KIP total scores ranged from 11 to 25 (*M* = 19). For the students (*n* = 19) in Teacher B's classroom, KIP total scores ranged from 13 to 39 (*M* = 25). Therefore, results indicate that overall the students found the mindfulness audio tracks to be slightly less acceptable as the average score was less than 24. However, while evaluating KIP scores for Teacher A and Teacher B, it appears that the students in Teacher B's classroom found the mindfulness audio tracks to be an acceptable intervention. Table 13 outlines the descriptive results of the KIP for students' perceptions of the mindfulness intervention. In sum, total KIP scores suggest that the mindfulness intervention was slightly below the acceptable level. However, while evaluating KIP scores by Teacher A and Teacher B's classroom, it appears that Teacher B's students found the mindfulness intervention more acceptable than Teacher A's students.

Children's Intervention Rating Profile (CIRP)

As previously discussed, the CIRP was administered to the students in the mindfulness condition to obtain a measure of acceptability of the mindfulness audio tracks. Table 6 summarizes that the students somewhat agreed that the audio tracks were helpful for doing better in school and would be useful to use with other children. Further, CIRP data indicates that the students on average "somewhat liked" the mindfulness audio tracks and tended to agree that the participating teachers were harsh. Table 14 outlines the Children's Intervention Rating Profile mean responses for each item. Overall, the CIRP data suggests that the students in the intervention classrooms generally agreed that the mindfulness audiotracks were helpful for doing better in school, would be helpful for other students, and that their teachers were harsh.

Intervention Fidelity

As previously mentioned, intervention fidelity was measured by having the two participating ELA teachers completing a self-report log to indicate which school days they administered the mindfulness intervention to the assigned classrooms. Only one of the two ELA teachers provided the intervention fidelity self-report log at the conclusion of the study. Put another way, there is only intervention fidelity data for one of the two participating teachers (Teacher A). There was a total of 156 school days in which the students in the mindfulness classrooms could have completed the MBI at the beginning of their ELA class. Out of the 156 total school days, one teacher reported that she administered the MBI to the assigned classrooms on 115 school days (74% of school days). However, it should be noted that there were 26 days (17% of school days) in which this teacher did not record a response on the self-report intervention fidelity log. In other words, there is missing data for 26 school days in which it is unclear if the mindfulness audiotracks were played or not for the intervention groups in Teacher A’s classrooms.

Results: Discrepancies from Multiple Imputation Data and Original Data

As noted in the previous sections, the majority of aforementioned analyses completed with the multiple imputation data and the original data set with missing values produced identical results. However, there were three instances in which discrepant results were observed between the multiple imputation data and the original data set. First, analyses using the multiple imputation data suggested that there was not a main effect of time, or an interaction between sex and time or condition and time on CHIME-A scores. However, the same analysis with the original data suggests that there was a main effect of time, but no interactions between sex and time or condition and time. Second, analyses with the multiple imputation data and the original data observed significant differences on STAR Lexile post-intervention scores. However, there was a slight discrepancy between the results in which one additional significant class difference was observed with the original data (Teacher A's 5th period had higher scores than Teacher A's 1st period class). Third, there was a discrepancy found while analyzing AIMSweb Maze scores from Time 2 to post-intervention. The multiple imputation data did not observe a significant interaction between time and sex, while the same analysis with the original data found that there was a significant interaction between time and sex.

Discussion

According to the National Assessment of Educational Progress (NAEP), 37% of American 4th graders and 36% of 8th graders are considered at or above a proficient level as measured by the NAEP standardized reading comprehension assessment (National Assessment of Educational Progress, 2018). The current research was employed in a school district where 13% of 3rd and 8th grade students achieved a proficient level or above performance on the 2017 New York State English-Language Arts assessment (New York State Education Department, 2018). A central goal of education in the elementary grades is the development of reading comprehension as this skill provides the root for a substantial amount of learning in secondary school settings. Further, a lack of reading comprehension skills is associated with decreased academic motivation and progress (Alvermann & Earle, 2003; Guthrie et al., 2004).

Evidently, there is a need for school-based interventions designed to increase student reading comprehension skills.

The purpose of the present study was to evaluate the effectiveness of a daily mindfulness intervention on 7th grade students' reading comprehension skills. Further, this study evaluated if changes in student reading comprehension scores is mediated through changes in executive attention. Executive attention was chosen as a mediating variable due to the previous research indicating that executive attention mediates the relation between working memory capacity and reading comprehension (McVay & Kane, 2012), and the may be susceptible to changes following a brief mindfulness intervention (Jha et al., 2007; Wenk-Sormaz, 2005).

It is important to note that many results in the current research with not statistically significant, but some analyses were marginally statistically significant and warrant further interpretation.

Mindfulness Audiotracks and Self-reported Levels of Mindfulness

As previously mentioned, the first aim of the current research was to demonstrate that self-reported levels of mindfulness increased over time for the students in the mindfulness classrooms and not for the students in the active control classrooms. This specific research question was evaluated by examining student self-reported trait mindfulness levels (e.g., CHIME-A) as well as self-reported state mindfulness levels (e.g., MAAS) across three time points (e.g., September, December, & May). Results suggest that trait levels of mindfulness did not differ between intervention and control classrooms at any time point. With regards to the state-level MAAS analyses, there was a significant interaction between time and condition, indicating that the control classrooms had higher average state-level self-reported mindfulness levels than the control classroom.

Overall, the results from the current study suggest that the five-minute daily mindfulness audio tracks were not an effective strategy to increase student self-reported trait and state mindfulness levels. Further, analyses revealed that the control classrooms on average had significantly higher trait-level mindfulness scores, which is in the opposite direction of the Aim 1 hypothesis. This was an unexpected result; however, the readability of the self-reported trait and state-level mindfulness forms may have impacted the observed results. For instance, the trait-level mindfulness form (e.g., CHIME-A) was assessed to have a Flesch-Kincaid Grade Level readability score of 25.1, which is typically associated with college graduates and above. Next, the state-level self-report mindfulness form (e.g., MAAS) was assessed to have a Flesch-Kincaid Grade Level readability score of 5.2, which is typically associated with students in the 5^{th} grade. As was seen with the student Lexile and Maze scores, many of the students included in the current study were considered below Average on norm-referenced reading comprehension tests. Therefore, it is possible that the readability of the self-report levels of mindfulness may have biased the obtained results. However, further research should evaluate the usefulness and acceptability of using the CHIME-A and MAAS with 7^{th} grade populations, and evaluate if brief mindfulness interventions are an efficacious strategy to increase student self-reported levels of trait or state mindfulness levels.

Mindfulness Audiotracks and Reading Comprehension

The second aim of the current research explored if there were differences in Maze reading comprehension scores between the mindfulness and control classroom students. As previously reported, analyses indicated that there was a marginally statistically significant interaction between the effects of condition assignment and AIMSweb Maze scores as Time 3. Therefore, the present research provides preliminary support that mindfulness-based interventions may positively impact student performances on tests of reading comprehension. Finally, results suggest that there were no significant differences between conditions on STAR Lexile scores.

One possible explanation for to observed results in which students in the mindfulness condition experienced significantly greater gains on the AIMSweb Maze reading comprehension test than students in the control condition is a that a demonstration of regression towards the mean occurred. However, regression towards the mean is an unlikely explanation for the observed results for multiple reasons. First, post-hoc analyses indicated that there was a significant effect of condition and gender on AIMSweb Maze scores at Time 3. Second, it is important to note that there was a main effect of time on the Maze analyses. This suggests that students generally performed better on the Maze Time 3 assessment as compared to the Maze Time 2 assessment. However, the students in the mindfulness condition experienced significantly greater gains on the Maze Time 3 scores as the students in the control classrooms. In sum, it appears plausible that an explanation for the observed results is that the exposure to the mindfulness audio tracks was related to the large gains demonstrated by the students in the mindfulness condition. While further research is necessary to gain more insight concerning this topic, it is postulated that the students in the mindfulness classrooms may have been able to access the ELA curriculum better over the school year. Put another way, it is plausible that the students in the mindfulness classrooms may have been able to use the strategies learned from the audio tracks to ignore task irrelevant stimuli while in the classroom, and thus had greater access to the ELA curriculum.

It is important to note that there were preexisting differences between classrooms on the Maze assessments at Time 2. Specifically, Teacher A's 2nd period class (a mindfulness classroom) had significantly higher Maze reading comprehension scores than Teacher B's 10th period class (control classroom). At Time 3, there were still significant differences between the aforementioned classrooms. Further, at Time 3, there were significant differences between Teacher A's 2nd period class (mindfulness), and Teacher A's 5th period class (control), Teacher A's 1st period class (mindfulness), and Teacher B's 1st period class (mindfulness). Further research examining the benefits of mindfulness-based interventions on student reading performances may want to screen reading skills pre-intervention to ensure there are no significant differences at the start of an intervention.

Relations between Mindfulness, Reading, and Attention

Aim 3 of the current research was designed to evaluate if significant differences in measures of reading comprehension were partially mediated by changes in executive functioning skills. As previously discussed, the present study failed to find significant indirect (i.e., mediation effects) of Time 2 executive functioning skills on Time 3 reading comprehension abilities. Further, results suggest that there were no significant effects of condition assignment on measures of executive attention at any time point.

It is plausible that the non-significant results of Aim 3 may be due to the measurement of executive attention. For instance, the current study measured executive attention via the NIH Flanker task, while previous research studies have used other measures of executive attention such as the Stroop task, Attention Network test, and Semantic-Attention-to-Response Task. As previously discussed, there is some preliminary evidence that mindfulness-based interventions may positively impact executive attention skills, and executive attention is associated with reading performances. Therefore, it is plausible that the results from the current study may be related to the specific NIH Flanker measure of executive attention. However, future research should be completed to further explore if changes in reading comprehension performances following a mindfulness-based intervention are partially mediated through changes in executive attention.

As explained in depth in the current research, it was hypothesized that changes in students' reading comprehension scores would be partially mediated by changes in executive attention based on fields of research that pertain to mindfulness, the relation between reading and attention, and the tripartite model of attention. However, it is important to note Maynard and colleagues (2017) have provided an addition theory to explain the mechanistic underpinnings of mindfulness-based interventions that may translate to increases is student academic performances. Specifically, Maynard and colleagues have described the Logic model to outline how changes in students' behavior, academic performances, and social-emotional skills may change following a mindfulness intervention. Broadly, the Logic theory suggests that mindfulness intervention generally include elements designed to teach students how to become aware of their thoughts, feelings, and behaviors by paying attention in the present moment, with a particular attitude marked by openness and non-judgment. These practices are then believed to affect cognitive processes such as attention, self-regulation, executive functioning, working memory, emotion regulation, and provide physiological responses (e.g., muscle tension, breathing, etc.). These changes in cognitive processes are then postulated to lead to changes in students' behavior, academic skills, and social-emotional skills. In sum, while the current study hypothesized that executive attention would be the mediating variable in changes in reading comprehension following a brief mindfulness intervention, it may be possible that other cognitive processes such as self-regulation, executive functioning, and working memory acted as the mediating variable.

Limitations

Several limitations are important while interpreting the results from the present research. First, it is important to note that there were several threats to internal validity. For instance, efforts failed to achieve true randomization of participants. Specifically, there were differences across different classes and Maze reading comprehension and STAR Lexile scores at all time points. Further, there were preexisting significant differences between class assignment on the self-reported mindfulness MAAS questionnaire during the Time 1 data collection period. Finally, there were also preexisting baseline differences on STAR Lexile scores, Time 2 Maze scores, and MAAS scores among students with and without an IEP.

The current research experienced high rates of missing data, and thus employed multiple imputation methods to predict the missing values of the missing data. While analyses with the multiple imputation and original data with missing values were generally identical, the observed results should be interpreted with some caution due to the large percentages of missing data. However, it is important to note that there were only three instances in which discrepancies were observed between the multiple imputation data and the original data set with high rates of missing values. The discrepancies were relatively minor and did not affect the robust RM-ANOVA results (i.e., interaction between time and condition).

Other threats to the internal validity of the present research included the possibilities of experimenter and measurement bias. With regards to experimenter bias, it is important to note that that the experimenters and data collectors were not blind to study conditions and this may have influenced participant responding. Further, the students in the mindfulness condition had increased experience with the primary author as he completed multiple mindfulness demonstration to the intervention classrooms, which may have persuaded responding among these students. Further, there is a possible threat of measurement bias as Time 3 data collection (i.e., post-intervention) occurred in the month of June, just a few weeks before the school year terminated. Qualitatively, both participating teachers reported that the students during this time of the year generally display difficulties with concentrating, which may have influenced responding during data collection.

There are two threats to external validity that are present in the current research. First, the observed results may in part be due to an inadvertent selection biases that were related to the lack of true randomization of students. Second, the current research is vulnerable to an issue of sample bias. The students included in this research were limited to 7th grade students in an urban middle school setting, most of which who received a free or reduced priced lunch. This suggests that the observed results may not generalize to other student populations of different grades or socioeconomic backgrounds.

Directions for Future Research

There are a number of implications for future research. For instance, the current research was the first empirical evaluation of how a mindfulness-based intervention may increase student reading performances. Therefore, it is imperative for future research to attempt to replicate the current results and provide additional support for the effectiveness of mindfulness-based interventions to impact student reading comprehension test performances. Additionally, future research may wish to examine if mindfulness-based interventions are an efficacious strategy for positively impacting student performances in other academic areas such as writing, spelling and mathematics.

Central to mindfulness-based intervention studies is a question concerning the necessary dosage to impact the outcome variable. The present study observed differences in reading comprehension performances between the intervention and condition assignment at only Time 3, which translates to the students in the mindfulness classrooms having completed daily five-minute mindfulness tracks for approximately eight months. Therefore, future research may wish to explore the necessary dosage for daily mindfulness audio tracks to impact student reading performances by having more than three time points. Put another way, future studies could include more than three data collection time points or complete the study in less than eight months to explore if similar results are obtained. Additionally, it will likely be beneficial for future research to employ different mindfulness strategies to explore if similar results can be replicated. As an example, future work could complete the entire *Learning to BREATHE* mindfulness-based curriculum instead of only including the audio tracks to explore if a more in-depth mindfulness intervention changes the results from the current study.

Finally, it is important to highlight that student reported intervention acceptability levels generally indicated that they found the mindfulness audio tracks to be near or slightly below the acceptable level. Further, the teachers demonstrated a passive role while the audio tracks were being played, and one teacher qualitatively indicated that she would sometimes provide students with a grade for being on or off-task while the audio tracks were being played in the classroom. Future research may wish to explore how to increase student acceptability ratings of the mindfulness intervention and examine if there are changes in the results if a teacher plays an active role in the intervention (e.g., practices the mindfulness exercise with the students). Increasing student acceptability of the mindfulness intervention may be achieved by more variation in mindfulness exercises than the present study, and not having a grade attached to the mindfulness practice.

Conclusions

Many American students struggle across measures of reading comprehension (National Assessment of Educational Progress, 2018). It is imperative to design interventions to address student reading comprehension abilities as this skill is associated with overall academic progress and motivation and has serious implications for students' later societal and life outcomes (Okkinga, van Steensel, van Gelderen, &

Sleegers, 2018). Mindfulness-based interventions have generally been employed in schools to address behavioral and psychosocial variables (Felver, Celis-De Hoyos, Tezanos, & Singh, 2016). However, the current research is the first empirical evaluation of how a brief daily mindfulness-based intervention may impact student reading comprehension performances.

Results from the current research provide initial support for the notion that a brief daily mindfulness-based intervention may positively impact student reading performances, even as the current research failed to support that the mindfulness classrooms reported higher levels of state and trait levels of mindfulness as compared to the control classrooms. The current study postulated that changes in executive attention would mediate the changes in reading comprehension scores, with the results failing to find support for executive attention as the mechanistic underpinning of changes in reading comprehension. Future studies should first attempt to replicate these results and may also be interested in exploring how different mindfulness-based interventions may impact reading comprehension abilities as well as other academic skills such as reading, spelling and writing.

Appendix A: Mindfulness Audio Tracks Transcripts

1. Body Scan
2. Awareness of Thoughts
3. Awareness of Feelings
4. Loving-Kindness

1. Body Scan Audio Track Transcript

This body scan meditation is designed to help you relax and pay attention to how your body feels, and what it might be telling you.

It's a time to listen to your body, and to be in your body as fully as possible.

If you're sitting on a chair, sitting with your back erect, but not stiff. With both feet on the floor; hands comfortably in your lap.

Close your eyes if that's comfortable for you. Listen to, and follow my instructions, as best you can. Try to stay awake and alert.

Remember to breathe completely, and let the breath flow freely into and out of the body.

And when you notice your mind wandering, as it will, gently bringing it back to focus on the instructions.

Now become aware of the belly rising as the breath moves into the body, and falling as the breath moves out of the body.

Not controlling the breath in any way; just letting it find its own rhythm.

Feeling your body sink more deeply into the mat, or your chair, on each outbreath.

And now on the next inbreath, direct your attention on all the way down through your body to the soles of both feet.

Become aware of your toes, the arches of your feet, the place where the heels meet the floor.

Notice any feelings in your feet; any warmth or coolness; pressure; tingling or tightness.

And now direct your breath to your feet, imagining you could breathe right into your feet – first into your right foot – and now breathing into the left foot.

And on each outbreath, letting go of any tiredness, any tension, right from the soles of both feet.

Remember that whenever you find your mind wandering, just let go of the thoughts as gently as you can, and come back to focus your attention once again on your body.

Moving the attention to the belly. Feeling the movement of the abdomen as it rises and falls with each breath. Taking a deep breath in, allowing the abdomen to really expand on the inbreath, then releasing, breathing out, and noticing the feeling of the abdomen deflating.

Breathe into the chest and the abdomen, breathing in new energy, and letting go of any tiredness, or tension.

And now opening up your awareness, see if you can feel your breath moving easily through your whole body, as you sit in your chair, noticing the movement of the breath from your head, all the way down to your feet, and noticing how the breath moves freely and easily from your feet all the way up to the top of your head.

And as we conclude this practice, being fully aware of your body, as a whole, complete, strong, at ease.

BELL

2. Awareness of Thoughts Audio Track Transcript

BELL

This is a short meditation to cultivate present moment attention

We'll be paying attention to our breath as we did in the body scan

We'll also be practicing noticing and letting go of thoughts as we repeatedly bring our attention back to the breath

Remember that cultivating your breathing will take practice

When you find that your attention has wandered from the breath

Gently but firmly escort it back to the breath no matter how often this happens

We are practicing steadiness and balance

So putting down anything you might be holding and sitting back in your chair

With your head back and neck erect but not rigid

With your shoulders relaxed and your hands comfortably placed in your lap

Gently closing your eyes when you feel ready

And now becoming aware of the breath moving into and out of your body

Just notice it

Wherever you can feel it in your body

Perhaps the sensation of breath moving past your nostrils

Perhaps the rising and the falling of the chest

Perhaps the feeling of your belly expending with each in breath and deflating on each out breath

Just feeling the breath as it goes in and goes out
Without trying to control the breath in any way
Just letting the breath be as it is

And as you sit here watching your breath you may find yourself thinking about something you did or something you need to do
Something that happened to you
Or something that is going to happen
These are the kind of thoughts that occur spontaneously in our mind all the time
See if you can notice when a thought arises in the space in your mind
Just becoming aware that you are thinking
Notice the thought without trying to push it away
But just letting it go away on its own
And then directing your attention back to the breath

Focusing your attention on the sensations in your abdomen, at the nostrils or the chest
Just paying attention to the actual sensations of breathing

Staying awake and alert
Till each moment until the sound of the bell

BELL

3. Awareness of Feelings Audio Track Transcript

This is a short meditation to cultivate present moment attention. We'll be paying attention to our breath, as we did in the body scan. We'll also be practicing noticing, and letting go of thoughts and feelings as we repeatedly bring our attention back to the breath.

Remember that cultivating your attention will take practice. When you find that your attention has wandered from the breath, gently but firmly escort it back to the breath, no matter how often this happens.

We are practicing steadiness and balance, so putting down anything you might be holding, and sitting back in your chair, with your head, back, and neck erect but not rigid. With your shoulders relaxed, and your hands comfortably placed in your lap. Gently closing your eyes when you feel ready. And now becoming aware of the breath moving into and out of your body.

Just notice it. Where ever you can feel it in your body. Perhaps the sensations of breath moving past the nostrils. Perhaps the rising and the falling of the chest. Perhaps the feeling of your belly, expanding gently on each in-breath, and deflating on each out-breath.

And as you sit here watching your breath, you may notice that thoughts come into your mind. You may also notice feelings that arise. See if you can notice when a feeling arises. See if you can notice the feeling in some part of your body. Perhaps your stomach, your chest, your shoulders, your throat. Wherever it is, just be aware of it. Notice how the feelings shift and change, as you pay attention to them in your body.

You might think of feelings like surges of energy in your body. Sometimes soft and quiet. Sometimes strong and intense. Sometimes sharp and fast. Sometimes slow. Just see if you can observe all these energies without getting caught up in them. As best you can right now, try not to react or judge any of your thoughts and feelings. But just observing whatever comes into the space of your mind.

Just sitting here watching the show, as thoughts and feelings arise, are present for a while, and then fade away.

Just observe what arises, and coming back to the breath, staying open and awake in the present moment, until the sound of the bell.

BELL

4. Loving-Kindness Audio Track Transcript

BELL

Now for this short period of time let's practice a slightly different kind of meditation. One that will help us cultivate feelings of loving kindness to ourselves and others. Loving kindness practice is simply the wish that we enjoy peace, happiness, and wellbeing.

The important thing to recognize is that we can cultivate these attitudes, if we practice.

In so many ways we practice meanness to ourselves, so why not practice some kindness?

During the course of this practice, you'll be invited to repeat inwardly certain phrases or wishes. Once you get used to this, you can use only one or two. It's helpful not to try too hard to feel something, especially at first. Just do the best you can.

So now sitting quietly, just begin by tuning into the breath.

Notice that you're breathing.

And now bringing to mind a time when you felt loved.

This love may have come from a person, like a parent, a relative, a friend, a teacher, a coach, or even a pet.

Take whatever memory comes, and try not to judge it.

Make the memory as vivid as possible. Visualize the event. Recalling what was said. Re-experiencing the feelings associated with being loved. And notice what this feels like in your body right now.. Really tune into the experience of being loved at this time.

And now take the feeling of being loved and cared for, and direct this feeling towards yourself, offering the gift of loving kindness to yourself as you inwardly repeat the phrases:

May I be strong

May I be balanced

May I be happy

May I be peaceful

Inwardly repeating the phrases as you practice directing the feelings of kindness and compassion towards yourself.

May I be strong

May I be balanced

May I be happy

May I be peaceful

Now recalling the person, relative, friend, teacher, coach, stranger, or pet that you remembered before. And calling to mind the special qualities of this person or pet

Now direct feelings of loving kindness to them:

Just as I wish to be strong, may you also be strong

Just as I wish to be balanced, may you also be balanced

Just as I wish to be happy, may you also be happy

And just as I wish to be peaceful, may you also be peaceful

And now for the rest of this meditation practice, choose to continue to extend loving kindness to yourself, to the loving person, or if you wish bringing to mind someone in your life who has caused you difficulty.

Just as with a friend or loved one, you can practice extending loving kindness to the difficult person, with the same intention.

Just do the best you can.

May I be strong

May I be balanced

May I be happy

May I be peaceful

BELL

Appendix B: Tables and Figures

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Figure 9. NIH Flanker Task Two-way Repeated Measures ANOVA

Figure 10. Aim 3: Saturated Path Model

Figure 11. Aim 3: Constrained Path Model

Table 1.

Demographic characteristics by condition

Variable	Mindfulness (k = 3; n = 36)	Control (k = 2; n = 20)
Percent female	50%	50%
Percent with IEP	14%	25%
Ethnicity		
White	17%	15%
African American	78%	80%
Asian	6%	0%
American Indian/Alaskan Native	0%	5%
Percent Free/Reduced Lunch	75%	90%

Note. No significant differences were observed between the Mindfulness and Control conditions on sex, IEP status, ethnicity, and free/reduced lunch variables.

Table 2

Descriptive Statistics: Percentage of missing data

Variable	Percent of missing data (*n* =)
Fall Lexile Score	4% (*n* = 2)
Winter Lexile Score	27% (*n* = 15)
Spring Lexile Score	20% (*n* = 11)
Maze Time 2	14% (*n* = 8)
Maze Time 3	16% (*n* = 9)
Maze Change Score	18% (*n* =10)
CHIME-A Time 1	21% (*n* =12)
CHIME-A Time 2	46% (*n* =26)
CHIME-A Time 3	41% (*n* =23)
MAAS Time 1	21% (*n* =12)
MAAS Time 2	48% (*n* =27)
MAAS Time 3	41% (*n* =23)
Flanker Time 1	13% (*n* = 7)
Flanker Time 2	16% (*n* = 9)
Flanker Time 3	14% (*n* =8)

Table 3

Missing Data: Pooled mean following imputation models

Variable	Original Data Mean	Imputation Mean
Fall Lexile Score	599.26 (298.24)	603.24 (253.28)
Winter Lexile Score	570.37 (376.37)	526.91 (343.95)
Spring Lexile Score	617.67 (360.67)	629.20 (313.21)
Maze Time 2	17.33 (7.27)	17.42 (6.52)
Maze Time 3	20.70 (7.29)	21.15 (6.46)
Maze Change Score	3.76 (5.04)	3.48 (4.27)
CHIME-A Time 1	93.05 (11.30)	93.91 (12.16)
CHIME-A Time 2	98.51 (13.46)	98.65 (7.73)
CHIME-A Time 3	102.91 (10.84)	100.89 (12.68)
MAAS Time 1	19.66 (7.04)	18.82 (6.74)
MAAS Time 2	18.72 (7.56)	18.70 (5.24)
MAAS Time 3	16.67 (7.42)	15.63 (6.63)
Flanker Time 1	7.61 (1.21)	7.68 (1.23)
Flanker Time 2	8.11 (0.93)	8.09 (1.03)
Flanker Time 3	8.01 (1.01)	8.18 (0.97)

Note. Imputation (i.e., pooled) mean is the average score of the five simulation models completed.

Table 4

Aim 1: CHIME-A Total Score Mean and Standard Deviations

Time Point	Mindfulness (*n* = 36)	Control (*n* = 20)
Time 1	94.42 (12.74)	93.00 (11.30)
Time 2	99.35 (7.79)	97.40 (7.65)
Time 3	103.52 (13.11)	96.16 (10.59)

Note. No significant effects were observed.

Table 5

Aim 1: MAAS Total Score Mean and Standard Deviations

Time Point	Mindfulness (*n* = 36)	Control (*n* = 20)
Time 1	17.81 (6.56)	20.65 (6.83)
Time 2	19.28 (4.75)	17.65 (6.01)
Time 3	14.47 (6.12)	17.72 (7.17)

Note. RM-ANOVA indicated a significant interaction between time and condition.

Table 6

Aim 2: STAR Lexile Score Mean and Standard Deviations

Time Point	Mindfulness (*n* = 36)	Control (*n* = 20)
Time 1	603.86 (285.12)	599.33 (189.57)
Time 2	571.96 (377.79)	445.82 (262.23)
Time 3	639.21 (362.32)	611.18 (203.00)

Note. Main effect of time was the only significant effect from the RM-ANOVA

Table 7

Aim 2: STAR Lexile Scores Mean and Standard Deviations by Class

Class	Fall	Winter	Spring
Teacher A 1st Period[a]	343.48 (196.03)	131.83 (223.70)	220.00 (254.01)
Teacher A 2nd Period[a]	803.40 (167.84)	853.72 (247.76)	922.97 (235.85)
Teacher A 5th Period[b]	611.80 (132.89)	581.55 (197.12)	713.49 (159.81)
Teacher B 1st Period[a]	533.85 (285.58)	517.70 (289.68)	569.78 (239.43)
Teacher B 10th Period[b]	580.63 (262.92)	242.25 (215.99)	457.72 (167.24)

Note. [a] *represents a mindfulness classroom;* [b] *represents a control classroom.*

Table 8

Aim 2: AIMSweb Maze Correct Responses Mean and Standard Deviations

Time Point	Mindfulness (*n* = 36)	Control (*n* = 20)	Males (*n* = 28)	Females (*n* = 28)
Time 2	17.60 (6.62)	17.10 (6.69)	16.18 (5.95)	18.66 (6.94)
Time 3	22.44 (6.69)	18.84 (5.46)	20.89 (6.08)	21.41 (6.92)
Change Score	4.47 (4.57)	1.70 (3.01)	4.43 (4.14)	2.53 (4.24)

Note. Change score is the difference of a participant's Time 3 Maze correct responses and Time 2 Maze correct responses

Table 9

Aim 2: AIMSweb Maze Correct Responses Mean and Standard Deviations by Class

Class	Time 2	Time 3
Teacher A 1st Period[a]	14.67 (7.56, *n* = 8)	17.42 (6.27, *n* = 8)
Teacher A 2nd Period[a]	20.94 (5.71, *n* = 15)	27.23 (6.27, *n* = 15)
Teacher A 5th Period[b]	20.17 (5.29, *n* = 12)	21.33 (4.42, *n* = 12)
Teacher B 1st Period[a]	15.56 (5.66, *n* = 13)	19.99 (4.48, *n* = 13)
Teacher B 10th period[b]	12.50 (5.53, *n* = 8)	15.11 (4.83, *n* = 8)

Note. [a] *represents a mindfulness classroom;* [b] *represents a control classroom.*

Table 10

Aim 3: NIH Flanker Computed Score Mean and Standard Deviations

Time Point	Mindfulness (*n* = 36)	Control (*n* = 20)
Time 1	7.57 (1.26)	7.86 (1.19)
Time 2	8.00 (1.09)	8.25 (0.91)
Time 3	8.24 (0.97)	8.07 (0.76)

Note. No significant effects following RM-ANOVA.

Table 11

Correlations Among Study Variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Fall Lexile	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2. Winter Lexile	**.70**	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3. Spring Lexile	**.72**	**.82**	-	-	-	-	-	-	-	-	-	-	-	-	-
4. Maze T2	**.52**	**.53**	**.58**	-	-	-	-	-	-	-	-	-	-	-	-
5. Maze T3	**.56**	**.61**	**.62**	**.76**	-	-	-	-	-	-	-	-	-	-	-
6. Maze Change	.07	.14	.07	**-.36**	**.32**	**-**	-	-	-	-	-	-	-	-	-
7. CHIME-A T1	-.04	-.05	-.07	-.13	-.06	.10	-	-	-	-	-	-	-	-	-
8. MAAS T1	**.30**	**.31**	**.39**	.08	.15	.13	.22	-	-	-	-	-	-	-	-
9. CHIME-A T2	.05	.25	.15	.17	.05	-.12	.22	.06	-	-	-	-	-	-	-
10.MAAS T2	.17	**.31**	.23	.14	.21	.04	.16	**.29**	.15	-	-	-	-	-	-
11. CHIME-A T3	.22	**.30**	.14	.05	.21	.19	.13	.25	**.36**	.18	-	-	-	-	-
12. MAAS T3	**.28**	.09	.17	.11	.07	-.05	.06	**.42**	-.21	**.47**	-.17	-	-	-	-
13. Flanker T1	.22	.20	.18	.17	**.28**	.19	.18	.18	.25	.13	.03	**.34**	-	-	-
14. Flanker T2	.16	-.01	.10	.24	.19	-.04	-.02	.10	.09	.18	-.08	**.31**	.14	-	-
15. Flanker T3	.26	**.32**	**.28**	**.36**	**.49**	.20	.02	.10	.12	.02	.08	.10	**.43**	**.33**	-

Note. Bold indicates p <.05.

Table 12

April 2018 BOSS Observations of Student On- and Off-task Behavior

Class	On-Task	Off-Task
Teacher A: Period 1	83%	17%
Teacher A: Period 2	75%	21%
Teacher B: Period 1	71%	33%

June 2018 BOSS Observations of Student On- and Off-task

Class	On-Task	Off-Task
Teacher A: Period 1	92%	21%
Teacher A: Period 2	50%	50%
Teacher B: Period 1	42%	58%

Note. Off-task scores are the combination of off-task verbal, motor, and passive scores.

Table 13

Descriptive Results of the Kids Intervention Profile for Students' Perceptions of the Mindfulness Audio Tracks

	Teacher A *M (SD)*	*Teacher B* *M (SD)*
Overall Intervention Acceptability	**18.63 (4.03)**	**24.84 (6.24)**
1. How much do you like the mindfulness audio tracks?	3 (1.00)	3 (1.02)
2. How much do you like being told to do the mindfulness audio tracks?	2 (0.78)	3 (1.25)
3. Were there times when you didn't want to do the mindfulness audio tracks?	2 (0.86)	2 (0.94)
4. Were there times when you wished you could do more mindfulness audio tracks?	2 (0.71)	3 (1.18)
5. How much do you like the mindfulness audio tracks?	3 (0.83)	4 (0.88)
6. How much do you think the mindfulness audio tracks helped with your reading?	2 (0.93)	3 (1.05)
7. Do you think your reading has improved?	2 (1.17)	3 (1.20)
8. Do you think your reading has gotten worse?	4 (1.05)	5 (0.76)

Table 14

Children's Intervention Rating Profile (CIRP)

Item	Mean response[a]
1. The method used to deal with the behavior problem was fair.	3 (1.23)
2. The child's teacher was too harsh on him.	3 (1.74)
3. The method used to deal with the behavior may cause problems with this boy's friends.	3 (1.54)
4. There are better ways to handle this child's problem than the one described here.	2 (1.23)
5. The method used by this teacher would be a good one to use with other children	3 (1.09)
6. I like the method used for this boy's behavior problem.	3 (1.49)
7. I think that the method used for this problem would help this child do better in school.	3 (1.39)

[a] *Student responses to CIRP items anchored as: 1 = "I do not agree" and 6 = "I agree"*

Table 15

AIMSweb Maze Clinical Utility: Number of Students in Tier 1, Tier 2 and Tier 3

	Mindfulness		Do Now	
Tier	Time 2	Time 3	Time 2	Time 3
Tier 1	5	6	2	0
Tier 2	8	13	10	11
Tier 3	15	8	8	9

Note. Tier 1 = At or above 45th percentile; Tier 2 = Between 15th-44th percentile; Tier 3 = At or below 14th percentile.

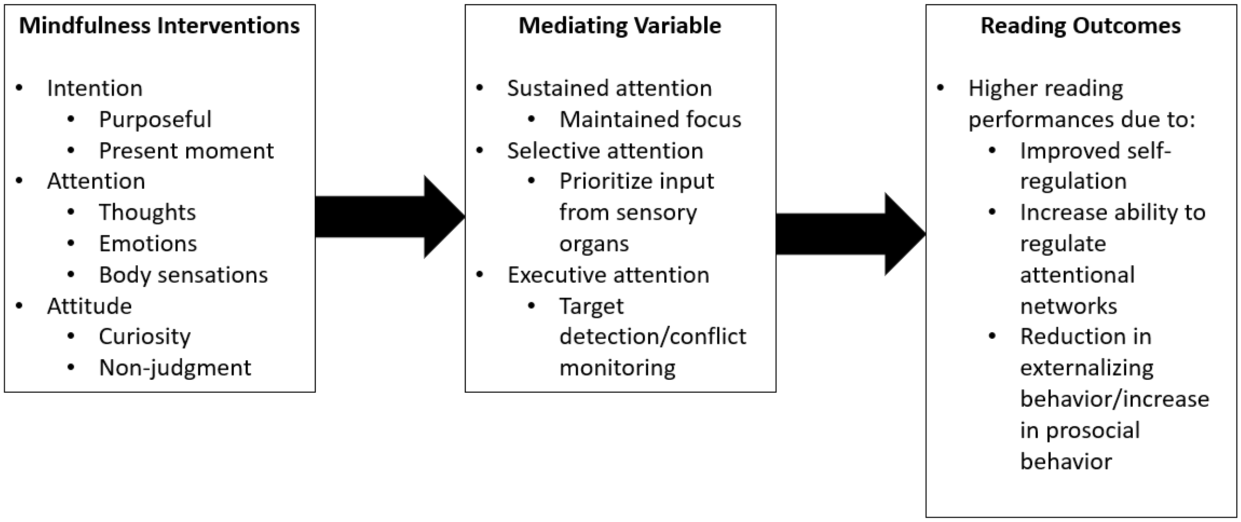

Figure 1. Visual model of the various processes involved in reading and mindfulness

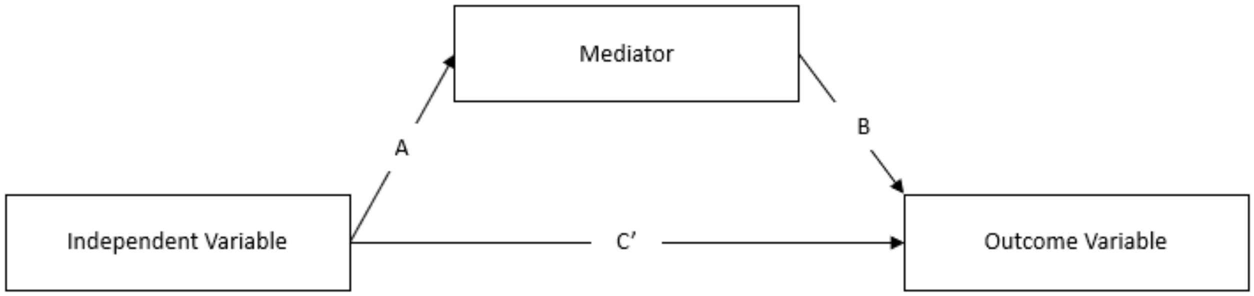

Figure 2. Baron and Kenny 1986 Model for Mediation

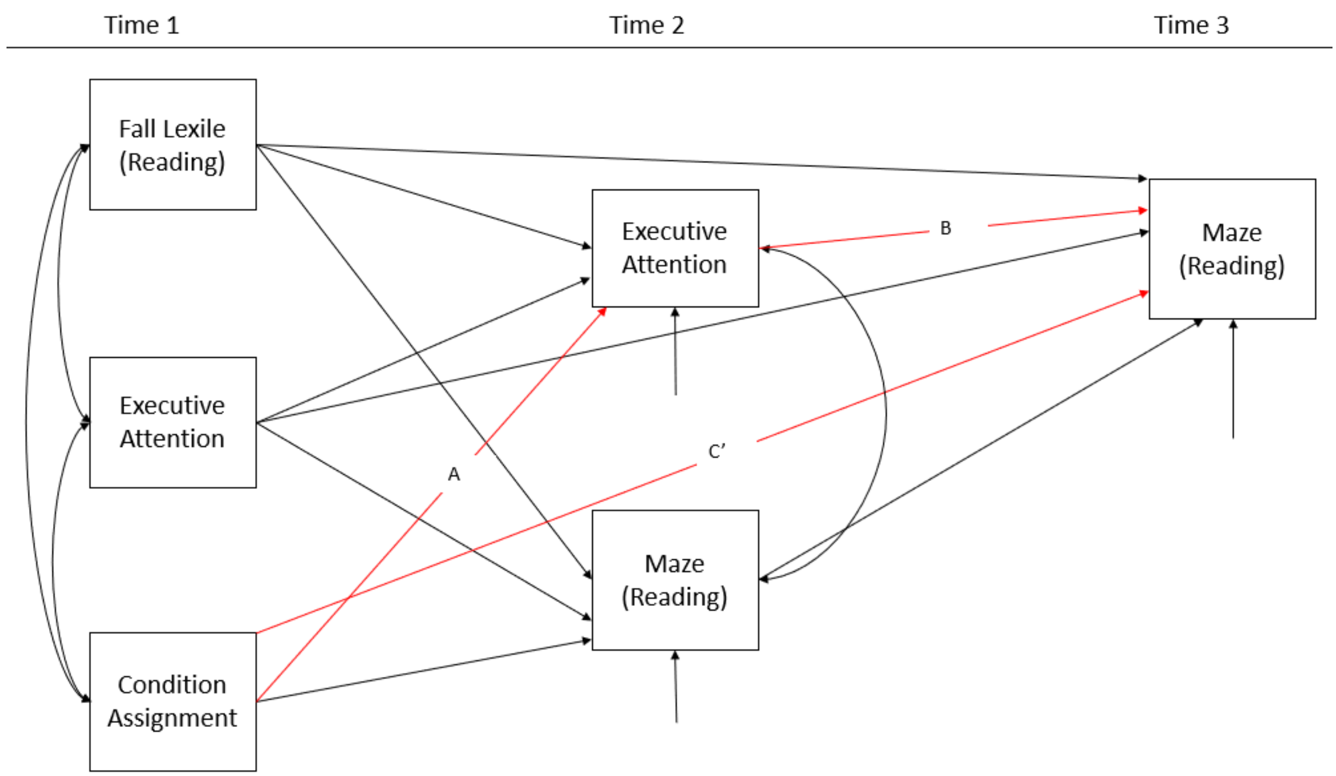

Figure 3. Theoretical Mediation Model

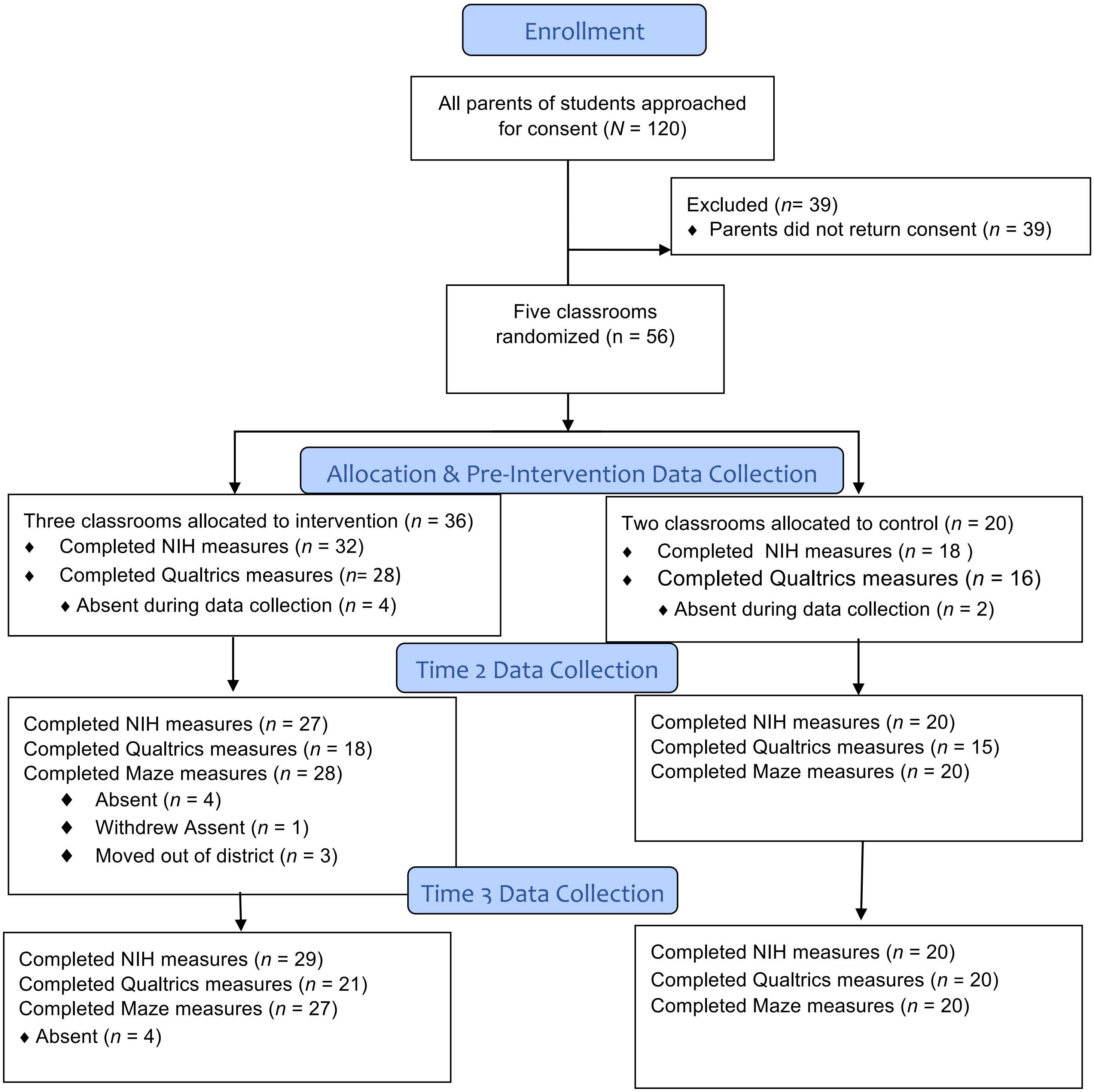

Figure 4. Flow of Participants

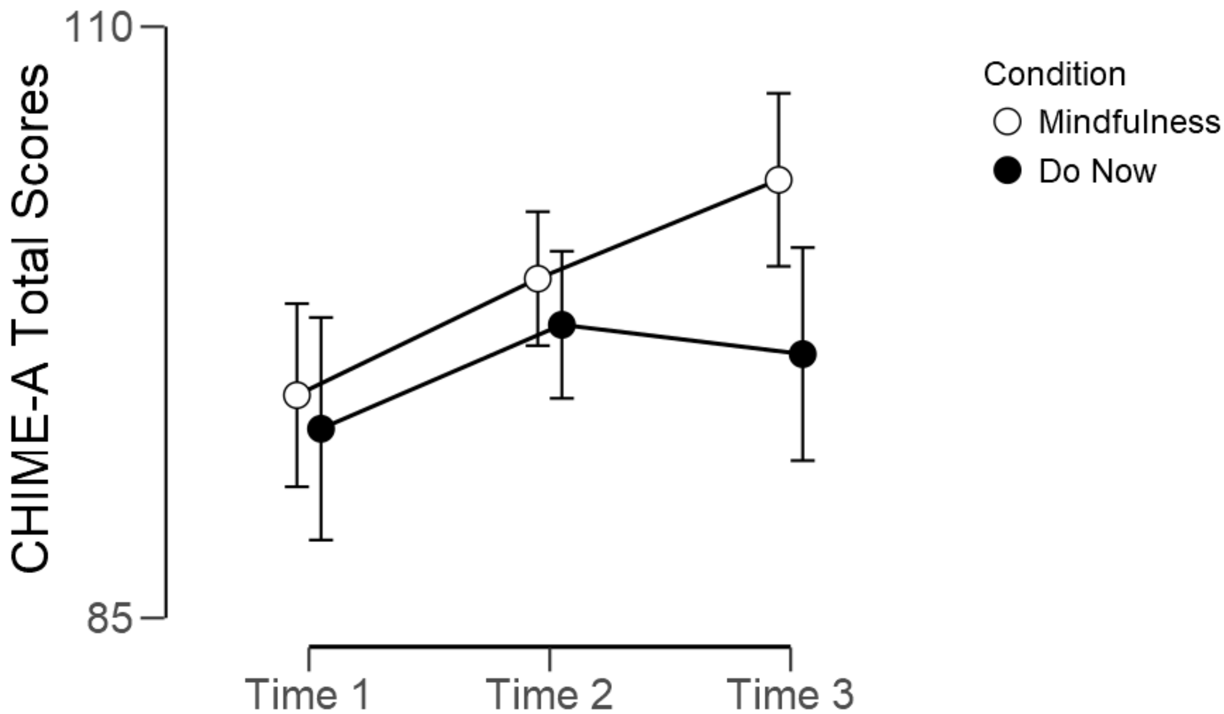

Figure 5. CHIME-A Two-way Repeated Measures ANOVA

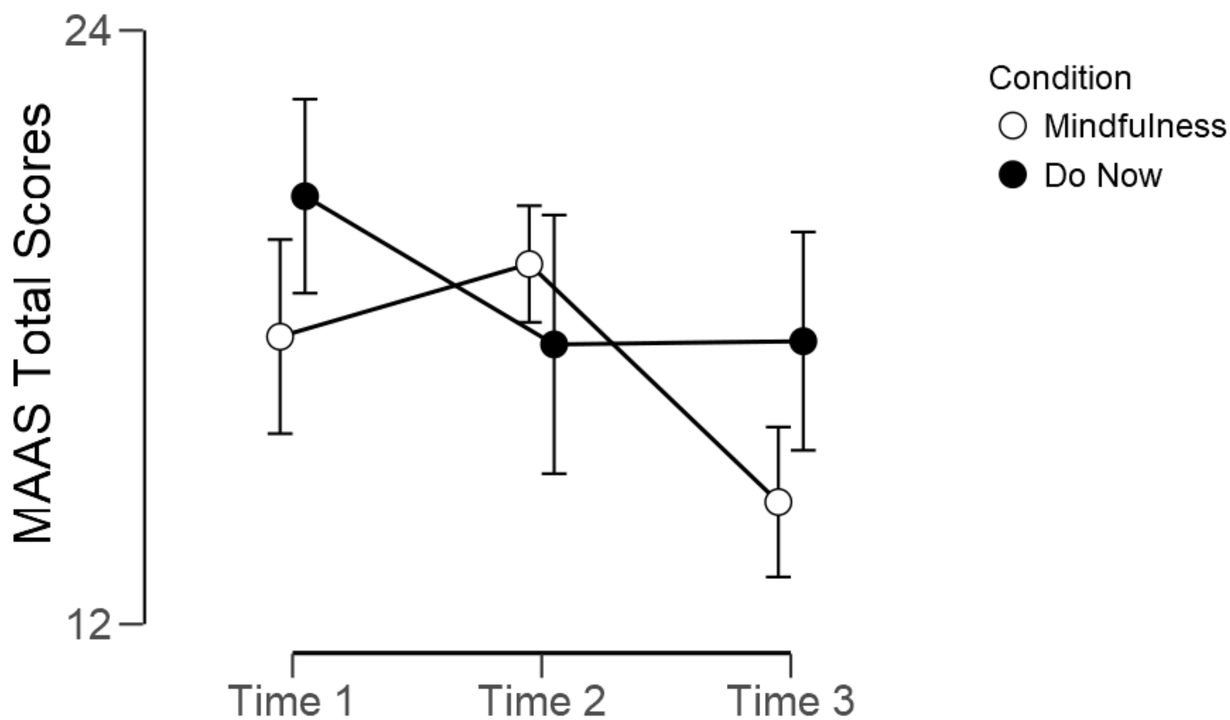

Figure 6. MAAS Two-way Repeated Measures ANOVA

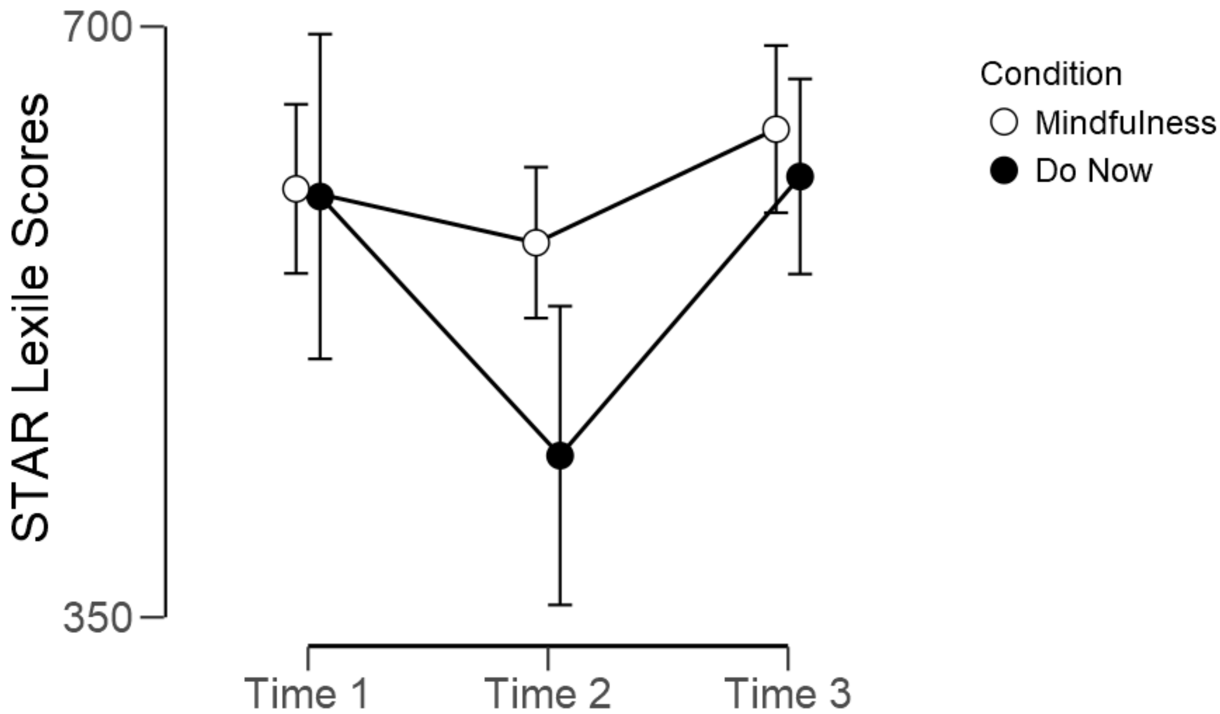

Figure 7. STAR Lexile Two-way Repeated Measures ANOVA

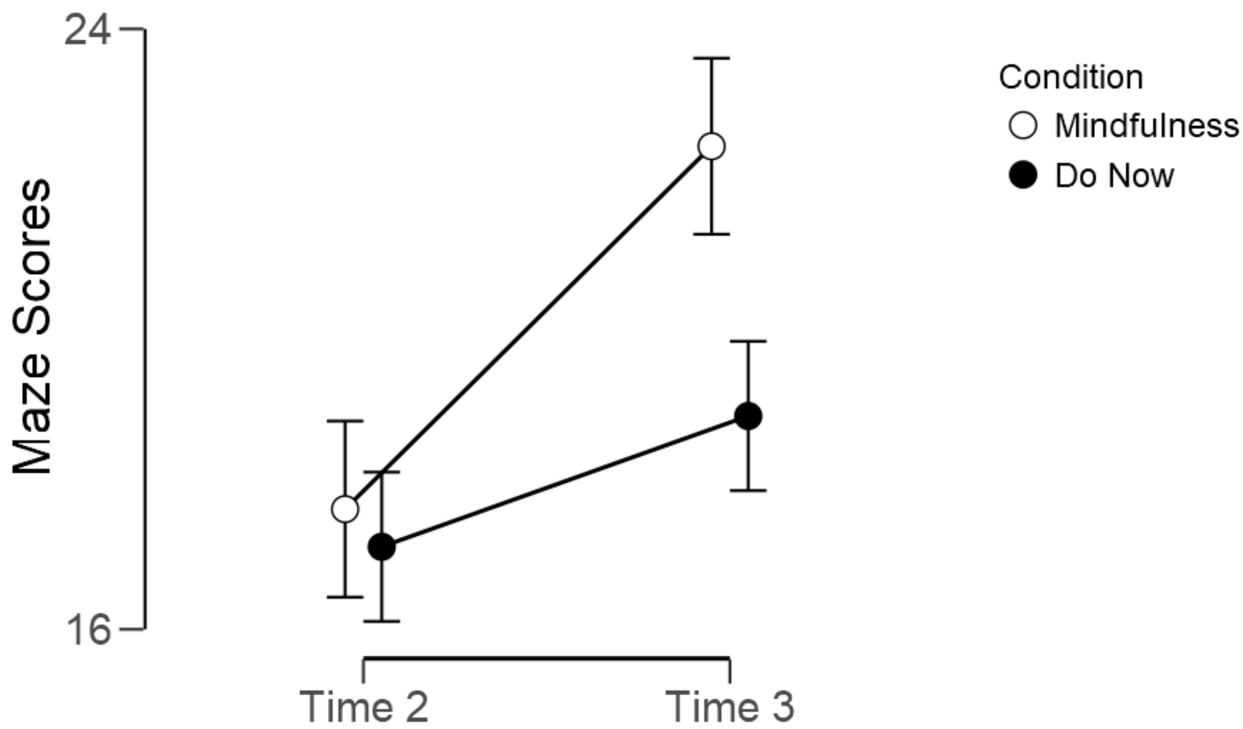

Figure 8. AIMSweb Maze Two-way Repeated Measures ANOVA

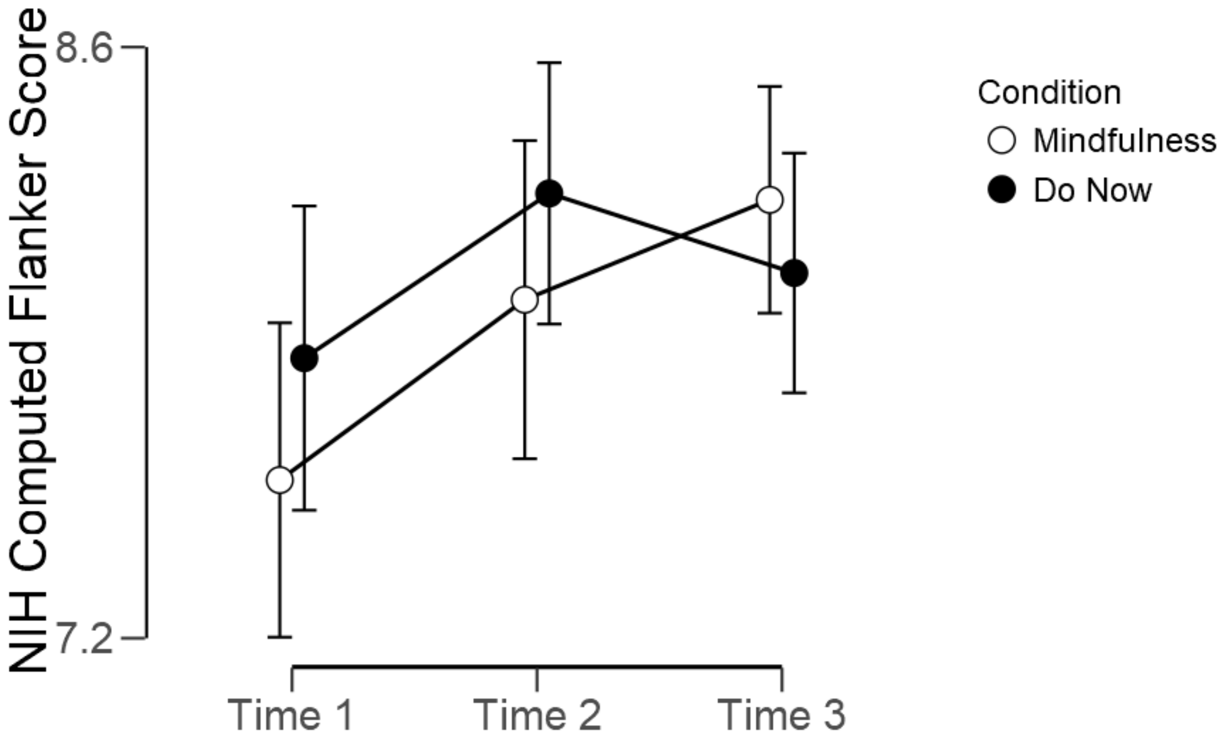

Figure 9. NIH Flanker Task Two-way Repeated Measures ANOVA

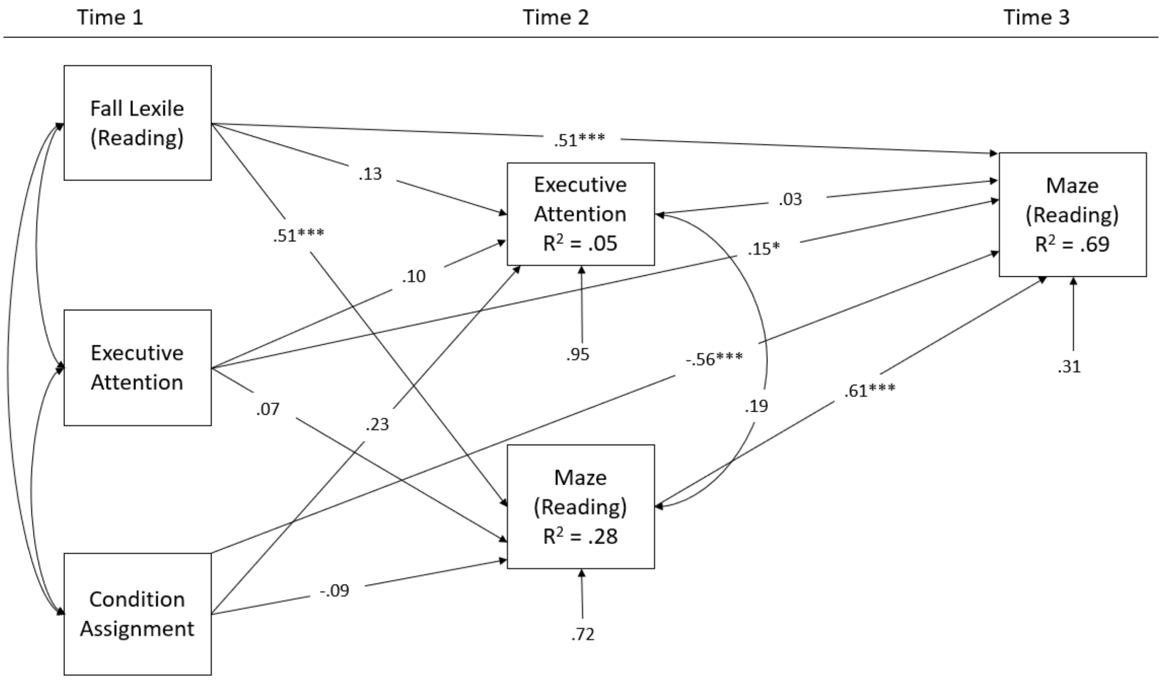

Figure 10. Aim 3: Saturated Path Model Standardized Coefficients
Note: **p*<.05.; ***p*<.01.; ****p*<.001.

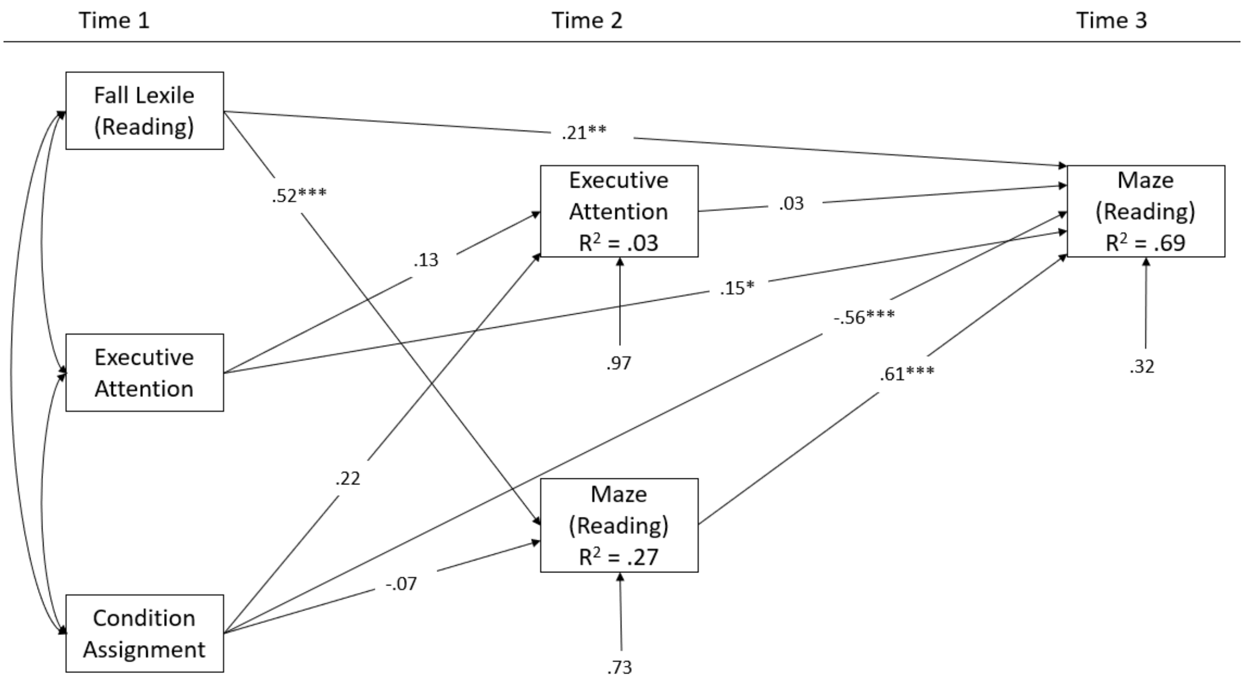

Figure 11. Aim 3: Constrained Path Model Standardized Coefficients
Note: *p<.05.; **p<.01.; ***p<.001.

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