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Changes in Attention and Depressive Symptoms Following a Brief, Internet-Delivered Mindful Breathing Intervention in an Undergraduate Sample

A DISSERTATION

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College students report high rates of depressive symptoms, with significant impacts on academic and social functioning. Mindfulness-based interventions (MBIs) have shown improvements in depressive symptoms in young adults, yet specific mechanisms of action remain to be clarified, including cognitive-affective processes.

The current study investigated whether a single component of MBIs, mindful breathing, could be delivered via a brief instructional session followed by individual online practice. A 3-week online mindful breathing intervention was compared to an active control time management intervention in a sample of undergraduate students (N = 80) with a range of depressive symptoms. Self-report measures of depressive symptoms, attention, worry, mindfulness, rumination, and behavioral measures of attention, were used to assess change from baseline to post-intervention.

The mindfulness group showed significant decreases in depressive symptoms and lower depressive symptoms than the time management group at post-intervention. Mindfulness participants showed a significant decrease in ADHD symptoms and a trend towards a significant decrease in worry. Mindfulness participants had changes in alerting and orienting attention, which were each associated with reduced depressive and ADHD symptoms. There were no significant changes or group differences in sustained or executive attention, mindfulness,
rumination, attentional control, perseverative thinking, state affect, or difficulties with emotion regulation. Changes in ADHD symptoms did not mediate the effect of mindful breathing on improvements in depressive symptoms.

Findings suggest that a time-limited online mindful breathing intervention, with brief but frequent practice sessions, could lead to improvements in depressive symptoms and attention regulation. Importantly, didactic components and group format may not be necessary to see benefits from mindfulness interventions. Changes in alerting and orienting attention may be important cognitive-affective processes targeted by mindful breathing, and may be related to improvement in depressive symptoms.
This dissertation by Katherine E. McMorran fulfills the dissertation requirement for the doctoral degree in clinical psychology approved by Nancy E. Adleman, Ph.D., as Director, and by Kathryn A. Degnan, Ph.D., and Barry M. Wagner, Ph.D. as Readers.

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Chapter 1
Mindfulness-Based Interventions for Depression:
Exploring Attention as a Mechanism of Change

**Depression**

Major depressive disorder (MDD) is a highly common mental disorder with burdensome impacts on emotional, physical, academic/occupational and interpersonal functioning (Kessler et al., 2005), and is a leading cause of disability at the societal level (Cuijpers, Beekman, & Reynolds, 2012). Lifetime prevalence rates in the US are 16.2% for adults, with 12-month prevalence rates of 6.6% (Kessler et al., 2003). It is especially important to understand depression in young adults as the first onset of depression increases in likelihood at puberty, with peak rates of incidence occurring among individuals aged 20-30 years (American Psychiatric Association [APA], 2013). Depression is often a chronic disorder, with a higher risk of recurrence for younger individuals and increasing rates of relapse with each additional depressive episode (APA, 2013).

**Depression in College Students**

University students are at increased risk of depression compared to the general population, with a weighted mean prevalence of 30.6% (Buchanan, 2012; Ibrahim, Kelly, Adams & Glazebrook, 2013). The American College Health Association’s (ACHA) national assessments of health and well-being among college students offer insight into the impacts of depression and subclinical depressive symptoms in this population. According to findings from the Fall 2017 reference group, depression was the second most common psychiatric disorder
(after anxiety) for which students were diagnosed or treated (17.8% of respondents) (ACHA, 2017).

Depression was the fourth leading cause of academic disruptions (e.g., lower grades, incomplete/dropped courses, or interruptions to research or practicum work) as reported by survey respondents (ACHA, 2017). Depressive symptoms can lead to negative impacts on psychosocial functioning as individuals withdraw socially and decrease engagement in extracurricular, work or leisure activities (Cuijpers et al., 2014; Judd et al., 2000). In college students, depression may negatively impact developmental trajectories as students struggle to develop independence and build the foundation for future careers.

Subclinical depressive symptoms are also prevalent among college students (ACHA, 2017). In addition to those who met full criteria for major depressive disorder, survey respondents reported high rates of specific depressive symptoms within the past 12 months, including feeling very sad (67.3%), hopeless (51.7%), very lonely (63.1%), and exhausted not from physical activity (83.4%). Students reported significant behavioral impacts, such as feeling so depressed that it was difficult to function (39.3%), seriously considering suicide (12.1%), engaging in self-injury (7.8%), or attempting suicide (1.9%). In addition to immediate impacts, subclinical symptoms are a risk factor for future depressive episodes (Cuijpers & Smit, 2004).

As overall rates of mental health concerns among university students have increased in recent decades (Guthman, Iocin & Konstas, 2010), there are greater demands placed on limited treatment resources on college campuses (Kitzrow, 2003). Thus, it is critically important to study efficient and effective methods for preventing and treating depression and depressive symptoms to reduce the impacts in this high-risk population (Buchanan, 2012). Fewer than half of college
students with mood disorders receive mental health treatment (Blanco et al., 2008). Barriers to seeking help include lack of time, emotional openness or perceived need for help, as well as concerns about privacy, cost, and treatment effectiveness (Hunt & Eisenberg, 2010). Furthermore, access to current treatment options such as individual or group psychotherapy may be limited, as college counseling centers frequently cap the number of treatment visits (Prince, 2015) and may lack adequate staff resources to meet student needs (Gallagher, 2009). Furthermore, it can be challenging for busy students to commit to intensive regular treatment visits. Thus, it may be useful to adapt and develop alternative approaches for depressive symptoms. Interventions that are shorter in duration, targeted, and less resource-intensive could be disseminated more broadly and help more students prevent or reduce the impact of depression (Hunt & Eisenberg, 2010).

There is evidence that depression can be prevented (Muñoz, Beardslee, & Leykin, 2012), but more research is needed to develop effective interventions, and to target them to high-risk groups such as college students. The most promising avenues for prevention include using a developmental perspective, increasing identification of high-risk groups, and testing evidence-based interventions that can be widely applied (Muñoz et al., 2012), such as online and self-guided interventions (Muñoz & Bunge, 2016). Given that subclinical symptoms are a risk factor for future depressive episodes (Cuijpers & Smit, 2004), another way to aid prevention and treatment efforts is to study the cognitive-affective processes that characterize subclinical presentations of depression (Marchetti et al., 2018).
Current Treatments for Depression

A range of interventions have demonstrated efficacy and/or effectiveness for the treatment of depressive disorders, including mindfulness-based interventions (Wang et al., 2018; Goldberg et al., 2018, van der Velden et al., 2015), cognitive behavior therapy (Beck, 2005), short-term psychodynamic therapy (Driessen et al., 2010), interpersonal therapy (Cuijpers et al., 2011), behavioral activation (Ekers, Richards, & Gilbody, 2008), and exercise (Schuch et al., 2016). Antidepressant medications are also effective in treating depression, with few observable differences among the various types (Gartlehner et al., 2011). When psychotherapy and pharmacotherapy are directly compared, they appear to be equally effective on average (Cuijpers et al., 2013), but the combination of psychotherapy and pharmacotherapy may be superior to most mono-therapies (Cuijpers, de Wit, Weitz, Andersson, & Huibers, 2015). In STAR-D, a large, pragmatic, open-label trial comparing MDD treatments for individuals who had failed a prior course of treatment, no significant differences in effectiveness were found between various pharmacotherapies and cognitive therapy (Sinyor, Schaffer, & Levitt, 2010). Remission rates ranged from 7-30% across treatments (Sinyor et al., 2010). Other studies have found that antidepressant medications, placebo pill, exercise, and CBT interventions show rates of response and remission ranging from approximately 30-55% (Blumenthal et al., 2007; Cuijpers et al., 2013; Entsuah, Huang, & Thase, 2001). As nearly half of individuals with depression are not effectively treated with currently available interventions, there is a pressing need to improve treatment options. Mindfulness-based interventions are especially worthy of additional investigation as they are highly acceptable to patients (Finucane & Mercer, 2006), can be done
by individuals with varying levels of physical ability, and have not been shown to carry risks of physical side effects.

**Investigating Dimensional Models of Depression**

Major depressive disorder is diagnosed when five or more of the following symptoms have been present nearly every day for 2 weeks or more, with at least one of the first two, including: depressed or sad mood, diminished interest or pleasure in all or most activities, significant changes in weight or appetite, insomnia or hypersomnia, psychomotor agitation or retardation, fatigue or loss of energy, feelings of worthlessness or inappropriate guilt, diminished ability to think, concentrate or make decisions, and recurrent suicidal ideation or attempts. The symptoms must also cause clinically significant distress or impairment in role functioning (APA, 2013).

Using current diagnostic criteria, there is significant heterogeneity of presentations, since diverse combinations of symptoms could fit a diagnosis of major depressive disorder. Furthermore, many depressive symptoms, such as attention problems, fatigue, sleep disturbance, and irritability, are non-specific, and occur in many other disorders. Altered or impaired attention and executive functioning are observed in numerous psychiatric disorders, such as mood and anxiety disorders, trauma-related disorders, substance use disorders, schizophrenia, and attention deficit hyperactivity disorder (APA, 2013). As attention problems are generally prevalent across many forms of psychopathology, it is important to tease apart specific components and patterns of these impairments to improve understanding and treatment of specific disorders.

To address the issues of heterogeneity and non-specificity affecting the current diagnostic system, the National Institute of Mental Health (NIMH) launched an effort to improve
understanding of psychiatric disorders through the application of Research Domain Criteria (RDoC) (NIMH, 2008). Proponents of the RDoC approach argue that current diagnostic categories have not been helpful in predicting treatment response (Insel et al., 2010). Instead, psychological symptoms should be investigated as dimensional constructs that may be present in healthy individuals as well as those with clinical disorders. By studying specific dimensional constructs, the limitations of categorical diagnostic conceptualization can be overcome to enhance our understanding of dysfunction and enable the discovery of novel treatment targets. As dimensional psychological constructs are identified for each disorder, they can be studied at multiple levels of analysis - genetic or molecular levels, neural circuits and physiology, and behavior and self-report of subjective experience. Discoveries at each level can inform the others, and improve understanding of psychological constructs and disorders.

Depression is characterized by the dimensional construct of “loss,” which involves cognitive-affective processes oriented to negative valence information (Woody & Gibb, 2015). The loss construct is manifested in cognitive processes and behavior related to attention, such as rumination, worry, impairments in sustained attention, attentional bias to negatively-valenced information, executive function deficits, and increased self-focus (Woody & Gibb, 2015). Furthermore, neural circuits that have been studied in depression overlap with those associated with executive regulation (Disner, Beevers, Haigh, & Beck, 2011) attentional control (de Raedt & Koster, 2010), and rumination (Cooney, Joormann, Eugène, Dennis, & Gotlib, 2010). Because impaired attentional processes are strongly implicated in depressive disorders, research at the level of cognitive and behavioral processes has attempted to explore how specific attention deficits manifest among individuals with depressive symptoms.
Attention

As attention is a broad construct encompassing multiple interacting processes, it is important to define and clarify the term as used in cognitive and psychological research. Attention refers to a set of cognitive processes that enable subjective awareness of external and internal stimuli (Posner & Rothbart, 2007). This awareness in turn enables the voluntary regulation of emotion and cognition (Posner & Rothbart, 2007). Converging research supports the existence of three anatomically distinct networks of attention, each of which enables a specific function: 1) alerting, 2) orienting, and 3) executive control (Fan et al., 2007; Fan, McCandliss, Fossella, Flombaum, & Posner, 2005; Westlye, Grydeland, Walhovd, & Fjell, 2011; Xuan et al., 2016). The alerting aspect of attention is defined as maintaining a state of sensitive awareness to changes in external stimuli (Posner & Rothbart, 2007). The orienting function of attention enables the “selection of relevant information from multiple sensory inputs” (Fan et al., 2009), which may be either voluntary or automatic. The third attention network, the executive control network, involves the monitoring and resolution of conflict among competing stimuli, such as thoughts, emotions, and behavioral responses (Posner & Rothbart, 2007). Cognitive and neuroimaging studies have identified specific neural substrates involved in these basic attention processes. Alerting attention is subserved by neural circuits connecting the locus coeruleus, parietal and right frontal cortices, with neuromodulation by norepinephrine (Posner & Rothbart, 2007). Substrates of orienting attention include superior parietal, temporal parietal junction, superior colliculus and frontal eye fields, with acetylcholine as an important neuromodulator (Posner & Rothbart, 2007). Executive attention is implemented by circuits connecting the anterior cingulate, basal ganglia, lateral ventral and prefrontal cortices, with dopamine playing a
neuromodulatory role (Posner & Rothbart, 2007). Although these functional networks are hypothesized to be anatomically distinct, there is also emerging evidence of their functional interaction and integration in complex behavior (Fan et al., 2009).

**Attentional Impairments in Depression**

Deficits in attention and executive regulation are primary cognitive markers of vulnerability to depression (Weiland-Fiedler et al., 2004), and are characteristic of patients with depression during depressive episodes and periods of euthymic mood (Roca, Vives, López-Navarro, García-Campayo, & Gili, 2015). Meta-analyses of studies with adolescent and young adult depressed patients reveal a range of cognitive deficits when compared to healthy controls, including impaired attention and executive function (Castañeda, Tuulio-Henriksson, Marttunen, Suvisaari, & Lönnqvist, 2008) although some research shows deficits only in executive function, but not in attention (Baune, Fuhr, Air, & Hering, 2014). Greater executive function deficits are positively correlated with greater symptom severity (Snyder, 2013). Furthermore, having more than three prior depressive episodes is associated with worse impairments in attention and executive function after depression remits (Hasselbalch, Knorr, & Kessing, 2011). Attentional impairments thus appear to reflect both trait and state deficits relevant to depression, and may serve as markers of vulnerability to chronic depression. Hasselbalch and colleagues (2011) have recommended that future research focus on distinguishing state from trait aspects of attention deficits in depression, and clarify associations between specific deficits and subclinical presentations of depression.

Attentional impairments related to depression have been investigated in various types of emotional information processing (e.g., attending to novel stimuli, conflict monitoring, updating
working memory) using a range of cognitive attention tasks. For instance, there is evidence for an attentional bias to negative information in depressed individuals. Attentional bias is a cognitive pattern in which individuals preferentially engage their attention on mood-congruent information even prior to conscious awareness (Gotlib, Krasnoperova, Yue, & Joormann, 2004). Individuals with depression show preconscious attentional preference, or attention bias, towards sad stimuli (de Raedt & Koster, 2010). This attention bias may involve the alerting and orienting networks of attention. Studies of attentional bias to negative information in depressed and dysphoric individuals have used attention tasks such as Posner’s exogenous cueing paradigm (1980) to investigate attention when processing emotional content such as negative words or sad faces. In the Posner task, individuals must detect a visual target that appears to the left or right of a fixation cross after either a valid (i.e., same side) or invalid (i.e., opposite) spatial cue with either emotional or neutral content (Koster, de Raedt, Goeleven, Franck, & Crombez, 2005). Attentional bias is inferred when reaction times are altered for responses to targets that follow emotional cues as compared to those following neutral cues, as this is presumed to demonstrate that attention was captured by the emotional information (Koster et al., 2005). The executive attention network is involved in difficulties with attentional control observed in depression, such as impaired inhibition for negative emotional information and impaired ability to remove negative information from working memory (Joormann & Gotlib, 2008).

In addition to attention deficits in currently depressed patients, there is evidence that impairments persist even after mood symptoms have resolved. For example, depressed patients with poor performance on attention and executive function tasks show improvement after the depressive episode remits, but their performance is still worse than that of never-depressed
healthy controls (Roca et al., 2015). Residual attention impairments following depressive episodes may be associated with slower processing speed and reduced cognitive flexibility (Hasselbalch, Knorr, Hasselbalch, Gade, & Kessing, 2012). The evidence of residual attention difficulties after remission of depressive episodes (Hasselbalch et al., 2011; Paelecke-Habermann, Pohl, & Leplow, 2005), suggests that problems with attention may be an underlying mechanism that maintains depressive symptoms, and could contribute to the tendency towards depressive relapse (Disner et al., 2011).

In contrast, there is evidence that function in other domains such as memory and verbal fluency may return to healthy levels once depression has remitted (Douglas & Porter, 2009). Thus, ongoing research is focused on exploring relationships between attention deficits and depression, to explore causal or bidirectional relationships between these factors. To better understand patterns of attention deficits related to depression, distinctions between impairments in various networks of attention could be investigated. For instance, impairments in disengaging attention from negative information have been observed in dysphoric (Ellenbogen, Schwartzman, Stewart, & Walker, 2002; Koster et al., 2005) and clinically depressed individuals (Leyman, de Raedt, Schacht, & Koster, 2007), which may reflect an important role of the executive attention network in depressive processes such as rumination.

**Attentional Impairments Reinforce and Maintain Depression**

Trait and state impairments in attention functioning and emotional information processing appear to reinforce negative schemas about the self, which maintain and exacerbate depressive symptoms in vulnerable individuals (Disner et al, 2011). For instance, individuals with depression show attentional bias towards sad or negative interpersonal stimuli, but not
neutral or positive stimuli (Gotlib et al., 2004), and impaired ability to disengage attention from
negative external or internal stimuli (Disner et al, 2011). Depressed individuals also show
prolonged processing of emotional experiences and increased self-referential information
processing (Disner et al., 2011). Once in a negative mood state, individuals tend to seek out
confirming information and over-attend to mood-congruent negative information.

Altered attentional processes may underlie ruminative response styles, which are
common in depressed individuals. Rumination is defined as passive, repetitive thinking as a
coping response to sad mood, in which attention is focused on negative affect as well as its
causes and consequences (Nolen-Hoeksema, 2000). Rumination is associated with the
development (Robinson & Alloy, 2003) and onset (Just & Alloy, 1997) of depression. It is also
associated with worsening course of depression (Kuehner & Weber, 1999), as well as longer
duration (Nolen-Hoeksema, Morrow & Frederickson, 1993) and greater chronicity (Nolen-
Hoeksema, 2000). The influence of negative cognitive styles and past depression on prospective
depressive episodes has been shown to be mediated by rumination (Spasojević & Alloy, 2001).
Importantly, rumination contributes to the maintenance of depression (Nolen-Hoeksema, Wisco,
& Lyubomirsky, 2008) by sustaining focus on negative mood states and on negative self-
evaluations and beliefs (de Raedt & Koster, 2010). Rumination and worry are both forms of
repetitive negative thinking characterized by focus on negative experiences, difficulty
disengaging from this content, and subjective experience of intrusiveness of these thoughts
(Ehring et al., 2011). If rumination is conceptualized as a tendency to sustain attention/focus on
negative information, and to have difficulty disengaging one’s attention from a repetitive cycle
of thoughts, then dysfunction in attention processes are likely to be implicated in ruminative
thinking styles (Gotlib & Joormann, 2010; Whitmer & Banich, 2007). Attention deficits may contribute to the onset and recurrence of depression through an intermediating pathway of ruminative coping (Mathews & MacLeod, 2002).

**Mindfulness-Based Interventions (MBIs)**

**Mindfulness-Based Interventions for Attention and Depression**

A growing body of research has shown that mindfulness-based interventions (MBIs) appear to influence attention regulation and effectively treat patients with depression. MBIs were created by Western psychologists under the broad framework of cognitive-behavioral therapies (Hofmann, Sawyer, & Fang, 2010). Thus, MBIs have relied on cognitive-behavioral conceptual models of psychological disorders, including the central importance of the relationship between thoughts and emotions. While MBIs were created within the field of Western psychology, most of them have explicitly drawn from Buddhist spiritual traditions, integrating Buddhist techniques, practices, and ways of conceptualizing the mind and human suffering (Chiesa & Serretti, 2009).

**Definition of Mindfulness**

Mindfulness is a broad term that encompasses multiple meanings, and is often variably defined across the field of psychology. Given this variation in usage, Bishop and colleagues (2004) developed an operational definition to identify core features of this construct, and to enhance comparability across psychological research studies. In their view, mindfulness includes two essential components: self-regulation of attention on immediate experience, and adoption of an orientation toward one’s present-moment experiences that is characterized by acceptance, curiosity, and openness (Bishop et al., 2004). In this definition, there are multiple possible
objects of awareness and attention. For instance, mindfulness may refer to paying attention to various types of internal experience (e.g., emotions, thoughts, physiological sensations) as well as external experience (e.g., sounds, sights, smells, tastes). Inherent to mindfulness is a dynamic, temporal process of attending to changes in experience as they occur. For instance, one may attend to thoughts arising spontaneously in the mind or to sensory experiences, such as tastes and textures while eating a raisin, or sensations in the legs and feet while walking.

In the operational definition above, mindfulness is described primarily as a state of consciousness or being. Mindfulness may occur spontaneously without conscious effort, yet it is usually considered to be distinct from typical daily experience, which is more often characterized by automatic thinking patterns, and a tendency for attention to be “captured” with the content of specific thoughts or novel stimuli. However, mindfulness is also considered, and studied, as a trait construct (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006) - one that is inherent based on individual differences or a skill acquired through long-term practice of specific mindfulness exercises (e.g., meditation, mindful breathing, eating, walking, etc.) (Bishop et al., 2004). As the term “mindfulness” may refer to a state, trait, skill, or type of practice, researchers must consider how best to measure mindfulness and its relationship to other psychological constructs (Hölzel et al., 2011).

**Attention Training in Mindfulness Practice**

Many MBIs, such as Mindfulness-Based Stress Reduction (Kabat-Zinn, 1990) and Mindfulness Based Cognitive Therapy (Teasdale et al., 2000), consider attention training to be central to the development of mindfulness skills. Mindful attention exercises are often categorized as either focused attention or open monitoring, and each type may affect distinct
attention processes in different ways. Traditional Buddhist approaches recommend practitioners follow a sequential path of developing sustained attention via focused attention practices first, which establishes a necessary foundation for effective engagement in open monitoring meditation practices (Hölzel et al., 2011).

In focused attention practices, the emphasis is on picking an object of focus, such as the breath, a word, an object of the senses, or an internal image (e.g., visualizing a candle), and sustaining one’s attention on this object as closely as possible (Lutz, Slagter, Dunne, & Davidson, 2008). It is considered inevitable, and not problematic, that the mind will wander, at least in early stages of practice. To develop the skill of sustained attention, one must also cultivate meta-cognition, or the ability to observe when one’s attention has wandered and return it to the object of focus (Lutz et al., 2008).

In open monitoring, one attempts to maintain an observing perspective on the constantly changing contents of consciousness, i.e., noticing the continuous stream of thoughts arising and fading in the mind. The emphasis in open awareness practice is on being an observer of the contents of consciousness and the constant fluctuation as thoughts, feelings, and images come and go. Attention is not sustained on one object but, rather, on maintaining an observer perspective and being in contact with aspects of the present moment as it unfolds (Vago & Silbersweig, 2012). The observing perspective appears to be associated with executive attention and decreased self-referential processing (Hölzel et al., 2011).

**Attention Training in MBIs May Improve Attention Deficits**

As a form of attention training, MBIs may enhance various components of attention, especially the ability to sustain or redirect attention related to executive function networks. This
may have relevance in the treatment of depression. MBIs may ameliorate attention deficits that maintain depressive symptoms, such as over-attention to negative stimuli (e.g., mood-congruent external reminders and internal mood states). Open monitoring mindfulness might be related to improvements in initial information processing such as alerting and orienting attention. Focused attention mindfulness in turn, with its emphasis on redirection of attention when the mind has wandered, could enhance executive control of attention to interrupt repetitive negative thinking patterns such as rumination.

**Major MBI Approaches**

Most of the primary MBIs were developed in the 1980’s, and have been refined, adapted, and tested with various populations in the ensuing years. Interest in mindfulness has continued to grow, and the past 2 decades have witnessed a substantial increase in the investigation of mindfulness and MBIs (Chiesa, Fazia, Bernardinelli, & Morandi, 2017). There are several major approaches under the broad umbrella of MBIs, also referred to as mindfulness and acceptance-based therapies. While each approach was pioneered by different researchers to treat different disorders, there are many commonalities in components, format, and theoretical underpinnings across MBIs. Each approach derived many concepts and practices from Buddhist spiritual traditions, and adapted them within western models of psychotherapy. As with other cognitive behavioral therapies, MBIs have several broad therapeutic goals that include building awareness, changing behavior, and reducing emotional and physical reactivity to distressing thoughts. For instance, both MBIs and CBT generally focus on “increasing awareness of how automatic behavioral and cognitive reactions to thoughts, sensations, and emotions can cause emotional distress” (Hofmann, Sawyer, & Fang, 2010). MBIs help individuals respond to stressors and
negative emotions with observation and acceptance rather than resistance, distraction or suppression, and thus they “counter experiential avoidance strategies that maintain and exacerbate emotional disorders” (Bishop et al., 2004). In this way, CBT and MBIs share the strategy of reducing cognitive and behavioral avoidance, but do so through divergent techniques.

One of the earliest MBIs was Mindfulness-Based Stress Reduction (MBSR), originally developed to treat individuals with chronic pain (Kabat-Zinn, 1982). MBSR is a group-based intervention that consists of 8 weekly 2.5-hour sessions and a single day-long retreat in which participants learn and develop mindfulness skills through various formal and informal mindfulness practices (Kabat-Zinn, 1990). Daily practice of skills is an important component, with the expectation that participants will engage in mindfulness practice six days per week for at least 45 minutes. MBSR uses three primary techniques, including the body scan, sitting meditation, and Hatha yoga practice (Kabat-Zinn, 1990). The body scan technique involves the sweeping of one’s attention across the entire body, with pauses to notice any sensations present in various body parts, while maintaining curiosity and acceptance towards these sensations. Sitting meditation incorporates both focused attention, such as maintaining attention on the physical sensations associated with breathing, and open monitoring, or noticing the internal flow of thoughts and external stimuli such as sounds, with non-judgmental awareness (Kabat-Zinn, 1990). Hatha yoga involves strengthening and stretching postures and breathing exercises intended to relax the body and decrease sympathetic nervous system activation (Kabat-Zinn, 1990).

Building on MBSR, Mindfulness-based Cognitive Therapy (MBCT) was developed in the 1990’s with a focus on relapse prevention in previously depressed patients (Teasdale et al.,
MBCT integrates MBSR with components of CBT for depression (Beck, Rush, Shaw, & Emery, 1979). MBCT employs a structure like MBSR, with 8 weeks of group sessions and homework focused on mindfulness practices including the body scan, sitting meditation, and Hatha yoga (Teasdale et al., 2000). In addition, MBCT teaches cognitive skills to help patients recognize habitual cognitive processes, such as rumination, which maintain depressive symptoms. Mindfulness practice helps participants develop the ability to take an observer perspective on negative thoughts (“decentering”). The practice is also theorized to strengthen the faculty of disengagement from negative thoughts by redirection of attention to present-moment experiences (Segal, Williams, & Teasdale, 2013). Teaching focused attention mindfulness skills when individuals are first experiencing subclinical depressive symptoms could potentially interrupt depressogenic thinking styles that contribute to the development of major depressive episodes.

**Treatment Outcomes in MBIs**

A large body of treatment outcome research, including meta-analytic and systematic reviews, demonstrates that MBIs effectively treat various psychological problems in a wide range of populations. For instance, mindfulness-based interventions (MBIs) are effective in treating anxious and depressive symptoms in clinical samples of individuals with anxiety and mood disorders (Chiesa & Serretti, 2011; Hofmann, Sawyer, Witt, & Oh, 2010) and other psychiatric and medical conditions (Goyal et al., 2014; Grossman, Niemann, Schmidt, & Walach, 2004; Ledesma & Kumano, 2009; Toneatto & Nguyen, 2007). MBIs are effective in reducing symptoms in current depressive episodes (Barnhofer et al., 2009; Strauss, Cavanagh, Oliver, & Pettman, 2014), and in those with residual depressive symptoms/partially remitted
depression (Britton, Haynes, Fridel, & Bootzin, 2010; Kingston, Dooley, Bates, Lawlor, & Malone, 2007). Results of meta-analyses indicate that MBCT is also effective for preventing relapse in individuals with three or more prior depressive episodes (Piet & Hougaard, 2011). MBCT has accordingly been recommended as a treatment of choice for reducing depression relapse (Gelenberg et al., 2010; National Collaborating Centre for Mental Health UK, 2010).

In a meta-analysis examining the relative efficacy of MBIs for psychiatric disorders, Goldberg and colleagues (2018) found that MBIs performed better than four categories of control conditions (no treatment, minimal treatment, non-specific active controls, specific active controls), but did not significantly differ from evidence-based treatments. For disorder-specific subgroups, the evidence for the effectiveness of MBIs was most consistent for depression, pain, smoking and addictive disorders (Goldberg et al., 2018). Similarly, a meta-analysis of randomized controlled trials of meditation programs for psychological stress and well-being showed moderate evidence of reductions in depression by 8 weeks, but MBIs did not outperform other active treatments such as exercise, behavioral therapies, or pharmacotherapy (Goyal et al., 2014). Another meta-analysis of randomized controlled trials of MBIs for depression revealed that MBIs were superior to treatment as usual (TAU) at posttest, but equivalent at follow-up assessment (Wang et al., 2018).

Among healthy and non-clinical populations, MBIs lead to reductions in stress, depression, anxiety symptoms, and rumination (Chiesa & Serretti, 2009; Goyal et al., 2014; Khoury, Sharma, Rush, & Fournier, 2015). MBIs have been tested with university students to reduce stress and improve psychological well-being, and have effectively reduced anxiety, stress,
and depressive symptoms (Regehr, Glancy, & Pitts, 2013). MBIs have been shown to improve adaptive emotional skills such as empathy and self-compassion (Chiesa & Serretti, 2009).

**Understanding How MBIs Work**

While there is substantial support for the efficacy of MBIs in improving psychological well-being in clinical and non-clinical populations, much remains to be learned about *how* they work. By investigating mechanisms of change, MBIs could be refined so that specific components could be emphasized to increase the potency of these multi-faceted interventions. In addition to identifying mechanisms most relevant to specific disorders or populations, individualized treatment interventions could be created with components targeting specific symptoms, traits, or cognitive deficits.

Most MBIs are multi-faceted interventions involving common therapeutic factors, such as group structure, social support and engagement, insight into symptoms and thought patterns, practice of emotion regulation skills, positive expectancies, and sense of active engagement and self-responsibility. Thus, a critical next step in evaluating the use of MBIs is to understand more about their mechanisms of action, i.e., the specific components or processes of MBIs that lead to beneficial outcomes. By investigating mechanisms of action, common and unique factors of various treatment approaches can be clarified. For specific disorders, it is important to understand how treatments may affect underlying cognitive-affective processes such as attention impairments in depression.

**Purported Mechanisms of Change in MBIs**

Initial research has identified potential mechanisms of action of MBIs, yet further clarification of specific mechanisms, including the cognitive-affective processes affected, is
necessary (Baer, 2003). Theoretical models suggest that greater mindfulness, enhanced concentration (Kabat-Zinn et al. 1992), and reduced rumination (Jain et al., 2007; Ramel, Goldin, Carmona, & McQuaid, 2004; Shahar, Britton, Sbarra, Figueredo, & Bootzin, 2010) contribute to the psychological benefits of MBIs. Other proposed theoretical mechanisms by which MBIs lead to reduction in depressive symptoms and improvements in overall psychological well-being include increases in decentering (Baer, 2003; Hölzel et al., 2011), insight (Brown, Ryan, & Creswell, 2007), and emotion regulation via coping skills and exposure (Baer, 2003; Hölzel et al., 2011; Shapiro, Carlson, Astin, & Freedman, 2006). Altered attitudes and beliefs, such as clarification of values (Shapiro et al., 2006), non-attachment (Brown et al., 2007; Grabovac, Lau, & Willett, 2011), acceptance, compassion, and engagement in ethical practices (Grabovac et al., 2011) have also been proposed as potential mechanisms of MBIs.

Models integrating neurobiological findings with experimental and self-report data suggest that improved attention regulation and executive control may be especially important in MBI interventions (Hölzel et al., 2011). For instance, meditation is suggested to improve self-awareness (Vago & Silbersweig, 2012) and cognitive flexibility (Shapiro et al., 2006), and reduce rumination (Grabovac et al., 2011). Furthermore, theorized mechanisms may interact and mutually influence each other in a developmental way. For instance, attention regulation may be a foundational mindfulness skill upon which other aspects can be developed, such as reappraisal and regulation of emotions (Hölzel et al., 2011). To summarize, theoretical models of mindfulness suggest the following as possible important mechanisms of change in MBIs: attention regulation, exposure, decentering, emotion regulation (decreased emotional reactivity
and rumination), cognitive and behavioral flexibility, coping skills, relaxation, acceptance, self-compassion, values, and ethical orientation.

Building on the theoretical models above, recent research has tested various psychological constructs and identified multiple factors that may mediate the effects of MBIs on psychological change. These factors include changes in attention and cognitive flexibility, rumination, mindfulness, emotion regulation, and self-compassion. In a quantitative synthesis of empirical studies, Gu, Strauss, Bond, and Cavanagh (2015) found strong, consistent evidence that cognitive and emotional reactivity mediate the effects of MBSR and MBCT on overall psychological functioning and well-being. Changes in mindfulness, rumination, and worry showed moderate consistent evidence of mediating the effects of MBIs. Self-compassion and psychological flexibility were determined to be possible mediators, with preliminary but insufficient evidence (Gu et al., 2015). Alsubaie and colleagues (2017) explored potential mediators of MBCT and MBSR in populations with comorbid physical and psychological conditions. Increased mindfulness had the most consistent support as a mechanism of change, with limited evidence for rumination, worry, positive affect, attentional processes, cognitive reactivity, emotional reactivity, self-compassion, and decentering as mediators (Alsubaie et al., 2017). Recommendations for future research included improving on methodological flaws in mediation studies.

For outcomes specifically related to MBCT for depression, there is consistent evidence that mindfulness, rumination, compassion and meta-awareness may be mechanisms of change (van der Velden et al., 2015). Changes in attention, emotional reactivity, and state affect have preliminary but limited evidence as possible mechanisms by which MBCT exerts its beneficial
effects on depression (van der Velden et al., 2015). In previously depressed individuals, increased mindfulness and self-compassion appear to mediate the effects of MBCT on preventing recurrence of depression (Kuyken et al., 2010).

**Attention as a Mediator of the Effects of MBIs**

Development of attention regulation is considered an essential component in most theoretical models of mindfulness (Baer, 2003; Hölzel et al., 2011). One theory of attention change in MBIs suggests that mindfulness practice develops sustained attention and executive inhibitory control (Isbel & Summers, 2017). That is, the instruction in meditation practice to redirect attention when the mind has wandered can be conceptualized as using the metacognitive skill of inhibitory control, or inhibiting automatic processes to maintain attention on the task (i.e., meditating). Through this effortful control, attention is not allocated to distracting external stimuli or self-referential thoughts, thereby building capacity to sustain attention (Isbel & Summers, 2017).

In a systematic review of neuropsychological outcomes of mindfulness training among non-clinical populations, there was mixed evidence of changes in various attention networks as measured by cognitive tasks (Chiesa, Calati, & Serretti, 2011). Two of seven RCTs found improvements in sustained attention, one of four showed changes in selective attention, and two of five studies reported improvement in executive attention (Chiesa et al., 2011). A subsequent study found that brief meditation on the breath led to improvements in electrophysiological markers of attentional control and focusing of attentional resources, suggesting that focused attention practices may affect executive attention networks (Moore, Gruber, Derose, & Malinowski, 2012). More recently, a review of associations between executive function changes
and mindfulness meditation found consistent evidence that mindfulness strengthens inhibitory control, but results were mixed for improvements in the updating and shifting components of executive attention (Gallant, 2016).

Among clinical samples, a systematic review of neuropsychological outcomes following MBSR or MBCT reported mixed findings for changes in specific components of attention (Lao, Kissane, & Meadows, 2016). Changes in alerting or sustained attention were evident in one of eight studies, and three studies measuring orienting/selective attention had mixed results. In three studies measuring executive attention, there was no evidence of change (Lao et al., 2016). However, evidence of improvements in attentional bias to negative information was observed in previously depressed individuals following MBCT (de Raedt et al., 2012) suggesting improvements in the inhibition aspect of executive control. Similarly, Chesin and colleagues (2016) found improved executive attention as measured by a Stroop task, but no changes in sustained attention following MBCT with depressed outpatients at high risk of suicide.

As changes in attention may develop over time with sustained mindfulness practice, several studies have compared attention performance in novice and experienced meditators. The most consistent evidence suggests that long-term meditators demonstrate better executive attention compared to non-meditators (Chan & Woollacott, 2007; Moore & Malinowski, 2009; van den Hurk, Giommi, Gielen, Speckens, & Barendregt, 2010). However, short-term focused attention meditation led novice meditators to show similar executive control as expert meditators, indicating that short-term practice can lead to changes in the executive attention network (Jha, Krompinger, & Baime, 2007). After four sessions of mindful breathing training, Zeidan, Johnson, Diamond, David, and Goolkasian (2010) saw evidence of improved executive
functioning and sustained attention in a sample of healthy college students. There is evidence that even a single session of training in mindfulness can lead to observable changes in sustained attention (Morrison, Goolsarran, Rogers, & Jha, 2014).

Other research indicates that attention networks may be differentially affected by type of meditation practice (Tsai & Chou, 2016). As measured by the Attention Network Test (Fan, McCandliss, Sommer, Raz, & Posner, 2002), which is designed to test all three attention networks, experts in open monitoring meditation showed better orienting attention than both experts in focused attention meditation and controls. After practice in focused attention meditation, both types of experts and novice meditators showed improvements in executive attention, again indicating that executive attention changes are observable even in novices. Thus, focused attention meditation may affect executive attention networks whereas open monitoring may affect orienting attention.

Attention processes are theorized to be central to mindfulness, rumination, and meta-awareness, and there is substantial evidence of attention impairments in depression, yet findings are mixed on attention changes as the mediator of the effects of MBIs on depressive symptoms. Thus, it is worth investigating the discrepancy between theorized relationships and the current lack of strong evidence for the role of attention changes in MBIs. One possibility is that current attention measures do not adequately capture the complex phenomena of attention changes resulting from MBIs. Future studies using improved methodology may clarify the true role of attention changes as potential mechanisms or mediators of the effects of MBIs on depression and depressive symptoms.
Methodological Challenges in MBI Research

While MBIs have demonstrated beneficial effects in a range of populations, and for various types of clinical symptoms and adaptive functioning, further research is needed to address limitations of existing research. These limitations include conceptual and methodological challenges unique to the study of mindfulness, as well as the need to test the specific effects of different mindfulness practices on various disorders and symptoms (Caspi & Burleson, 2005). The research base is limited in terms of distinguishing differential effects of various mindfulness practices on clinical symptoms (Perez-De-Albeniz & Holmes, 2000). Moreover, the multiple components of MBIs may contribute to symptom improvement through a synergistic interaction of changes in various related factors (van der Velden et al., 2015). For instance, meditation practice may lead to decreased attentional bias to negative information and improved meta-awareness of ruminative thinking patterns. In turn, the emphasis on approaching difficult thoughts and emotions with an accepting attitude, may lead to less rigidity in negative beliefs about the self (van der Velden et al., 2015).

Researchers have recommended the use of consistent, comparable mindfulness measures (Isbel & Summers, 2017; Wang et al., 2018). Several recent meta-analyses have recommended that future MBI research should employ more rigorous methodologies including larger sample sizes, randomized controlled trials, comparison groups using evidence-based treatments that enable testing of specific and non-specific mechanisms of MBIs, blinding, longer study duration including follow-up assessments, and evaluation of treatment fidelity (Chiesa & Serretti, 2011; Goldberg et al., 2018; van der Velden et al., 2015). In addition, further investigation of the impact of mindfulness practice and exploration of individual differences as moderators of
differential outcomes would enhance current understanding of mindfulness interventions (Goldberg et al., 2018).

Further research is needed to clarify predictors and moderators of treatment response in MBIs. In addition, more consistent use of strong comparison groups would help isolate the specific effects of MBIs, as opposed to non-specific effects such as group support, social engagement, expectancy, and positive regard from group facilitator or therapist (Chiesa & Serretti, 2011). Präßlitch, Kossowsky, Gaab, and Krummenacher (2016) investigated the effect of positive and negative expectations in a comparison of a focused attention meditation with sham meditation on changes in multiple components of executive attention. They found that both focused attention and sham meditation groups saw improvements in interference control and verbal fluency when told that meditation improves attention, and declines in performance when told that meditation has negative effects on attention (Präßlitch et al., 2016). This study suggests that positive expectations for the benefits of mindfulness can affect changes in executive attention, and that future research would be strengthened by controlling for expectancy effects.

**Strengths and Limitations of Existing Mindfulness Scales**

In most of the psychological literature, mindfulness has been assessed using self-report measures that have been developed and tested with both experienced mindfulness practitioners, such as long-term meditators (Baer et al., 2008; Buchheld, Grossman, & Walach, 2001), as well as with mindfulness-naive individuals (Baer, Smith, & Allen, 2004; Brown & Ryan, 2003). Commonly used self-report mindfulness measures include the Kentucky Inventory of Mindfulness Skills (KIMS; Baer et al., 2004), Five Factor Mindfulness Questionnaire (FFMQ; Baer et al., 2008), and the Mindful Attention and Awareness Scale (MAAS; Brown & Ryan,
2003). Other measures include the Cognitive and Affective Mindfulness Scale (CAMS; Feldman, Hayes, Kumar, Greeson, & Laurenceau, 2007), Philadelphia Mindfulness Scale (PHLMS; Cardaciotto, Herbert, Forman, Moitra, & Farrow, 2008), Frieburg Mindfulness Inventory (FMI; Walach, Buchheld, Buttenmüller, Kleinknecht, & Schmidt, 2006), and Toronto Mindfulness Scale (TMS; Lau et al., 2006). These self-report measures have several advantages. First, items typically include questions about experiences that reflect the definitions and concepts from operational definitions of mindfulness. Thus, they tend to have good face validity. Second, these measures were developed and tested with long-term meditators, who have conceptual and experiential knowledge of mindfulness, which would lend construct validity to the items. Third, the scales have good psychometric properties related to internal consistency as well as convergent and discriminant validity (Bergomi, Tschacher, & Kupper, 2013).

However, self-report scales of mindfulness have several limitations (Bergomi et al, 2013). First, self-report measures in general are subject to retrospective memory bias, social desirability, and other response styles (Cohen, 2005). Second, there is heterogeneity of constructs assessed by mindfulness measures. For instance, the Mindful Attention Awareness Scale measures a single factor of attentive awareness (Brown & Ryan, 2003) whereas the Five Facet Mindfulness Questionnaire (Baer et al., 2008) measures five mindfulness factors, including observing, describing, acting with awareness, non-judging and non-reactivity to experience. Third, most scales measure trait mindfulness, with only one scale intended specifically to assess state mindfulness as experienced during meditation practice (Toronto Mindfulness Scale, Lau et al., 2006). Yet there is evidence that state mindfulness during meditation has little relationship to the construct of trait mindfulness (Thompson & Waltz, 2007). A recently developed measure, the
Applied Mindfulness Process Scale (Li, Black, & Garland, 2016), was designed to measure mindfulness as a process (vs. as a state or trait). It includes 15 items that assess how individuals apply mindfulness to respond to daily stressors, and includes factors of decentering, positive emotion regulation, and negative emotion regulation (Li et al., 2016). Thus, broader comparisons across studies may be hampered by the divergent ways of measuring the complex construct of mindfulness.

Self-report mindfulness measures may also be subject to variable responding by different samples. Comprehension of items about conceptual aspects of mindfulness may be difficult for those without prior knowledge of or training in mindfulness (Brown et al., 2007), leading to inaccurate interpretation of questions and greater variability in responding within mindfulness-naive individuals. When mindfulness self-report measures are completed before and after receiving an MBI, individuals may have learned more about mindfulness concepts, and thus perceive and report their own mindfulness to be greater simply due to enhanced understanding of terminology without actual increases in their thinking or behavior (Grossman, 2008). In addition, individuals without prior experience may interpret and answer items in a very different way than those with years of mindfulness practice (Bergomi et al., 2013).

Another limitation of existing mindfulness scales is that insight into one’s thinking pattern is inherent to the definition of mindfulness. Metacognitive awareness may be needed to accurately observe one’s own mindfulness ability, and there may be significant differences between how individuals rate themselves and how mindful they truly are (Grossman, 2008). Anecdotally, when individuals begin to practice mindfulness, they seem to become more aware of their mind wandering and lack of mindfulness and thus may report increased mind wandering.
during early training as compared to baseline (Baer et al., 2006). As reported by meditators with long-term experience, mind wandering eventually decreases after significant practice (Brewer et al., 2011). Thus, the relationship between actual mindfulness and self-reported mindfulness may not be a linear relationship for certain types of items, especially those related to attention processes and awareness about the objects of one’s attention. In other words, both those who are experienced meditators and those who are mindfulness-naïve may perceive their attention and ability to focus to be quite good, whereas those who are early in mindfulness training may undergo a developmental process of becoming more aware of their lapses in attention, and thus report lower levels of attentional focus. That is, novice meditators may have developed greater insight and report less mindful attention than those who are meditation-naïve. If measured behaviorally, however, the novice meditators might show attention performance intermediate between mindfulness-naïve individuals and long-term meditators.

**Improving Mindfulness Assessment with Behavioral Measures**

Because of the inherent limitations in self-report measures and in those limitations specific to self-report of mindfulness, researchers have begun to develop new ways to assess mindfulness. These new methods of assessment are designed to more precisely capture various phenomenological aspects of mindfulness. For instance, if mindfulness is a dynamic state in which an individual is paying attention to ever-changing moment-to-moment experiences, it may be useful to capture this mental state unfolding in time. One way to achieve this may be through experience sampling methods (Gotink et al., 2016; Shoham, Goldstein, Oren, Spivak, & Bernstein, 2017), which ask participants to answer questions or report on variables during meditation or at frequent intervals in daily life. Further, assessment can be prompted or generated
independently by the participant when s/he experiences a thought or emotion that is relevant to the variables being assessed. These data may be gathered outside of the laboratory via texts, email, or smartphone technology, or even using paper diaries or recording forms (Gotink et al., 2016). Experience sampling methods have numerous advantages, including increased ecological validity and reliability, and reduction of retrospective memory bias (Csikszentmihalyi & Larson, 1987). By collecting longitudinal, within-subject data at multiple time points, dynamic processes and causal relationships can be tested using multilevel modeling methods (Gotink et al., 2016).

Another advance in the scientific study of mindfulness has been the development of behavioral measures of mindfulness, which avoid some of the limitations of self-report measures. Several researchers have developed and tested behavioral mindfulness measures (Burg & Michalak, 2011; Morrison et al., 2014; Rohde, Adolph, Dietrich, & Michalak, 2014). Importantly, as researchers attempt to operationalize mindfulness in terms of observable and/or reportable behaviors, this endeavor can bring greater precision to the definition of mindfulness. As mindfulness is a multi-faceted construct, different behavioral measures can be generated for different types of mindfulness practices. By creating new measures, individual components of MBIs can be better compared against each other, to determine specific effects and to tailor interventions. As more intervention studies employ rigorous methodologies, the research base supporting the unique and specific effects of MBIs will become more robust. New research continues to improve on earlier efforts by refining the methods used to measure mindfulness, and by better operationalizing this multi-faceted construct.
Research indicates that aspects of mindfulness could be measured behaviorally by modifying existing cognitive attention tasks. In a study investigating the effects of mindful breathing training on mind-wandering, attention, and working memory in healthy college students, Morrison et al. (2014) modified the Sustained Attention to Response Task (SART; Robertson, Manly, Andrade, Baddeley, & Yiend, 1997) to assess participants’ subjective experience of mind-wandering. Experience-sampling probe questions were embedded in the SART task, allowing for real-time assessment of mind-wandering. At 28 randomly generated intervals, participants were asked to report whether their attention was on-task or off-task and how aware they were of where their attention was focused using 6-item Likert scales (Morrison et al., 2014). There is evidence that less mind-wandering is associated with greater mindfulness in healthy college students after brief mindful training (Mrazek, Franklin, Phillips, Baird, & Schooler 2013). Thus, while Morrison et al. (2014) were not studying mindfulness per se, the modified SART may point to a way of measuring the developmental process of gaining mindfulness skill. However, the use of embedded questions during an attention task may be problematic in that it demands a shift in attention to reflect on and answer the questions. These interruptions could in turn require greater ability to redirect attention to return to the primary task of responding to visual targets. Future research should continue to develop and test ways to accurately assess aspects of mindfulness through modification of existing attention measures.

Another approach to behaviorally assessing mindfulness involves having participants count and report their breaths during mindful breathing practice (Levinson, Stoll, Kindy, Merry, & Davidson, 2014). Breath counting is in fact a primary technique used in mindfulness practices, with the assumption that the ability to accurately count one’s breaths reflects mindful attention
(Levinson et al., 2014). In a study of healthy participants, greater self-reported meta-awareness was associated with more accurate breath counting (as confirmed by physiological data measuring breathing rates), as well as less mind-wandering (Levinson et al., 2014). The researchers also found that experienced meditators had better accuracy in breath counting than non-meditators, suggesting that breath counting may be a valid way to behaviorally assess mindfulness. Of interest, breath counting was distinct from measures of sustained attention, indicating that breath counting may capture a quality of mindfulness such as meta-awareness, that is not synonymous with sustained attention. Another advantage of breath counting is that it does not depend on reaction time responses, which may reduce measurement error related to differences in motor speed. However, because the outcome measure is total count over an extended period, the breath counting technique is limited in its ability to assess mindfulness on a moment-to-moment basis.

Burg and Michalak (2011) developed a Mindful Breathing Exercise (MBE) to behaviorally assess mindful attention in a study investigating associations between rumination and mindfulness. Using the MBE, they found evidence that better mindful attention was associated with lower rumination, repetitive thinking, and depression (Burg & Michalak, 2011). In the study, healthy undergraduate participants engaged in a Mindful Breathing Exercise (MBE), which consisted of mindful awareness of physical sensations of breathing during a single study visit (Burg & Michalak, 2011). To assess sustained attention, participants were asked to report on the focus of their breath by pressing a mouse button when prompted by an auditory signal at semi-random intervals during the 18-minute long mindful breathing exercise. If a participant was mindfully attending to his/her breath, s/he would press the left mouse button for
that response. If, instead, attention had wandered and the participant was caught up in a stream of thoughts, s/he would press the right mouse button. Participants were also instructed to press the right mouse button press when their mind had wandered, independent of any auditory prompts. Participants were considered to have sustained mindful attention for phases (between auditory prompts) in which they did not independently report mind-wandering and they reported their attention being on the breath when prompted. The sum of time for all mindful periods was calculated and used as the mindful attention score for the MBE task (Burg & Michalak, 2011).

Of note, these mindful periods did not need to be continuous. In this way, mindfulness was assessed as a state, with the hypothesis that better state mindfulness would be associated with greater self-reported trait mindfulness (Burg & Michalak, 2011) as measured by the KIMS (Baer et al., 2004).

One limitation of the MBE approach to measuring mindful attention is that two individuals could have a similar total score, but different internal experiences. For example, one person could have reported attention on the breath at multiple time points, with no significant mind-wandering in between prompts. Another person could have been reporting their attention on the breath, but have many quick fluctuations and mind-wandering throughout the period of “sustained” attention without noticing and independently reporting them. Another limitation is that the redirection of attention that is considered crucial to beginning mindfulness practice is not assessed directly in this operationalization of mindfulness. That is, the “normal” state of the mind is assumed to be a chain of thoughts, and mindfulness is, in part, the ability to observe these thoughts without being caught up in them. Mindfulness may be both the state of staying focused on an object of attention, and the ability to notice when attention has wandered. In fact,
experienced meditators describe early mindfulness practice as the process of becoming more aware of the mind wandering, and gaining practice in catching and redirecting it. After much experience, it is considered easier for the mind to remain focused without wandering, and thus the mind may remain for a longer period on a single object, or even be in a state of “not thinking” (Jha et al., 2007). Thus, the skill or action of mindfulness may qualitatively differ based on the experience/skill of the practitioner (Hölzel et al., 2011).

While the MBE was initially developed to capture sustained attention as a behavioral measure of mindfulness, other researchers have noted that the non-judging/accepting component of mindfulness was not adequately captured with this measure. Rohde et al. (2014) modified the MBE to include two related but distinct factors that comprise the operational definition of mindfulness: 1) present-moment awareness, and 2) non-judging attitude towards one’s experience (towards the contents of conscious awareness) (Bishop et al., 2004). Thus, the behavioral measure of mindfulness included two outcome measures. In addition to measuring sustained attention to breath via cued and uncued responses during mindful breathing, non-judging attitude was measured using three components: skin conductance response (SCR); electromyography (EMG) of the corrugator muscle during the MBE; and self-critical thoughts self-reported after the MBE (e.g. “While returning to your breathing after an episode of drifting, were you annoyed? Were you disappointed with yourself? Did you blame yourself?” (Rohde et al., 2014, p. 38). Skin conductance response was used to assess intensity of emotional arousal during the task. Contraction of the corrugator muscle between the eyebrows (i.e., frowning) after responses of mind-wandering were considered potential moments of self-critical judging, i.e., non-mindfulness. Activation of the corrugator muscle has been associated with negative affect,
especially sadness and anger (Bradley, Codispoti, Cuthbert, & Lang, 2001). Rohde et al. (2014) found that currently depressed participants reported that their attention had wandered from breathing at higher rates, and showed increased corrugator activity after reporting drifted attention, than did never-depressed healthy controls.

Benefits of the mindful breathing exercise (MBE) as used by Rohde et al. (2014) include the ability to measure mindfulness in real time and operationalization of two specific aspects of mindfulness (attention and non-judging attitude). EMG of the corrugator muscle is an inventive strategy to assess non-mindful judging, but is non-specific. Rather, corrugator activation is associated with various types of negative affect, including frustration, sadness, and anger (Bradley et al., 2001). In fact, Rohde et al. (2014) found that increased corrugator activation was not associated with self-critical thoughts in response to attention drifting. Moreover, the non-judging aspect of mindfulness extends beyond task performance and includes a non-evaluative approach to various thoughts and feelings (i.e., accepting negative emotions) and being a neutral observer of both internal and external phenomena (e.g., rain or sunlight could be noticed without being labeled as good/bad, or pleasant/unpleasant). In both studies using the MBE (Burg & Michalak, 2011; Rohde et al., 2014), the method for calculating the attention component of mindfulness has a significant limitation. By using the sum of phases in which attention was reported as on the breath, mindful attention was operationalized as sustained attention. Yet mindful attention also involves meta-awareness, and the MBE calculation does not account for potential fluctuations in attention between prompts. That is, individuals may differ in their meta-awareness and not accurately report attention drifting without prompts. Future research could
address this limitation by adding number of un-prompted responses of drifting as an outcome measure to capture changes in meta-awareness of attention.

Given the limitations of self-report measures, and the limited research using behavioral measures of mindfulness, future research should continue to test new ways of behaviorally assessing mindfulness. Behavioral measures of attention continue to be important aspects of a multi-method approach to studying the mechanisms of MBIs, as they are supported by an extensive research base that allows for comparisons across studies. By using behavioral tasks to measure attention, it will be possible to better assess whether attention at a basic cognitive level is changed by MBIs.

**Structure of MBIs and Effects of Practice**

Beyond improving assessments of mindfulness and attention, future research should explore aspects of mindfulness training that may be relevant to changes in psychological outcomes. For instance, type of meditation practice, such as focused attention vs. open monitoring, appear to affect attention in different ways, and these differences should be further investigated. Ways of teaching and delivering mindfulness may also differentially impact outcomes. Thus, future research should compare brief training and self-guided online interventions to multi-week group interventions led by therapists. Improvements in mindfulness and other psychological outcomes have been observed after interventions with various durations (minutes per session), frequency of practice (number of times per day or week), and overall length of intervention (days to weeks). Further research is needed to understand factors related to intervention structure and practice, and to clarify relationships between these aspects of practice and changes in specific networks of attention and components of mindfulness.
Chapter 2
Investigation of a Brief, Online, Mindful Breathing Intervention for Depressive Symptoms in College Students

Background

Depression and subclinical depressive symptoms are prevalent among young adults aged 18-25 years (Kessler & Bromet, 2013), and contribute to significant impairments in academic and social functioning (ACHA, 2017). College students have an elevated risk of depression (Ibrahim et al., 2013), yet face numerous barriers to accessing help, including lack of time and availability of treatment (Hunt & Eisenberg, 2010). Furthermore, current treatments such as antidepressant medication and psychotherapies have limited rates of treatment response and do not adequately prevent relapse (Rush et al., 2006). Thus, research is needed to explore brief, accessible, and feasible interventions such as online interventions (Kemper, Mo, Khayat, & Cramer, 2016) to prevent and reduce depressive symptoms in this at-risk group.

Recently developed psychotherapeutic approaches such as Mindfulness-Based Interventions (MBIs) have shown improvements in mood for depressed individuals (Hofmann, Sawyer, Witt, & Oh, 2010) and non-clinical samples (Chiesa & Serretti, 2009). MBIs have been hypothesized to lead to positive psychological outcomes through changes in a range of cognitive-affective processes, including attention regulation, emotion regulation, and change in perspective on the self (Hölzel et al., 2011). Research has begun to investigate factors that mediate the impact of MBIs on psychological symptoms, but given the complexity and variety of MBIs and the range of disorders targeted by these interventions, additional studies are needed to identify
these relationships with greater precision. In particular, new research is needed to clarify which constructs mediate improvements in depressive symptoms following MBIs.

Attention regulation may be an especially important mechanism of change in mindfulness, as there is evidence of improvements in attention following MBIs (Chiesa et al., 2011; Gallant, 2016). Deficits in attention appear to be a cognitive marker of vulnerability to depression (Weiland-Fiedler et al., 2004), as they have been observed both during depressive episodes (Zhao, Gong, Chen, & Miao, 2010) and after depression has remitted (Paelecke-Habermann et al., 2005) as well as in first degree relatives of patients with depression who are themselves at higher risk for the disorder (Evers, der Veen, Jolles, Deutz, & Schmitt 2009; Le Masurier, Cowen, & Harmer, 2007). Depressive thinking styles such as rumination (Gotlib & Joormann, 2010), may be a trait manifestation of attention deficits related to disengaging focus from negative content (de Raedt & Koster, 2010). There is evidence that improved attention regulation, such as that developed through MBIs, may strengthen attentional control related to emotional information (Farb, Segal, & Anderson, 2012), thereby decreasing rumination and other depressive symptoms. However, findings are mixed with regard to changes in specific components of attention following MBIs, such as sustained, alerting, orienting and executive attention (MacCoon, MacLean, Davidson, Saron, & Lutz, 2014; MacLean et al., 2010), and it is unclear whether changes in one versus another of these components is more strongly related to changes in depressive symptoms. As attention and mindfulness are each complex, multifaceted constructs, additional research is needed to clarify associations and possible mediating relationships among changes in various components.
Mindful breathing, a common technique in MBIs (Kabat-Zinn, 1990; Teasdale et al., 2000), has been used in numerous studies involving mindful attention training (Burg & Michalak, 2011; Rohde et al., 2014), and thus allows for comparisons with existing research. Because mindful breathing involves attention regulation, it may be an optimal method by which to investigate whether changes in attention regulation are a central mechanism of mood improvements associated with mindfulness. By studying brief, online practice of mindful breathing, the feasibility and effectiveness of brief mindful training can be explored in a college student population with a range of depressive symptoms. In addition, the use of behavioral attention measures in a brief mindful breathing intervention study enables the investigation of changes in multiple components of attention, as well as in rumination, mindfulness and depressive symptoms related to MBIs.

**Study Aims**

The purpose of the current study was to investigate relationships between attention, mindfulness, and depressive symptoms following a brief online mindful breathing intervention in an undergraduate sample, using an active control group that received a time management intervention. This study aimed to 1) identify whether a limited, frequent dose of mindful breathing training leads to changes in attention, mindfulness, and depressive symptoms in an undergraduate sample, as well as whether this approach to mindfulness training was feasible; and 2) use behavioral measures to test whether specific components of attention (i.e., sustained attention, shifting of attention, orienting of attention, executive control of attention) are differentially affected by mindful breathing training and/or mediate changes in depressive symptoms. Findings from the study may inform the development of targeted, effective clinical
interventions for depression by clarifying the impact of mindful breathing on changes in attention regulation and depressive symptoms.

We expected that participants who received the mindful breathing intervention would show greater improvements in mindfulness and depressive symptoms compared to the time management control group. We also predicted that mindful breathing participants would demonstrate greater improvements than controls in self-report measures of attentional control and behavioral measures of sustained, alerting, orienting, and executive attention. We expected that improvements in attentional measures would be correlated with decreases in depressive symptoms and increases in mindfulness. If evidence was found for these correlations, we predicted that changes in attention would mediate the effect of mindful breathing on changes in depressive symptoms.

**Method**

**Participants**

Participants were recruited from the psychology department research participant pool at the Catholic University of America during the Spring 2017 semester, which was composed of students enrolled in a section of introductory general psychology (PSY 201). Inclusion criteria were being 18 years or older and enrolled in a section of PSY 201. Individuals were excluded if they were enrolled in a course taught by the faculty advisor for this study, Dr. Nancy Adleman or by the student principal investigator, Katherine McMorran. Participants were not excluded on the basis of prior mindfulness experience, history of psychiatric diagnosis, or current use of psychotropic medication.
Eighty participants were recruited, attended the initial study visit, and completed informed consent. Participants were randomly assigned to one of the two intervention conditions (Mindful Breathing Exercise or Time Management Skills) in alternating fashion, resulting in forty participants in each group. Data on demographic and background characteristics were collected for 79 participants, as one participant did not complete the demographic form (see Appendix C for demographic and background questions). The sample was comprised of 58.2% women, 40.5% men, and 1.3% transgender individuals. The mean age of participants was 19.77 years ($SD = 1.95$, $SE = .22$, Range = 18-32). Of the full sample, 67.5% reported some prior mindfulness experience, 18.8% denied prior mindfulness experience, 7.5% were unsure, and 6.3% did not answer. Meditation and yoga were the most frequently reported types of prior exposure to mindfulness practices. There were no differences between groups in terms of age, gender distribution, or distribution of prior mindfulness experience (see Table 1 for descriptive statistics for participants).

Individuals who reported having a past or current psychiatric diagnosis comprised 16.5% of the sample. Reported psychiatric diagnoses included: ADHD, mood disorders (depression, bipolar disorder), anxiety disorders (generalized anxiety, social anxiety, panic, separation anxiety and unspecified anxiety disorders), obsessive-compulsive disorder, posttraumatic stress disorder, paranoid schizophrenia, and dissociative identity disorder. Participants who were currently taking psychotropic medication comprised 12.7% of the sample. Reported psychotropic medications included: Prozac, Adderall, Concerta, Intuniv, Latuda, Depakote, clonazepam, sertraline, gabapentin, lithium, and hydroxyzine. There were no differences between groups in distributions of psychiatric diagnoses or psychotropic medications (see Table 1).
Table 1

**Participant Characteristics and Tests of Between-Group Differences at Baseline**

<table>
<thead>
<tr>
<th>Participants</th>
<th>MBE (n = 40)</th>
<th>TMS (n = 40)</th>
<th>Group Comparisons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age in years</td>
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</table>

Note. MBE = Mindful Breathing Exercise group. TMS = Time Management Skills group. Participants who completed demographic and background questions at the first study visit were included in group comparisons. All comparisons of group differences were non-significant (p > .05).

**Procedure**

**Overview of Study Procedures.** All study visits were conducted by the student principal investigator, Katherine McMorran, and/or trained research study assistants who were master’s or undergraduate level students in psychology and members of Dr. Adleman’s research lab. The protocol was administered to each participant individually. The study consisted of two conditions: 1) a mindful breathing exercise (MBE) intervention (experimental condition), and 2) a time management (TMS) intervention (active control condition). Additional details about these
interventions are given below. Each participant was randomly assigned to one of these two conditions.

The protocol required approximately 5 hours to complete, with 2.5 hours spent in study visits at the research lab and 2.5 hours of individual participation at home using a computer with internet access. Participants were scheduled for two lab visits, which included completion of self-report measures, cognitive tasks, and intervention exercises. At the first visit, participants spent 1.5 hours, which comprised the consent process, completion of self-report and behavioral measures, and completion of an intervention exercise (either mindful breathing or time management self-assessment). During this visit participants were informed about and trained on the at-home practice portion of the study. At-home practice consisted of 10-minute training sessions accessed on a personal computer via the internet, with 5 sessions per week over the course of 3 consecutive weeks. At the second study visit, participants completed self-report measures, cognitive tasks, and intervention exercises, followed by a debriefing for the study.

Study visits were conducted in the research lab space of Dr. Nancy Adleman in the psychology department at The Catholic University of America in one of two designated offices. The offices had a standard set-up of a large desk or table, two chairs, and a networked IBM desktop computer with keyboard, mouse, and speakers. Descriptions of assessment measures, cognitive tasks and intervention components are below (see Figure 1 for schematic of study procedures).
Recruitment. Recruitment was conducted by posting flyers on research bulletin boards in the psychology department at CUA, and via posts on an electronic research sign-up bulletin board on Blackboard, which was accessible to students and instructors of PSY 201 (see Appendix A for recruitment flyer). Links to the study consent form were available on the electronic research bulletin board, so that potential participants could review additional information about the study before scheduling a study visit. From the electronic bulletin board, a link was provided for interested individuals to access a web-based scheduling application (YouCanBook.Me). Individuals selected from pre-determined research appointment slots and entered their name and contact information to confirm an appointment. Participants were instructed to confirm that they were at least 18 years of age and not enrolled in a course taught
by Dr. Adleman or Katherine McMorran by selecting options from a drop-down menu. They were also asked for permission to receive appointment reminders via text. After completing the online sign-up form, a confirmation email was sent to the participant, indicating date, time, and location of the research study appointment, researcher contact information, and instructions to bring their laptop computer (if available) to the study visit. A link to cancel or reschedule the appointment was embedded in this confirmation email. Students were offered research credit for participating in the current study. Alternative options for earning credit towards the research course requirement for PSY 201 were available, and thus students were not coerced to participate in this study.

**Pre-Visit and Random Assignment.** Self-report measures were converted into an online interface using Google Forms, which allows for automatic collection of data into a spreadsheet, and reduces the potential for errors associated with manual data entry. Prior to active participant recruitment, a set of 200 five-digit ID numbers was randomly generated using a random generator website. These ID numbers were then compiled into a list to be used for random assignment to group during the study. In addition, each ID number was associated with a task order for the first study visit, and a different task order for the second visit. Thus, the task orders were counterbalanced across visits (within participants) and across participants within an intervention group. The same set of counterbalanced task orders was used for each intervention group. Because participants were recruited continuously and received the intervention individually, assignment to group followed an *every other* pattern chronologically. Thus, the first scheduled participant was assigned to the experimental group (mindful breathing exercise (MBE) intervention), the second participant was assigned to the active control group (time management
skills (TMS) intervention), and so forth. Automatically generated email reminders were sent to participants two days in advance of their appointments. On the day of the visit, participants received a text message reminder prior to their appointment.

Measures

**Self-Report Questionnaires**

**Beck Depression Inventory (BDI-II).** The BDI-II (Beck, Steer, & Garbin, 1988) is a widely used and well-validated measure of depressive symptoms consisting of 21 items, rated in intensity on a Likert scale from 0 to 3 (0 = “low intensity” and 3 = “high intensity”). Items ask about mood, pessimism, sense of failure, lack of satisfaction, guilt feelings, sense of punishment, self-dislike, self-accusation, suicidal wishes, crying, irritability, social withdrawal, indecisiveness, body image, work inhibition, sleep, fatigability, appetite, weight, somatic preoccupation, and loss of libido (Beck et al., 1988). A meta-analysis of the BDI-II reported \( \alpha = .86 \) for psychiatric patients and \( \alpha = .81 \) for non-psychiatric patients, indicating a high internal consistency (Beck et al., 1988). Also, the correlation coefficients between the BDI-II clinical rating and Hamilton Rating Scale of Depression (HRSD) in psychiatric patients were .72 and .73 respectively (Beck et al., 1988); the correlation coefficients for non-psychiatric patients were .60 and .74 respectively (Beck et al., 1988). These data support the external validity of the BDI-II.

**Positive and Negative Affect Schedule (PANAS).** The Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988) is a 20-item measure of state positive and negative affect, with items consisting of single-word emotion states. Participants are asked to indicate the extent to which they experienced each emotion over a specified time period using a Likert scale ranging from 1 to 5 (1 = “very slightly or not at all” and 5 = “extremely”) with how
they’re feeling right now OR the extent to which they’ve felt that way in the past week (Watson et al., 1988). In this study, participants rated how they felt at the time they were taking the questionnaire. Watson and colleagues (1988) reviewed the normative and data reliability, test retest reliability, scale validity, and external validity of the PANAS questionnaires with both student and non-student populations. Their results indicated acceptable levels of the following: 1) internal consistency reliabilities in normative and data categories of positive affect (PA, $\alpha = .86 - .90$) and negative affect (NA, $\alpha = .84 - .87$); 2) correlation between the two scales, PA and NA ($r = -.12 - -.23$); 3) test-retest reliability of PA ($r = .54 - .68$) and NA ($\alpha = .45 - .71$); 4) convergent correlation and discriminant correlation of the scale’s validity ($r = .89 - .95$ and $r = -.22 - .18$, respectively); and, 5) convergent correlation and discriminant correlation of the rating scale effects ($r = .76 - .92$ and $r = -.30 - -.20$, respectively) (Watson et al., 1988). The NA scale of the PANAS shows significant correlation with the Hopkins Symptoms Checklist (HSCL), Beck Depression Inventory (BDI), and STAI state Anxiety Scale (A-State), and the PA scale shows significant negative correlation with these three measures, indicating valid external validity of the questionnaire (Watson et al., 1988).

**Ruminative Response Scale (RRS).** The 22-item Ruminative Response Scale (RRS; Nolen-Hoeksema et al., 1993) is a subscale of the Response Styles Questionnaire that assesses cognitive and behavioral response to dysphoric mood. Items are rated on a scale from 1 to 4 (1 = almost never and 4 = almost always), and reflect responses that are focused on the self, symptoms, the causes or consequences of the dysphoric mood, or behavioral responses to dysphoric mood. Items load onto three subscales, including Depression (12 items), Brooding (4 items), and Reflection (6 items) (Treynor, Gonzalez, & Nolen-Hoeksema, 2003). The RRS has
shown internal consistency reliability of \( \alpha = .90 \), moderate to high test-retest reliability of \( r = .47 - .67 \), and good predictive validity (Treynor et al., 2003). The RRS has also demonstrated strong psychometric properties in undergraduate populations, such as internal consistency reliability of \( \alpha = .87 - .90 \), a test-retest reliability of \( r = .67 \), and evidence supporting convergent, discriminant, and predictive validity (Roelofs, Muris, Huibers, Peeters, & Arntz, 2006).

**Perseverative Thinking Questionnaire (PTQ).** The Perseverative Thinking Questionnaire (PTQ; Ehring et al., 2011) is a 15-item self-report measure that was developed to assess transdiagnostic repetitive negative thinking, in which thought content is not specific to a single disorder. Participants are asked to rate each item on a Likert scale ranging from 0 (never) to 4 (almost always). The PTQ was validated in both clinical and non-clinical populations. It assesses a higher-order general factor of repetitive negative thinking as well as three lower-order factors: 1) core characteristics (repetitiveness, intrusiveness, and difficulties with disengagement), (2) perceived unproductiveness, and (3) capturing of mental capacity. The validation study (Ehring et al., 2011) indicated that the PTQ has excellent internal consistency (\( \alpha = .94 \)) adequate test-retest reliability (\( r = .69 \)), and significant and substantial correlations with other measures of repetitive thinking such as the Rumination Response Scale (\( r = .72 \)) and the Penn State Worry Questionnaire (PSWQ; \( r = .70 \)).

**Penn State Worry Questionnaire (PSWQ).** The Penn State Worry Questionnaire (PSWQ; Meyer, Miller, Metzger, & Borkovec, 1990) was designed to measure the trait of worry, defined as a cognitive form of anxious response. There are 16 items rated on a scale from 1 to 5 (1 = Not at all typical and 5 = Very typical) that assess the generality, frequency, and uncontrollability of worry. In the initial validation study with a non-clinical sample, the PSWQ
demonstrated high internal consistency (α = 0.93), test-retest reliability (r >= 0.74 across 2 to 10 week intervals), and good convergent and discriminant validity (Meyer et al., 1990). In clinical samples, the PSWQ has been found to show high levels of internal consistency, concurrent validity, and differentiation of individuals with Generalized Anxiety Disorder from those with mood or other anxiety disorders (Brown, Antony, & Barlow, 1992).

**Five Facet Mindfulness Questionnaire (FFMQ).** The Five Facet Mindfulness Questionnaire (FFMQ; Baer et al., 2006) is a 39-item self-report measure of mindfulness, with subscales assessing five factors: 1) observing, 2) describing, 3) acting with awareness, 4) non-judging of inner experience, and 5) non-reactivity to inner experience. Items are rated on a 5-point Likert scale from 1 to 5 (1 = Never or very rarely true and 5 = Very often or Always true) and are worded to reflect both mindful and non-mindful (reverse-scored) thoughts and behaviors. Baer and colleagues (2008) reported that the measure has adequate to good internal consistency across the facets (α = .67 – .92) as well as adequate reliability and validity. Additional research has shown internal consistencies of α = .85 in non-meditating samples and α = .90 in meditating samples (de Bruin, Topper, Muskens, Bögels, & Kamphuis, 2012). The FFMQ has shown high correlations with other mindfulness measures, suggesting strong convergent validity (Cebolla et al., 2012).

**Difficulties in Emotion Regulation Scale (DERS).** The Difficulties in Emotion Regulation Scale (DERS; Gratz & Roemer, 2004) is a 36-item self-report survey that assesses various aspects of difficulties with emotion regulation, including lack of mindfulness. The DERS includes six subscales, including 1) non-acceptance of emotional responses, 2) difficulty engaging in goal-directed behavior, 3) impulse control difficulties, 4) lack of emotional
awareness, 5) limited access to emotion regulation strategies, and 6) lack of emotional clarity. Participants are asked to indicate how often various statements apply to themselves on a 5-point Likert scale from 1 to 5 (1 = almost never / 0-10%) and 5 = almost always / 91-100%); a composite score is calculated based on the scores of the subscales. A validation study (Gratz & Roemer, 2004) found high internal consistency (α = .93) and good test-reliability (r = .88). The DERS has shown positive correlations with measures of maladaptive emotion regulation and negative correlations with measures of emotional expressivity, providing evidence for the construct validity of the DERS (Gratz & Roemer, 2004). The correlations between all the subscales (non-acceptance, goals, impulse, awareness, strategies, and clarity) ranged from r = .16 – .69. In addition, the DERS has been shown to be positively correlated with experiential avoidance and negatively correlated with emotional expressivity (Gratz & Roemer, 2004). These analyses indicate high internal consistency and construct validity.

**Attentional Control Scale (ACS).** The Attentional Control Scale (ACS; Derryberry & Reed, 2002) is a 20-item self-report measure of individual differences in attentional skills related to voluntary executive control. The ACS measures attention as a heterogeneous construct, including the capacity to 1) focus, 2) resist distraction, and 3) shift attention. The ACS is measured on a four point Likert scale from 1 to 4 (1 = “almost never” and 4 = “always”). According to Fajkowska & Derryberry (2010), there is a strong validity of item-discrimination coefficients of α = .29 - .63. The test-retest reliabilities were r = .45 – .73 (Fajkowska & Derryberry, 2010). Internal consistency reliability for the total scale was reported as α = .88, and the Spearman-Brown coefficient was .82 (Fajkowska & Derryberry, 2010). These results indicate that the scale has a high internal consistency and strong validity.
**Adult ADHD Self-Report Scale Screener (ASRS).** The World Health Organization Adult ADHD Self-Report Scale (ASRS) Screener (Kessler et al., 2005) was developed to provide a brief, self-administered assessment of adult Attention-Deficit Hyperactivity Disorder. The ASRS Screener includes 6 items asking respondents how often a particular symptom of ADHD occurred over the past six months on a five-point response scale of never (0), rarely (1), sometimes (2), often (3), and very often (4). According to validation studies, the ASRS has adequate sensitivity (68.7%), excellent specificity (99.5%), excellent total classification accuracy (97.9%), and a good Kappa (.76) in the general US population (Kessler et al., 2005). The ASRS Screener has shown internal consistency reliability of $\alpha = .63 – .72$, test-retest reliability of $r = .58 – .77$, and strong concordance with diagnoses made by clinicians (area under the receiver operating characteristic curve (AUC) of .90). Together these findings indicate that the ASRS Screener is a valid screening measure of ADHD in both clinical and community samples.

**Perceived Stress Scale (PSS).** The Perceived Stress Scale (PSS; Cohen, Kamarck, & Mermelstein, 1983) is a brief 14-item measure of perceived stress. In a validation study, the PSS demonstrated high reliability across three non-clinical samples ($\alpha = .84, .85, \& .86$). Test-retest reliability was higher over a 2-day interval ($r = .85$) than over a 6-week interval ($r = .55$), supporting its use as a state measure (i.e., correlations should be higher across shorter intervals). The PSS was found to have better predictive validity than stressful life-event scores and shows discriminant validity in relation to depressive symptomatology (Cohen et al., 1983).

**Behavioral Measures of Attention.** After completing self-report measures of psychological constructs, participants completed two validated and widely used cognitive tasks as performance-based assessments of attention.
**Sustained Attention to Response Task (SART).** The Sustained Attention to Response Task (SART; Robertson et al., 1997) is a behavioral measure of sustained attention that has been widely used in cognitive (e.g., Bastian & Sackur, 2013) and electrophysiological studies of attention (e.g., Hart et al., 2015). The SART is a “go/no-go” task that allows for the assessment of sustained attention and impulsivity/inhibitory control. A longer variation of this task, the Conner’s Continuous Performance Test, is used in neuropsychological testing and has been shown to reliably differentiate individuals with Attention Deficit Hyperactivity Disorder from healthy controls (Epstein et al., 2003). Versions of the SART have previously been used in mindfulness studies, e.g. in a study investigating cognitive changes following short-form mindfulness training in university students (Morrison et al., 2014). The SART was modified for the current study to have a duration of 5 minutes preceded by a 60-second practice block. In the original study, the task lasted 4.3 minutes and was preceded by a 21.7 second practice block (Robertson et al., 1997).

During the SART task, participants viewed a computer screen and made responses using the space bar on a keyboard. A continuous sequence of single digits (0-9) appeared on an empty background, with a center fixation cross appearing between trials. Each digit appeared for 250ms, and the fixation cross was presented for 900ms between each trial. Participants were instructed to respond to all digits except “3” by pressing the space bar with their dominant hand (“go” trials). Participants were instructed to withhold responding when a “3” appeared (“no-go” trials). Go-trials comprised 95% of total trials and no-go trials comprised 5% of total trials. Trial order was pseudo-randomized so that no-go trials were not adjacent to each other. Participants were instructed to respond as quickly as possible while maintaining accuracy. Outcome variables
of the SART included mean overall accuracy, mean reaction time on correct “go” trials, number of commission errors (incorrect responses to “no-go” trials), and coefficient of variation of reaction time (CVRT), a measure of reaction time variability, which is computed by dividing the standard deviation of RT by the mean RT (Morrison et al., 2014). Greater reaction time variability reflects inattentive responding and may also be an index of mind wandering (Bastian & Sackur, 2013).

**Attention Network Test (ANT).** The Attention Network Test (ANT, Fan et al., 2002) is a reaction time cognitive task based on a Posner cueing paradigm, which allows for assessment of functional attention networks: alerting, orienting, and executive control. The task has been used with various modifications in several studies investigating cognitive processes of attention (Breckel et al., 2013; Fan et al., 2002, Fan et al., 2005, Fan et al., 2009; Johnson, Conture, & Walden, 2012). The original ANT developed in 2002 was modified for this study using e-Prime software to adjust duration and visual components. For the current study, the ANT consisted of a 1-minute practice block followed by three experimental blocks lasting 5 minutes each.

During the task, participants were asked to focus their attention on a white center fixation cross on a dark background (see Figure 2 for schematic of ANT). Two white-outline boxes remained on the screen throughout the task, with one above and one below the fixation cross. Target arrows appeared in one of the boxes on each trial and consisted of a row of 5 horizontal arrows (one center arrow and four flanker arrows). Participants were asked to respond by pressing either the left or right arrow button on a keyboard to correspond to the direction of the center arrow. There were two conditions for target arrows: congruent or incongruent. On congruent trials, the center arrow faced in the same direction as the flanker arrows. On
incongruent trials, the center arrow faced in the opposite direction as the flanker arrows. Target arrows were immediately preceded by a visual cue condition. Trials consisted of various combinations of visual cue and target stimuli. Trials had one of four cueing conditions: no-cue, double cue, valid cue or invalid cue. In no-cue trials, the target arrows appeared without any cueing information. In double-cue trials, the outlines of both boxes brightened in intensity before the target set appeared. On valid cue trials, one box brightened (either above or below), and the target arrows appeared in this box. On invalid cue trials, target arrows appeared in the box that did not brighten. The direction of target arrows and position of cue (above/below fixation) were counterbalanced across trials. Among trials with spatial cues, 75% used valid cues and 25% used invalid cues. Differences in reaction time across cueing conditions were calculated for each participant and each session to obtain network scores for alerting, orienting, and executive control. Network scores were calculated as follows: Alerting = RT [No cue] – RT [Double cue], Orienting = RT [Double cue] – RT [Valid cue], and Executive Control = RT [Incongruent flanker] – RT [Congruent flanker] (Fan et al., 2009). In addition, overall accuracy and mean reaction time on correct trials were calculated as outcome measures of the ANT.
Figure 2. Schematic of Attention Network Test task
Study Visit 1

Participants were welcomed at their individual appointment time and asked to turn off and put away their mobile phones. They were asked to read a printed copy of the study consent form, and had the opportunity to ask questions (see Appendix B for consent form). The researcher then answered any questions and reviewed important details from the form to ensure participant comprehension. Participants were asked to confirm verbally that they were at least 18 years old. Once participant questions or concerns had been addressed, the participant and researcher signed the consent form. Consent forms were stored in a locked file cabinet separately from participant data. Participants were then given a unique ID number, which had previously been allocated to either the experimental group or the active control group.

After consenting and being assigned to a group, participants answered demographic questions and completed study activities according to a pre-set counterbalanced task order. The counterbalanced tasks included self-report measures and two behavioral attention tasks administered by a computer (see Table 2 for summary of measures).

Demographic and self-report measures were administered in an online format using Google Forms on a desktop computer. Behavioral attention measures were administered on an IBM laptop computer using e-Prime software. After completing the self-report measures and behavioral tasks, participants in the mindfulness group were trained in the mindful breathing exercise by the researcher, using a standardized script and allowing participants to ask questions. They then engaged in the mindful breathing exercise for 10 minutes. Participants in the time management group completed a time management self-assessment exercise for 10 minutes.
Table 2

*Summary of Measures*

<table>
<thead>
<tr>
<th>Construct</th>
<th>Measure</th>
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<td>Demographics</td>
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<td>Positive and Negative Affect Schedule (PANAS)</td>
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<td></td>
<td>Difficulties in Emotion Regulation (DERS)</td>
</tr>
<tr>
<td></td>
<td>Prior Mindfulness Experience <em>(Visit 2 only)</em></td>
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<tr>
<td></td>
<td>Behavioral</td>
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<tr>
<td></td>
<td>Mindful Breathing Exercise</td>
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<tr>
<td>Attention</td>
<td>Self-report</td>
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<td></td>
<td>Attentional Control Scale (ACS)</td>
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<td></td>
<td>Adult ADHD Self Report Scale Screener (ASRS)</td>
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<tr>
<td></td>
<td>Behavioral</td>
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<td></td>
<td>Sustained Attention to Response Task (SART)</td>
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<td></td>
<td>Attention Network Task (ANT)</td>
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<tr>
<td>Perceived Stress</td>
<td>Perceived Stress Scale (PSS) <em>(Visit 2 only)</em></td>
</tr>
</tbody>
</table>

The demographic and background questionnaire asked participants to report: 1) age, 2) gender, 3) current and past psychiatric or neurological diagnosis, and 4) current and past prescription medications taken for psychiatric or neurological conditions.
Participants completed validated self-report questionnaires of depression symptoms, current mood (state affect), rumination, perseverative thinking, worry, mindfulness, difficulties with emotion regulation attentional control, ADHD symptoms, and perceived stress, which took approximately 30 minutes. The order of measures was counterbalanced across participants. Measures were converted into digital format using Google Forms. Participants entered their responses using the Google Forms interface on a desktop computer. All self-report responses were identified by anonymous participant ID number, and no personally identifying information was obtained with self-report measures. After completing self-report questionnaires, participants completed both behavioral attention measures (SART and ANT) in counterbalanced order. Participants were then given exercises based on group (MBE or TMS) as described below.

**Mindful Breathing Exercise – Training and Practice.** Participants in the mindful breathing intervention group engaged in a mindful breathing exercise (MBE), based on procedures developed by Burg and Michalak (2011). Training in the MBE was conducted by the student principal investigator for all mindful breathing participants (see Appendix D for script used to teach the MBE). After learning how to observe physical sensations of breathing and notice when attention had wandered, participants engaged in a practice trial using the online MBE interface that was developed for this study.

In the current study, the duration of the MBE was shortened from the 18 minutes used by Burg and Michalak (2011) to 10 minutes, with a corresponding adjustment in the number of times that participants were prompted to respond about their focus of attention. Ten auditory prompts were programmed to occur semi-randomly between 0 minutes 15 seconds to 9 minutes
45 seconds of the exercise, with no more than 1 prompt within each 1 minute interval. The MBE interface consisted of a white fixation cross appearing on a dark background (see Figure 3).

![Mindful Breathing Exercise computer screen visual display](image)

Figure 3. Mindful Breathing Exercise computer screen visual display (same for study visits and online home practice). Counterbalanced versions. Left screen was displayed for participants with odd ID numbers (‘F’ key press corresponded to attention wandering; ‘J’ key press corresponded to attention on breath). Right screen was displayed for participants with even ID numbers; ‘F’ key press corresponded to attention on breath; ‘J’ key press corresponded to attention wandering.

Participants were instructed to maintain a soft gaze on this center cross, or close their eyes during the MBE. Two boxes containing the words “Breath” and “Other” appeared in either the bottom left or the bottom right of the screen (counterbalanced among participants), and served as indicators of whether to press a key on the left (“F”) or right (“J”) of the keyboard to make a responses. Participants were instructed to give responses in two ways. First, they were told to report, whenever they heard an auditory prompt, whether their attention was on their breathing or had drifted to other content by pressing either the key corresponding to “breath” or “other” as shown on the screen. Second, they were asked to report any moments in which they independently noticed that their attention had drifted from their breathing sensations by pressing the key corresponding to “other.” The practice trial lasted 90 seconds and included 3 auditory prompts. As a validity check, participants were asked to briefly describe their experience of doing the exercise, including whether they had made cued and un-cued responses, and whether
they adequately comprehended the instructions. Following the practice trial, participants completed the full 10-minute exercise using the online interface.

**Time Management Skills - Self-Assessment.** Participants in the active control group completed a time management skills (TMS) intervention, based on procedures used in a self-compassion intervention study with college students (Smeets, Neff, Alberts, & Peters, 2014). At the first study visit, participants spent 10 minutes completing a self-report assessment of their time management ability. The self-assessment exercise was adapted from a guide to time management for students (Fleet & Reaume, 1994). It consisted of 20 items rated on a 5-point Likert scale (1=No, 5=Yes) with reverse scoring for half of the items. Sample items included “I prioritize tasks effectively,” “I am easily distracted by school work by my friends, TV, etc.,” “I have set up a regular plan for my study activities,” and “I often miscalculate how long homework tasks will take.” As part of the self-assessment, participants calculated their scores and identified areas of improvement (based on item responses).

At the end of the first visit, all participants were given instructions for completing the at-home practice, with different instructions for the mindfulness and time management groups. An appointment was scheduled for the participant to return to the lab in approximately 3 weeks for the second study visit.

**Online Home Intervention**

All participants completed a total of 2.5 hours of at-home practice using the online study interface on their personal computers. For both groups, practice consisted of 10-minute sessions involving either the mindful breathing exercise or practice of a time management skill. Participants could complete no more than one session per day, and could choose how to space
the 15 sessions over the 21-day intervention period (e.g., 15 consecutive sessions in 15 days, or skipping up to six days at intervals of their choice).

Participants completed practice sessions by logging into the study website using their unique participant ID number. Following each practice session, participants were asked to rate “How difficult was it to engage in this practice today?” on a 7-point Likert scale (1 = Not at all difficult and 7 = Very difficult). Once their response was submitted, participants received a standard message of positive feedback and encouragement to continue engaging with the at-home practice.

Participation was tracked online using participant ID number to ascertain whether an online session had been completed each day. Participants received daily email reminders indicating the number of sessions completed, and available days remaining to complete the 15 sessions. Reminders included the link to the study website.

**Mindful Breathing Exercise Intervention.** Online practice for the mindful breathing intervention consisted of engaging in the mindful breathing exercise for 10 minutes, with the same interface used at study visits (see Appendix E for online instructions and screen display). Participants were instructed to give responses about the focus of their attention when prompted by auditory cues at quasi-randomly generated intervals, as well as independently report when their attention had drifted from their breathing, using the “F” and “J” keys on their keyboard.

**Time Management Skills Intervention.** A time management skills intervention was used as an active control comparison based on prior mindfulness-based intervention research with undergraduate students (Smeets et al., 2014). Time management skills are applicable to student life, and could help control for nonspecific effects of brief interventions that could reduce
stress and improve affect. For the online practice, participants logged in to the study website and completed one time management skill building exercise during each 10-minute session using the online interface. Five separate exercises were delivered in sequence three times during the course of the at-home intervention for a total of 15 sessions. Exercises were drawn from procedures used in time management skills building courses, including those used in prior studies (Smeets et al., 2014). The following exercises were included: 1) record of daily activities during past 3 days using a time log; 2) self-reflection on recent time management, including current goals and barriers to spending time on areas of importance; 3) identifying goals and categorizing them according to urgency and importance; 4) setting SMART (Specific, Measurable, Achievable, Relevant, Time-bound) goals (Rubin, 2002) and identifying intermediate action steps; and 5) scheduling time on a calendar to complete specific action steps towards goals during the upcoming week (see Appendix F for time management skills exercises).

**Study Visit 2**

Participants were scheduled to return to the lab for a post-intervention assessment that occurred approximately 3 weeks after the first study visit (a minimum of 21 days from the first visit and up to 30 days depending on participant and study team availability). Participants completed all self-report measures and cognitive behavioral attention tasks in a counterbalanced order. Mindful breathing participants engaged in a 10-minute mindful breathing exercise (MBE). Time management participants completed a post-intervention time management self-assessment using the same form as at the first study visit. In addition, all participants were given a measure of perceived stress (Perceived Stress Scale; Cohen et al., 1983) to account for external events that could have contributed to changes in outcome variables during the at-home intervention.
period. Participants were asked to answer questions describing any experience with mindfulness practices they had prior to study participation. Participants were asked about: 1) type of experience (yoga, meditation, MBSR, tai chi), 2) format (course, workshop, book/audio/video guided, self-guided, research study), 3) number of years of practice, 4) estimated total hours of practice, and 5) typical frequency of practice (see Appendix G for questionnaire). Participants were able to select from several response options or complete a free response by selecting “other” and writing a comment. Information about prior mindfulness experience was collected after the intervention so as not to create participant expectancy with regard to potential benefits of mindfulness training.

Debriefing

After participants completed the study, they were verbally debriefed, provided with a debriefing handout (see Appendix H), and given the opportunity to ask questions or share feedback. Participants were offered the option to engage in the intervention they did not receive during the study. In this way, any potential benefits of either the mindful breathing intervention or the time management intervention were equally available to all study participants.

Results

Attrition and Study Completion

A total of 80 students recruited for the study gave informed consent, were randomly assigned (40 participants per intervention group), and completed measures at the first study visit. Participants were considered to have dropped out of the study if they did not complete all 15 sessions of online home practice, and thus were not scheduled for the second study visit. Participants were considered study completers if they engaged in 15 online sessions lasting 10
minutes each during their individual 21-day intervention period. Participants could take additional days to complete all 15 sessions up until the date of their scheduled second visit (up to 30 days from first visit). Participation in the home practice was verifiable, as sessions were tracked through the online interface.

Of those who began the study, 5 of 80 recruited participants dropped out, resulting in an attrition rate of 6.25%. There were 3 out of 40 participants in the MBE group who did not complete the study, and 2 out of 40 participants dropped out from the TMS group. Thus, there were 37 MBE participants and 38 TMS participants with data for both study visits and the online practice. There was no difference in proportion of completers between the groups as assessed by chi-square test, $\chi^2(1) = 0.21, p = 0.644$. All participants who attended the second study visit had completed the home practice.

**Missing Data**

For all self-report measures, if participants were missing data for one or more items, a total score for that measure was not included in relevant analyses. Percentage of missing data did not differ between groups for any measure ($p > 0.05$) except for the measure of rumination (RRS). On the RRS scale, there was a trend towards a significant difference between groups in percentage of missing data, $\chi^2(1) = 3.53, p = 0.060$. In the MBE group, 77.5% of participants had complete data at both time points. In the TMS group, 92.5% of participants had complete data at both time points.

**Outliers and Data Reduction**

Data for self-report and behavioral measures were considered outliers if the calculated value of studentized residuals (standardized scores) was ±3. If there were outliers for a given
measure, analyses were run both including and excluding outlier data to test whether results differed. Except where noted, there were no differences in analyses when outliers were removed, and reported analyses included all participants.

For one of the behavioral measures of attention (ANT), responses in which reaction time was less than 200ms were classified as errors/misses (Federico, Marotta, Adriani, Maccari, & Casagrande, 2013) during data cleaning. Such responses are faster than possible for the nature of the task (processing visual information and producing a motor response), and thus likely represent an invalid/erroneous response. For the other behavioral attention measure (SART), very fast response times are possible when participants engage in automatic responding (i.e., failure to inhibit responses), with a tendency for errors to increase during faster responses due to a speed-accuracy tradeoff (Robertson et al., 1997). The use of overall accuracy, response trial reaction time, and number of commission errors as outcome variables allows for the interpretation of automatic responding without the need to eliminate trials in which response times were < 200ms.

**Differences in Group Characteristics**

Even with random assignment to group, it was important to test for group differences in characteristics that might influence outcome variables of interest. Demographics were assessed at the first study visit. Perceived stress was assessed at the second study visit to control for factors external to the study that might have influenced group differences during the intervention period. Outcome variables were assessed prior to the intervention to ensure that group comparisons of change did not merely reflect pre-existing differences between groups.
Baseline Differences Between Groups. Chi-square tests of independence were conducted to test group differences at baseline on demographics including gender, current or past psychiatric diagnosis, and current use of psychiatric medication. Means, frequencies, and results of group comparison tests are presented in Table 1. Participants in the two intervention groups did not significantly differ by gender, $\chi^2(2) = 1.84, p = .399$, by current or past psychiatric diagnosis, $\chi^2(1) = 0.92, p = .337$, or by current psychotropic medication use, $\chi^2(1) = 0.52, p = .472$. An independent samples t-test was conducted to test group differences in age. The groups did not significantly differ in age, $t(77) = 0.47, p = .643$ (see Table 1). The groups did not differ at baseline in proportion of individuals who scored above the clinical cutoffs for ADHD, $\chi^2(1) = 0.13, p = .719$, or depression, $\chi^2(1) = 0.001, p = .975$ (see Table 3).

Post-Intervention Differences Between Groups. To control for the effect of external life stressors on outcome variables, a measure of perceived stress (Perceived Stress Scale) was given at the second study visit. Participants were asked to use the past 3 weeks as a time frame when answering items on this questionnaire (i.e., length of at-home intervention period). The groups did not significantly differ in the level of perceived stress experienced during the period of study participation, as assessed at posttest, $t(72) = -1.56, p = .122$ (see Table 3). Participants’ prior mindfulness experience was assessed at the second study visit to avoid creating an expectancy about the intervention. Participants in the two intervention groups did not significantly differ by whether they had mindfulness experience prior to study participation, $\chi^2(3) = 0.34, p = .952$ (see Table 1).
Table 3

**Group Differences in Baseline Depressive and ADHD Symptoms and Post-Intervention Perceived Stress**

<table>
<thead>
<tr>
<th>Participants</th>
<th>MBE</th>
<th>TMS</th>
<th>Group Comparisons</th>
</tr>
</thead>
<tbody>
<tr>
<td>BDI-II at baseline</td>
<td>$n = 32$</td>
<td>$n = 32$</td>
<td></td>
</tr>
<tr>
<td>$M \pm SD$</td>
<td>10.63 ± 6.55</td>
<td>12.83 ± 10.79</td>
<td>$t(66) = -1.00$</td>
</tr>
<tr>
<td>% of group above</td>
<td>28.1%</td>
<td>27.8%</td>
<td>$\chi^2(1) = 0.001$</td>
</tr>
<tr>
<td>clinical cutoff</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASRS at baseline</td>
<td>$n = 37$</td>
<td>$n = 36$</td>
<td></td>
</tr>
<tr>
<td>$M \pm SD$</td>
<td>10.89 ± 3.73</td>
<td>10.97 ± 3.87</td>
<td>$t(71) = -0.09$</td>
</tr>
<tr>
<td>% of group above</td>
<td>16.2%</td>
<td>19.4%</td>
<td>$\chi^2(1) = 0.13$</td>
</tr>
<tr>
<td>clinical cutoff</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSS at posttest</td>
<td>$n = 36$</td>
<td>$n = 38$</td>
<td></td>
</tr>
<tr>
<td>$M \pm SD$</td>
<td>14.81 ± 7.06</td>
<td>17.47 ± 7.59</td>
<td>$t(72) = -1.56$</td>
</tr>
</tbody>
</table>

Note. MBE = Mindful Breathing Exercise group. TMS = Time Management Skills group. BDI-II = Beck Depression Inventory, 2nd edition; higher scores indicate greater depressive symptoms; clinical cutoff is for mild depression. ASRS = Adult ADHD Self Report Scale Screener total score; higher scores indicate greater ADHD symptoms; clinical cutoff is for high probability of ADHD diagnosis using screener. For baseline depressive and ADHD symptoms, only participants with data at both time points were included in calculations of mean, standard deviations, and comparison of group means. PSS = Perceived Stress Scale; higher scores indicate greater perceived stress, and was assessed only at posttest. There were no significant differences between groups on any measures ($p > 0.05$).

**Between-Group Changes in Outcome Measures**

Mixed-design repeated measure ANOVAs were conducted to investigate group differences in change, using group as the between-subjects factor and time as the within-subjects factor. Separate analyses using this model were conducted for each of the following outcome variables: ADHD symptoms (as measured by the ASRS), depressive symptoms (as measured by the BDI-II), worry (as measured by the PSWQ), rumination (as measured by the RRS), perseverative thinking (as measured by the PTQ), state positive affect (as measured by the positive affect subscale of the PANAS), state negative affect (as measured by the negative affect...
subscale of the PANAS), attentional control (as measured by the ACS), mindfulness (as measured by the FFMQ), and difficulties with emotion regulation (as measured by the DERS).

Total scores for outcome measures were not computed for participants with missing data (i.e., those who did not answer all items, or did not complete a study visit). Only participants with data at both time points were included in ANOVAs. Due to missing data, sample sizes are slightly different for each analysis, and are indicated separately for each measure below.

Interaction and main effects are reported for each variable. For variables in which there was a significant group by time interaction, univariate ANOVAs were conducted to determine simple main effects. Effect sizes were calculated and reported as $\eta^2_p$ (partial eta squared). For mean scores by group, see Table 4.

For each mixed-model ANOVA, outliers were determined by assessing for values of studentized residuals greater than ±3. For outcome variables with outlier data, tests were conducted both with and without outliers. Results were not affected by outliers, except as noted.

Unless otherwise noted, Levene’s test indicated homogeneity of variances ($p > .05$), and Box’s M test indicated homogeneity of covariances ($p > .05$). If the assumption of homogeneity of covariances was not met ($p < .05$), the $F$ value for Pillai’s trace was used (Tabachnick & Fidell, 2001).

Self-report Measures

**ADHD Symptoms (Adult ADHD Self-Report Scale Screener, ASRS).** There were no outliers and Box’s M test ($p = .012$) indicated a violation of the assumption of homogeneity of covariance. There was a significant interaction of group and time on ASRS score, $F(1, 71) = 4.64, p = .035, \eta^2_p = .06, (MBE n = 37, TMS n = 36)$. The interaction effect appears to be driven
by a significant effect of time in the MBE group (see Figure 4). Participants in the MBE group showed a significant decrease in ASRS score from pretest to posttest, $F(1, 36) = 4.54, p = .040$, $\eta_p^2 = .11$, but there was no significant change in ASRS score for those in the TMS group, $F(1, 35) = 0.42, p = .521$. Groups did not differ on mean ASRS scores at pretest, $F(1, 71) = 0.008, p = .928$, or at posttest, $F(1, 71) = 2.70, p = .105$. Lower ASRS scores reflect fewer ADHD symptoms. MBE participants showed a significant decrease in ASRS scores, reflecting an improvement in ADHD symptoms over the course of the intervention.
Figure 4. Mean scores by group at pretest and posttest on Adult ADHD Self-Report Scale Screener (ASRS). SE = Standard Error.
*p < .05.

Depressive Symptoms (Beck Depression Inventory, 2nd ed., BDI-II)

Full Sample. There was one participant with outlier data (TMS group) at both pretest and posttest. Box’s M test ($p = .005$) indicated a violation of the assumption of homogeneity of covariance. A trend towards a significant interaction between group and time was observed for BDI-II scores, $F(1, 66) = 3.71, p = .058, \eta^2 = .05$, (MBE $n = 32$, TMS $n = 36$). There were no
group differences in BDI-II scores at pretest, $F(1, 66) = 1.01, p = .319$, but the MBE group had significantly lower BDI-II scores than the TMS group at posttest, $F(1, 66) = 4.74, p = .033, \eta^2_p = .07$. Both groups showed a significant decrease in BDI-II scores from pretest to posttest, MBE group $F(1, 31) = 15.05, p = .001, \eta^2_p = .33$; TMS group, $F(1, 35) = 4.44, p = .042, \eta^2_p = .11$ (see Figure 5).

Lower BDI-II scores indicate fewer depressive symptoms. Both groups showed a significant decrease in BDI-II scores, reflecting an improvement in depressive symptoms over the course of the intervention. However, MBE participants had significantly lower BDI-II scores than TMS participants at posttest, reflecting lower levels of depression in the MBE group.

When excluding the outlier data (MBE $n = 32$, TMS $n = 35$), the pattern of results was similar, including the trend towards a significant interaction effect, $F(1, 65) = 3.65, p = .061, \eta^2 = .053$. The posttest difference between groups changed to a trend towards significance, $F(1, 65) = 3.98, p = .050, \eta^2 = .058$. The decrease in depressive symptoms from pretest to posttest among TMS participants changed to a trend towards significance, $F(1, 34) = 4.13, p = .050, \eta^2 = .108$, whereas the decrease in depressive symptoms among MBE participants remained significant, $F(1, 31) = 15.05, p = .001, \eta^2 = .327$.

Participants Above Clinical Threshold at Baseline. To investigate whether participants with clinical levels of depressive symptoms at baseline responded differently to the interventions, data from participants scoring $\geq 14$ on the BDI-II (considered the clinical cutoff for mild depression; Beck & Steer, 1987) at baseline (MBE $n = 9$; TMS $n = 10$) was analyzed separately. There were no group differences in proportion of individuals scoring above this cutoff at baseline. Due to the small sample in this secondary analysis, the TMS participant with
outlier data (high BDI-II score) was included to test differences in the effect of the intervention for those with high symptom levels.

*Figure 5.* Mean scores by group at pretest and posttest on Beck Depression Inventory, 2nd ed. (BDI-II), using full sample. *SE* = Standard Error. *p < .05.*
As with the full sample, there was a trend towards a significant interaction of time and intervention on depressive symptoms, $F(1, 17) = 3.21, p = .091, \eta^2_p = .16$, in the subgroup of participants who met clinical cutoffs on the BDI-II. This interaction appeared to be driven by a significant difference between groups at posttest, $F(1, 17) = 7.30, p = .015, \eta^2_p = .30$, with MBE participants showing lower BDI-II scores than TMS participants. In addition, MBE participants showed a significant decrease in BDI-II scores from pretest to posttest, $F(1, 8) = 12.06, p = .008, \eta^2_p = .60$, whereas there was no significant change in BDI-II scores among TMS participants, $F(1, 9) = 1.10, p = .321$. There were no group differences in BDI-II scores at pretest $F(1, 17) = 2.50, p = .132$. Results among individuals who began the study with clinical levels of depressive symptoms are similar to the full sample, with significant improvement in the MBE group over time and lower levels of depressive symptoms at posttest compared to the TMS group.

**Worry (Penn State Worry Questionnaire, PSWQ).** There were no outliers and Box’s M test ($p = .028$) indicated a violation of the assumption of homogeneity of covariance. A trend towards a significant interaction between group and time was observed on PSWQ scores, $F(1, 66) = 3.12, p = .082, \eta^2_p = .05$, (MBE $n = 36$, TMS $n = 32$). Within the MBE group, there was a trend towards a significant decrease in PSWQ scores from pretest to posttest, $F(1, 35) = 3.67, p = .064$, but no significant change in PSWQ scores in the TMS group, $F(1, 31) = 0.27, p = .609$. The groups did not significantly differ on PSWQ scores at either pretest, $F(1, 66) = 0.22, p = .640$, or posttest, $F(1, 66) = 0.37, p = .547$ (see Figure 6). Lower PSWQ scores indicate fewer symptoms of worry. MBE participants showed a trend towards a decrease in worry during the intervention that was not evident in the TMS group.
Rumination (Ruminative Response Scale, RRS). There were no outliers. There was no interaction between group and time on RRS scores $F(1, 66) = 1.03, p = .314$, or main effect of group on RRS scores, $F(1, 66) = 0.35, p = .557$, (MBE $n = 31$, TMS $n = 37$). There was a main effect of time on RRS scores, $F(1, 66) = 11.55, p = .001, \eta^2_p = .15$, with participants showing a
decrease in RRS scores from pretest to posttest. Lower RRS scores reflect lower levels of rumination.

**Perseverative Thinking (Perseverative Thinking Questionnaire, PTQ).** There were no outliers. There was no interaction between group and time on PTQ scores, $F(1, 69) = 1.32, p = .255$, or main effect of group on PTQ scores, $F(1, 69) = 0.44, p = .509$, (MBE $n = 35$, TMS $n = 36$). There was a main effect of time on PTQ scores, $F(1,69) = 5.50, p = .022, \eta_p^2 = .07$, with participants showing a decrease in PTQ scores from pretest to posttest. Lower PTQ scores reflect lower levels of perseverative thinking.

**Positive and Negative Affect (Positive and Negative Affect Schedule, PANAS)**

*Positive Affect subscale.* There were no outliers. There was no interaction between group and time on PA scores, $F(1, 68) = 0.02, p = .902$, or main effect of group on PA scores, $F(1, 68) = 0.002, p = .963$, (MBE $n = 34$, TMS $n = 36$). There was a trend towards a significant main effect of time on PA scores, $F(1, 68) = 3.55, p = .064$, with participants showing a decrease in PA scores from pretest to posttest. Lower PA scores reflect lower levels of positive affect.

*Negative Affect subscale.* Two participants (1 in MBE group and 1 in TMS group) had outlier data at pretest and one participant (1 in TMS group) had outlier data at posttest. There were no main effects of group, $F(1, 68) = 0.23, p = .634$, or time, $F(1, 68) = 0.37, p = .545$, nor was there an interaction between group and time on NA scores, $F(1, 68) = 0.22, p = .644$, (MBE $n = 37$, TMS $n = 33$). Results did not differ when outlier data were excluded.

**Attentional Control (Attentional Control Scale, ACS).** There were no outliers and Levene’s test indicated that the assumption of homogeneity of variances was violated at pretest ($p = .016$). There were no main effects of group, $F(1, 66) = 0.02, p = .902$, or time, $F(1, 66) = .002$.
0.04, \( p = 0.851 \), nor was there an interaction between group and time on ACS scores, \( F(1, 66) = 0.14, p = 0.712 \), (MBE \( n = 33 \), TMS \( n = 35 \)).

_Mindfulness (Five Facet Mindfulness Questionnaire, FFMQ)._ There were no outliers. There were no main effects of group, \( F(1, 64) = 0.01, p = 0.918 \) or time, \( F(1, 64) = 0.003, p = 0.956 \), nor was there an interaction between group and time on FFMQ scores, \( F(1, 64) = 2.58, p = 0.113 \), (MBE \( n = 33 \), TMS \( n = 33 \)).

_Difficulties in Emotion Regulation (Difficulties in Emotion Regulation, DERS)._ There was one participant in the TMS group with outlier data at both time points. There were no main effects of group, \( F(1, 61) = 0.08, p = 0.784 \), or time, \( F(1, 61) = 0.79, p = 0.377 \), nor was there an interaction between group and time on DERS scores, \( F(1, 61) = 0.11, p = 0.738 \), (MBE \( n = 31 \), TMS \( n = 32 \)). Results did not differ when outlier data were excluded.
Table 4

*Means, Standard Deviations, and ANOVA Results for Self-Report Outcome Measures*

<table>
<thead>
<tr>
<th>Measure</th>
<th>MBE Pre M (SD)</th>
<th>MBE Post M (SD)</th>
<th>TMS Pre M (SD)</th>
<th>TMS Post M (SD)</th>
<th>ANOVA group by time interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASRS</td>
<td>10.89a (3.73)</td>
<td>9.62b (4.36)</td>
<td>10.97 (3.87)</td>
<td>11.19 (3.79)</td>
<td>$F(1, 71) = 4.64^*$, $p = .035$, $\eta^2_p = .06$</td>
</tr>
<tr>
<td>BDI-II</td>
<td>10.63a (6.55)</td>
<td>6.69b (6.19)</td>
<td>12.83a (10.79)</td>
<td>11.28c (10.40)</td>
<td>$F(1, 66) = 3.71^+$, $p = .058$, $\eta^2_p = .05$</td>
</tr>
<tr>
<td>BDI-II</td>
<td>18.22a (5.26)</td>
<td>10.22b (8.21)</td>
<td>25.60 (13.05)</td>
<td>23.30c (12.23)</td>
<td>$F(1, 17) = 3.21^+$, $p = .091$, $\eta^2_p = .16$</td>
</tr>
<tr>
<td>High Scorers</td>
<td>54.56 (15.95)</td>
<td>51.47 (12.96)</td>
<td>52.88 (13.25)</td>
<td>53.59 (15.94)</td>
<td>$F(1, 66) = 3.12^+$, $p = .082$, $\eta^2_p = .05$</td>
</tr>
<tr>
<td>PSWQ</td>
<td>47.71 (14.66)</td>
<td>44.81 (16.86)</td>
<td>51.19 (17.10)</td>
<td>45.81 (16.56)</td>
<td>$F(1, 66) = 1.03$, NS</td>
</tr>
<tr>
<td>PTQ</td>
<td>27.94 (13.56)</td>
<td>23.89 (15.01)</td>
<td>28.72 (14.86)</td>
<td>27.33 (13.60)</td>
<td>$F(1, 69) = 1.32$, NS</td>
</tr>
<tr>
<td>PA</td>
<td>26.76 (9.46)</td>
<td>25.21 (11.18)</td>
<td>26.78 (8.22)</td>
<td>25.00 (8.45)</td>
<td>$F(1, 68) = 0.02$, NS</td>
</tr>
<tr>
<td>NA</td>
<td>14.95 (5.84)</td>
<td>15.62 (4.46)</td>
<td>15.79 (5.56)</td>
<td>15.88 (5.97)</td>
<td>$F(1, 68) = 0.22$, NS</td>
</tr>
<tr>
<td>ACS</td>
<td>50.30 (6.66)</td>
<td>50.42 (8.25)</td>
<td>50.31 (9.35)</td>
<td>49.94 (8.50)</td>
<td>$F(1, 66) = 0.14$, NS</td>
</tr>
<tr>
<td>FFMQ</td>
<td>123.67 (17.97)</td>
<td>125.42 (18.70)</td>
<td>125.94 (18.65)</td>
<td>125.94 (18.65)</td>
<td>$F(1, 64) = 2.58$, NS</td>
</tr>
<tr>
<td>DERS</td>
<td>80.19 (21.33)</td>
<td>82.25 (23.59)</td>
<td>79.29 (21.05)</td>
<td>80.25 (24.41)</td>
<td>$F(1, 61) = 0.11$, NS</td>
</tr>
</tbody>
</table>
Behavioral Measures

Sustained Attention to Response Task (SART). On the Sustained Attention to Response Task (SART), the primary outcome variables of interest were overall accuracy, mean reaction time (RT) for correct response “go” trials, and number of commission errors (incorrect responses to “no-go” trials). In addition, intra-subject reaction time variability was calculated as the coefficient of variation (CVRT) for correct response trials. CVRT is obtained by dividing the standard deviation of RT by the mean RT (Morrison et al., 2014). Accuracy, mean RT, commission errors, and CVRT were calculated for each participant at pretest and posttest (MBE n = 36, TMS n = 38). Separate mixed-model ANOVAs were conducted for each outcome variable, with group as the between-subjects factor and time as the within-subjects factor, to test for group differences in change from pretest to posttest (see Table 5).
### Table 5

**Means, Standard Deviations, and ANOVA Results for Sustained Attention to Response Task**

<table>
<thead>
<tr>
<th>Measure</th>
<th>MBE Pre M (SD)</th>
<th>MBE Post M (SD)</th>
<th>TMS Pre M (SD)</th>
<th>TMS Post M (SD)</th>
<th>ANOVA Group by time interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Accuracy %</td>
<td>94.49 (0.03)</td>
<td>93.95 (0.05)</td>
<td>94.18 (0.04)</td>
<td>92.40 (0.09)</td>
<td>$F(1, 72) = 1.18$, $p = .280$</td>
</tr>
<tr>
<td>Mean RT (ms)</td>
<td>288.00 (56.84)</td>
<td>305.87 (88.15)</td>
<td>272.00 (45.60)</td>
<td>277.96 (60.94)</td>
<td>$F(1, 72) = 0.89$, $p = .349$</td>
</tr>
<tr>
<td>Correct Responses</td>
<td>.31 (0.12)</td>
<td>.32 (0.16)</td>
<td>.30 (0.14)</td>
<td>.36 (0.23)</td>
<td>$F(1, 72) = 2.15$, $p = .147$</td>
</tr>
<tr>
<td>CVRT Correct Responses</td>
<td>.31 (0.12)</td>
<td>.32 (0.16)</td>
<td>.30 (0.14)</td>
<td>.36 (0.23)</td>
<td>$F(1, 72) = 2.15$, $p = .147$</td>
</tr>
<tr>
<td>Commission Errors</td>
<td>8.14 (3.12)</td>
<td>8.03 (3.79)</td>
<td>9.13 (3.66)</td>
<td>8.66 (4.05)</td>
<td>$F(1, 72) = 0.30$, $p = .583$</td>
</tr>
</tbody>
</table>

*Note.* MBE = Mindful Breathing Exercise group. TMS = Time Management Skills group. RT = Reaction time. CVRT = Coefficient of variation of reaction time. Reported means include outlier data unless noted. None of the analyses were significant, $p > .05$. 

**Overall Accuracy.** There were no outliers at pretest and 3 outliers at posttest (3 in TMS group), and Box’s M test ($p = .002$) indicated a violation of the assumption of homogeneity of covariance. There was no interaction between group and time on overall accuracy, $F(1, 72) = 1.18$, $p = .280$, or main effect of group, $F(1, 72) = 0.68$, $p = .413$, on overall accuracy. There was a significant main effect of time on overall accuracy, $F(1, 72) = 4.12$, $p = .046$, $\eta^2_p = .05$, with participants showing a decrease in overall accuracy from pretest to posttest. After excluding outliers (MBE $n = 36$, TMS $n = 35$), the main effect of time on overall accuracy was no longer significant, $F(1, 69) = 1.18$, $p = .281$.

**Mean Reaction Time (RT) for Correct Responses (Go Trials).** There were 2 outliers at pretest (1 in MBE group and 1 in TMS group) and 2 outliers at posttest (1 in MBE group and 1
in TMS group). There was no interaction between group and time, $F(1, 72) = 0.89, p = .349$, or main effect of group, $F(1, 72) = 2.60, p = .111$, on mean RT for correct response trials. There was a trend towards a significant main effect of time on mean RT for correct response trials, $F(1, 72) = 3.56, p = .063, \eta^2_p = .05$, with participants showing an increase in mean RT (i.e., slower responding) for correct response trials from pretest to posttest. After excluding outliers (MBE $n = 34$, TMS $n = 37$), results did not differ.

**Coefficient of Variation of Reaction Time (CVRT).** There were 2 outliers at pretest (2 in TMS group) and 1 outlier at posttest (1 in TMS group). There was no interaction between group and time, $F(1, 72) = 2.15, p = .147$, or main effect of group, $F(1, 72) = 0.04, p = .844$, on CVRT for correct response trials. There was a significant main effect of time on CVRT for correct response trials, $F(1, 72) = 4.41, p = .039, \eta^2_p = .06$, with participants showing greater RT variability for correct response trials at posttest than at pretest. After excluding outliers (MBE $n = 36$, TMS $n = 36$), there were no changes in these results. Higher CVRT values reflect greater variability in reaction time, which has been hypothesized to indicate worse sustained attention and greater mind wandering (Cheyne, Solman, Carriere, & Smilek, 2009; Morrison et al., 2014).

**Commission Errors (False Alarms).** There were no outliers. There was no main effect of group $F(1, 72) = 1.06, p = .307$, or time, $F(1, 72) = 0.79, p = .377$, nor was there an interaction between group and time, $F(1, 72) = 0.30, p = .583$, on number of commission errors.

**Attention Network Test (ANT).** The primary outcome variables of interest were overall accuracy, mean reaction time (RT) for correct response trials, and network effect scores for alerting, orienting, and conflict (Fan et al., 2009). Accuracy, mean RT, and network effect scores were calculated for each participant (MBE $n = 36$, TMS $n = 38$) at pretest and posttest, unless
otherwise noted. Separate mixed-model ANOVAs for each outcome variable, with group as the between-subjects factor and time as the within-subjects factor, were conducted to test for group differences in change from pretest to posttest (see Table 6).

**Accuracy.** Accuracy was measured as the percentage of correct responses to all trials. There were no outliers at pretest and one participant with outlier data at posttest (TMS group). Box’s M test ($p < .001$) indicated a violation of the assumption of homogeneity of covariance, and Levene’s test indicated a violation of the homogeneity of variances at posttest ($p = .039$). There was no main effect of group, $F(1, 72) = 0.40$, $p = .529$, or time, $F(1, 72) = 0.001$, $p = .976$, nor was there an interaction between group and time, $F(1, 72) = 1.78$, $p = .187$, on overall accuracy. Excluding outlier data (MBE $n = 36$, TMS $n = 37$), there were no changes in the results of the ANOVA, but the assumptions of homogeneity of covariance (Box’s M, $p = .056$) and variance (Levene’s, $p = .085$) were no longer violated.

**Mean RT for Correct Responses.** There was one participant with outlier data at pretest (MBE group) and one participant with outlier data at posttest (MBE group). There was no interaction between group and time, $F(1, 72) = 0.43$, $p = .512$, or main effect of group, $F(1, 72) = 2.17$, $p = .145$, on mean RT for correct responses. There was a significant main effect of time on mean RT for correct responses, $F(1, 72) = 24.47$, $p < .001$, $\eta_p^2 = .25$, with a decrease in RT (i.e., faster responses) from pretest to posttest. After excluding outlier data (MBE $n = 34$, TMS $n = 38$), results of the analyses did not change.
Table 6

**Means, Standard Deviations, and ANOVA Results for Attention Network Test**

<table>
<thead>
<tr>
<th>Measure</th>
<th>MBE Pre M</th>
<th>MBE Post M</th>
<th>TMS Pre M</th>
<th>TMS Post M</th>
<th>ANOVA Group by time interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(SD)</td>
<td>(SD)</td>
<td>(SD)</td>
<td>(SD)</td>
<td></td>
</tr>
<tr>
<td>Overall Accuracy %</td>
<td>91.11</td>
<td>92.41</td>
<td>91.44</td>
<td>90.08</td>
<td>F(1, 72) = 1.78</td>
</tr>
<tr>
<td></td>
<td>(5.96)</td>
<td>(4.94)</td>
<td>(6.32)</td>
<td>(12.46)</td>
<td>p = .187</td>
</tr>
<tr>
<td>Mean RT (ms) for Correct Responses</td>
<td>529.35</td>
<td>509.22</td>
<td>509.16</td>
<td>493.76</td>
<td>F(1, 72) = .43</td>
</tr>
<tr>
<td></td>
<td>(56.91)</td>
<td>(61.36)</td>
<td>(48.34)</td>
<td>(50.16)</td>
<td>p = .512</td>
</tr>
<tr>
<td>Alerting Effect (all subjects)</td>
<td>n = 36</td>
<td>n = 36</td>
<td>n = 38</td>
<td>n = 38</td>
<td>F(1, 72) = 1.98</td>
</tr>
<tr>
<td></td>
<td>11.34</td>
<td>18.55</td>
<td>14.83</td>
<td>11.21</td>
<td>p = .164</td>
</tr>
<tr>
<td></td>
<td>(21.92)</td>
<td>(20.59)</td>
<td>(19.80)</td>
<td>(24.42)</td>
<td></td>
</tr>
<tr>
<td>Alerting Effect (excluding outlier)</td>
<td>n = 36</td>
<td>n = 36</td>
<td>n = 37</td>
<td>n = 37</td>
<td>F(1, 71) = 3.50</td>
</tr>
<tr>
<td></td>
<td>11.34</td>
<td>18.55</td>
<td>15.35</td>
<td>8.98</td>
<td>p = .065+</td>
</tr>
<tr>
<td></td>
<td>(21.92)</td>
<td>(20.59)</td>
<td>(19.80)</td>
<td>(20.46)</td>
<td></td>
</tr>
<tr>
<td>Orienting Attention</td>
<td>30.39</td>
<td>23.15</td>
<td>21.40</td>
<td>25.68</td>
<td>F(1, 72) = 4.46</td>
</tr>
<tr>
<td></td>
<td>(21.38)</td>
<td>(16.74)</td>
<td>(18.89)</td>
<td>(15.68)</td>
<td>p = .038*</td>
</tr>
<tr>
<td>Disengaging Attention</td>
<td>28.44</td>
<td>27.54</td>
<td>37.62</td>
<td>26.32</td>
<td>F(1, 72) = 2.48</td>
</tr>
<tr>
<td></td>
<td>(20.95)</td>
<td>(18.58)</td>
<td>(24.46)</td>
<td>(23.82)</td>
<td>p = .120</td>
</tr>
<tr>
<td>Conflict Effect</td>
<td>112.44</td>
<td>92.57</td>
<td>105.97</td>
<td>84.19</td>
<td>F(1, 72) = 0.16</td>
</tr>
<tr>
<td></td>
<td>(32.89)</td>
<td>(25.97)</td>
<td>(32.07)</td>
<td>(29.42)</td>
<td>p = .688</td>
</tr>
</tbody>
</table>

*Note.* MBE = Mindful Breathing Exercise group. TMS = Time Management Skills group. RT = Reaction time. Reported means include outlier data unless noted. F-values with asterisks reflect significant group by time interaction effects using mixed-model ANOVA tests. Significantly different means following univariate ANOVA tests are indicated by different subscripts. 

+ p < .10. *p < .05.
Alerting Effect. An index of alerting attention was calculated as Alerting = RT [No cue] – RT [Double cue], which reflects the difference in reaction time due to alerting cues (Fan et al., 2009). There were no outliers at pretest and one participant with outlier data at posttest (TMS group). There was no main effect of group, $F(1, 72) = 0.34, p = .560$, or time, $F(1, 72) = 0.22, p = .643$, nor was there an interaction between group and time, $F(1, 72) = 1.98, p = .164$, on the alerting network effect.

After excluding the outlier data (MBE $n = 36$, TMS $n = 37$), there was a trend towards a significant interaction between group and time on the alerting network effect, $F(1, 71) = 3.50, p = .065$, with no observed changes to the main effect of group, $F(1, 71) = 0.75, p = .389$, or time, $F(1, 71) = 0.01, p = .909$, on alerting. The trend towards a significant interaction appears to be driven by a trend towards a significant difference between groups at posttest, $F(1, 71) = 3.97, p = .050$, $\eta^2_p = .05$, in which the MBE group had a higher alerting index, or greater benefit in reaction time from alerting cues. The groups did not significantly differ on alerting scores at pretest, $F(1, 71) = 0.67, p = .415$. There was no significant change in alerting score from pretest to posttest for the MBE group, $F(1, 35) = 2.07, p = .159$, or the TMS group, $F(1, 36) = 1.48, p = .232$.

Orienting Effect (Moving + Engaging Attention). An index of orienting attention was calculated as Moving + Engaging = RT [Double cue] – RT [Valid cue] (Fan et al., 2009). Higher scores reflect a larger orienting benefit, suggesting greater ability to make use of orienting cues to engage attention on the target.

There were no outliers at either time point. Levene’s test indicated homogeneity of variances ($p > .05$) and Box’s M indicated homogeneity of covariance ($p > .05$). The interaction
between group and time on the orienting scores was significant, $F(1, 72) = 4.46, p = .038, \eta^2_p = .06$. The interaction effect appears to be driven by a trend towards a significant difference between groups at pretest and a trend towards a significant effect of time on orienting scores in the MBE group. There was a trend towards a significant difference between groups at pretest, $F(1, 72) = 3.68, p = .059, \eta^2_p = .05$, with higher orienting scores in the MBE group, but no significant difference between groups at posttest, $F(1, 72) = 0.45, p = .504$. Participants in the MBE group showed a trend towards a significant decrease in orienting scores from pretest to posttest, $F(1, 35) = 3.25, p = .080$. There was no significant change in orienting scores for those in the TMS group, $F(1, 37) = 1.33, p = .256$.

**Disengaging Attention.** An index of the cost of disengaging attention from invalid cues was calculated as Disengaging = $RT_{[\text{Invalid cue}]} - RT_{[\text{Double cue}]}$ (Fan et al., 2009). Higher disengaging scores reflect a longer time to disregard information from invalid cues and suggest greater difficulty disengaging one’s attention from external stimuli.

There were no outliers at either time point. There was a trend towards a significant main effect of time on disengaging attention, $F(1, 72) = 3.41, p = .069, \eta^2_p = .05$, with participants showing a decrease in disengaging attention score from pretest to posttest. Neither the interaction between group and time, $F(1, 72) = 2.48, p = .120$, nor the main effect of group, $F(1, 72) = 1.02, p = .316$, on disengaging attention were significant.

**Conflict Effect.** The conflict effect score is an index of the executive control network of attention, and is calculated as an Executive Control (Flanker Conflict) effect = $RT_{[\text{Incongruent flanker}]} - RT_{[\text{Congruent flanker}]}$ (Fan et al., 2009). Conflict effect scores indicate the difference in reaction time when the target is surrounded by incongruent information versus congruent...
information, and thus higher scores reflect more interference of conflicting information on attention.

For conflict effect scores, there were 2 outliers at pretest (1 in MBE group and 1 in TMS group) and no outliers at posttest. There was a significant main effect of time on conflict scores, $F(1, 72) = 77.78, p < .001, \eta^2 = .52$, with participants showing a decrease from pretest to posttest. Neither main effect of group, $F(1, 72) = 1.23, p = .266$, nor the interaction between group and time, $F(1, 72) = 0.16, p = .688$, on conflict scores were significant. Results did not change when outliers were excluded from the analysis.

**Correlations Between Change Scores on Self-report Measures**

To explore relationships between changes in outcome measures, tests of the significance of correlation coefficients were conducted across all participants. First, change scores for outcome measures were calculated for each participant by subtracting the pretest (i.e., first visit) from posttest (i.e., second visit) scores. Mean change scores and standard deviations were then calculated for participants with valid change scores (data for both time points; see Table 7). Correlation coefficients between change scores for all outcome variables were calculated in the full sample of participants with valid change scores (see Table 8).

Change scores for several variables were significantly correlated in expected directions. Decrease in depressive symptoms (as measured by the BDI-II) was associated with both decrease in worry (as measured by the RRS), $r = .43, p = .001$, and with increase in mindfulness (as measured by the FFMQ), $r = -.29, p = .020$. Decrease in rumination (as measured by the RRS) was associated with increase in mindfulness (as measured by the FFMQ), $r = -.31, p = .014$ and with an increase in attentional control (as measured by the ACS), $r = -.39, p = .002$. 
Table 7

Summary of Means and Standard Deviations for Change Scores on Self-Report Outcome Measures

<table>
<thead>
<tr>
<th>Change Scores (T2-T1) for Outcome Measures</th>
<th>MBE group $M \pm SD$</th>
<th>TMS group $M \pm SD$</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASRS</td>
<td>-1.27 ± 3.63</td>
<td>0.14 ± 2.03</td>
</tr>
<tr>
<td>BDI</td>
<td>3.94 ± 5.74</td>
<td>1.56 ± 4.43</td>
</tr>
<tr>
<td>PSWQ</td>
<td>3.08 ± 9.66</td>
<td>-0.72 ± 7.86</td>
</tr>
<tr>
<td>RRS</td>
<td>-1.51 ± 11.95</td>
<td>-5.38 ± 8.78</td>
</tr>
<tr>
<td>PTQ</td>
<td>-4.06 ± 11.20</td>
<td>-1.09 ± 8.09</td>
</tr>
<tr>
<td>PA</td>
<td>-1.56 ± 6.38</td>
<td>-1.34 ± 7.95</td>
</tr>
<tr>
<td>NA</td>
<td>0.68 ± 5.48</td>
<td>0.25 ± 5.00</td>
</tr>
<tr>
<td>ACS</td>
<td>-0.12 ± 5.34</td>
<td>0.37 ± 5.61</td>
</tr>
<tr>
<td>FFMQ</td>
<td>-2.27 ± 11.58</td>
<td>2.12 ± 10.65</td>
</tr>
<tr>
<td>DERS</td>
<td>0.90 ± 13.22</td>
<td>2.00 ± 12.70</td>
</tr>
</tbody>
</table>

*Note. $M =$ Mean and $SD =$ standard deviation. ASRS = Adult ADHD Self Report Scale Screener; BDI-II = Beck Depression Inventory, 2nd edition; PSWQ = Penn State Worry Questionnaire; RRS = Ruminative Response Scale; PTQ = Perseverative Thinking Questionnaire; PA = Positive Affect subscale, Positive and Negative Affect Schedule; NA = Negative Affect subscale, Positive and Negative Affect Schedule; ACS = Attentional Control Scale; FFMQ = Five Facet Mindfulness Questionnaire; DERS = Difficulties in Emotion Regulation.*
Table 8

**Intercorrelations for Change Scores on Self-Report Outcome Measures in Full Sample**

<table>
<thead>
<tr>
<th>Change Scores for Outcome Measures</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ASRS</td>
<td>—</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. BDI</td>
<td>.09</td>
<td>—</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>.460</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. PSWQ</td>
<td>.22&lt;sup&gt;+&lt;/sup&gt;</td>
<td>.43&lt;sup&gt;**&lt;/sup&gt;</td>
<td>—</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>.068</td>
<td>.001</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. RRS</td>
<td>.25&lt;sup&gt;*&lt;/sup&gt;</td>
<td>-.07</td>
<td>-.02</td>
<td>—</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>.040</td>
<td>.596</td>
<td>.857</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>5. PTQ</td>
<td>.25&lt;sup&gt;*&lt;/sup&gt;</td>
<td>.18</td>
<td>.19</td>
<td>.42&lt;sup&gt;**&lt;/sup&gt;</td>
<td>—</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>.038</td>
<td>.148</td>
<td>.129</td>
<td>.001</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. PA</td>
<td>-.05</td>
<td>-.19</td>
<td>-.10</td>
<td>.31&lt;sup&gt;*&lt;/sup&gt;</td>
<td>.01</td>
<td>—</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>.683</td>
<td>.127</td>
<td>.451</td>
<td>.013</td>
<td>.930</td>
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*Note.* Top = r value. Bottom = p value. Change scores were calculated for each participant by subtracting pretest from posttest scores (T2-T1). Mean change scores and standard deviations were calculated for the full sample of participants with valid change scores. ASRS = Adult ADHD Self Report Scale; BDI-II = Beck Depression Inventory, 2nd edition; PSWQ = Penn State Worry Questionnaire; RRS = Ruminative Response Scale; PTQ = Perseverative Thinking Questionnaire; PA = Positive Affect subscale from Positive and Negative Affect Schedule; NA = Negative Affect subscale from Positive and Negative Affect Schedule; ACS = Attentional Control Scale; FFMQ = Five Facet Mindfulness Questionnaire; DERS = Difficulties in Emotion Regulation. + p < .10. *p < .05. **p < .01.
Decrease in rumination (as measured by RRS) was also associated with decrease in ADHD symptoms (as measured by the ASRS), $r = .25, p = .040$, with decrease in perseverative thinking (as measured by the PTQ), $r = .42, p = .001$, and with decrease in difficulties with emotion regulation (as measured by the DERS), $r = .44, p = .001$. Decrease in ADHD symptoms (as measured by the ASRS) was associated with decrease in perseverative thinking (as measured by the PTQ), $r = .25, p = .038$. Finally, increase in mindfulness (as measured by the FFMQ) was associated with increase in attentional control (as measured by the ACS), $r = .40, p = .001$, and with decrease in difficulties with emotion regulation (as measured by the DERS), $r = -.32, p = .013$.

For any measures in which change scores were significantly correlated in the full sample, correlation coefficients were calculated for each group separately. To test for potential differences between the correlations in the MBE and TMS groups, a Fisher’s $r$-to-$z$ transformation was performed, which gives a $z$-score representing the difference and variance of the difference between $r$ values in the two groups (see Table 9). Two-tailed tests of significance revealed a significant difference between groups for three of the significantly correlated change scores from the full sample. Change in ADHD symptoms (as measured by the ASRS) was significantly positively correlated with change in rumination (as measured by the RRS) in the MBE group, $r = .46, p = .009$, but not in the TMS group, $r = -.03, p = .886$. The difference between groups was significant, $z = 2.03, p = .042$. Thus, a decrease in ADHD symptoms was associated with a decrease in rumination in the MBE group but not in the TMS group.
Table 9

Results of Fisher’s $r$-to-$z$ test for Significantly Correlated Change Scores on Self-Report Outcome Measures

<table>
<thead>
<tr>
<th>Significantly Correlated Measures</th>
<th>Correlation in Full Sample</th>
<th>Correlation in MBE Group</th>
<th>Correlation in TMS Group</th>
<th>Fisher’s $r$ to $z$ test</th>
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Change in ADHD symptoms (as measured by the ASRS) was significantly positively correlated with change in perseverative thinking (as measured by the PTQ) in the MBE group, $r = .40$, $p = .018$, but not in the TMS group, $r = -.19$, $p = .287$. The difference between groups was significant, $z = 2.43$, $p = .015$. Thus, a decrease in ADHD symptoms was associated with a decrease in perseverative thinking in the MBE group but not in the TMS group.

Change in rumination (as measured by the RRS) was significantly positively correlated with change in perseverative thinking (as measured by the PTQ) in the MBE group, $r = .62$, $p < .001$, but not in the TMS group, $r = .18$, $p = .290$, and this difference between groups was
significant, $z = 2.09, p = .037$. Thus, a decrease in rumination was associated with a decrease in perseverative thinking in the MBE group but not in the TMS group.

**Correlations Between Change Scores on Self-report and Behavioral Measures**

To explore relationships between changes in self-report and behavioral task outcome measures, tests of the significance of correlation coefficients were conducted. Change scores for outcome measures were calculated for each participant by subtracting the pretest from posttest scores for each participant with valid data for both time points. Correlation coefficients between mean change scores for all outcome variables were obtained in the full sample of participants.

**Attention Network Test (ANT).** There were several significant relationships between outcome measures. Decrease in ADHD symptoms (as measured by the ASRS) was associated with decrease in disengaging attention scores (as measured by the ANT), $r = .30, p = .009$, and associated with increase in orienting attention scores, $r = -.33, p = .004$. Similarly, decrease in depressive symptoms (as measured by the BDI-II) was associated with decrease in disengaging attention scores (as measured by the ANT), $r = .30, p = .015$, and increase in orienting attention scores, $r = -.31, p = .010$. These results suggest that improvements in depression and ADHD symptoms were each associated with improvements in the orienting attention network, including greater benefit from orienting cues to engage attention on targets and lower cost to disengage attention from invalid cues. There were no other significant correlations between self-report measures and ANT outcome variables (accuracy, mean RT, alerting effect, orienting effect, conflict effect).

**Sustained Attention to Response Task (SART).** Decrease in ADHD symptoms (as measured by the ASRS) was associated with faster reaction times (decrease in RT from T1 to
T2) on “go” trials in a measure of sustained attention (SART), \( r = .24, p = .043 \). Decrease in rumination (as measured by the RRS) was associated with decrease in overall accuracy on sustained attention (as measured by the SART), \( r = .24, p = .048 \). No other significant associations were observed between self-report measures and SART outcome variables (reaction time, overall accuracy, CVRT).

**Mediation Analysis**

A mediation analysis was conducted to test the hypothesis that change in attention symptoms (ASRS) mediated the effect of the intervention on change in depressive symptoms (BDI-II) (see Figure 7). A simple mediation model was tested using Hayes’ Process Macro for SPSS (Hayes, 2017). A bias-corrected bootstrapping estimation approach with 5,000 samples was used to test the indirect effect (ab path), and was non-significant.

Results indicated that the intervention was a significant predictor of change in ADHD symptoms, \( b = 1.52, p = .035, \text{CI} [0.11, 2.92] \), but change in ADHD symptoms was not a significant predictor of change in depressive symptoms, \( b = .05, p = .808, \text{CI} [-0.39, 0.49] \). The total effect of intervention on change in depressive symptoms, controlling for change in ADHD symptoms (i.e., not included in the model as a mediating variable) was significant, \( b = 2.54, p = .045, \text{CI} [0.06, 5.02] \). Approximately 6% of the variance in change in depressive symptoms was accounted for by the MBE intervention (\( R^2 = .06 \)). Receiving the MBE intervention was associated with 2.54 points lower depressive symptoms, but this was not significantly mediated by change in ADHD symptoms. Together, these results suggest that the mediational hypothesis is not supported. Instead, results indicate that the MBE intervention is a significant predictor of change in depressive symptoms when controlling for change in ADHD symptoms.
Discussion

A primary aim of the current study was to explore whether an online mindful breathing intervention would lead to changes in attention, mindfulness, depressive symptoms, and other psychological variables in undergraduates with a range of depressive symptoms. If the intervention led to decreased depressive symptoms, would improvements in attention mediate this relationship? To build on existing research on mindfulness and depression, an active control time management intervention was used to help determine specific vs. non-specific effects of mindfulness interventions. In addition, the study aimed to clarify the effects of mindfulness on specific components of attention by using a multi-method approach to measuring attention.
Secondary goals of the study were to test the feasibility and effectiveness of a particular structure and delivery mode of a mindfulness intervention. Specifically, would participants engage in and benefit from brief, frequent, and short-term practice of mindful breathing (a single component of complex mindfulness interventions), and would online practice at home following a single training session be sufficient to observe changes in important constructs of interest? Finally, the study aimed to examine important relationships between attention, mindfulness, depression and related psychological variables, including rumination, perseverative thinking, worry, positive and negative affect, and difficulties with emotion regulation. Results of the present study suggest that a brief, online mindful breathing intervention could lead to significant improvements in depressive and ADHD symptoms in a sample of undergraduates.

**Depressive Symptoms**

The primary outcome of interest was change in depressive symptoms. Significant decreases in depressive symptoms were observed in both groups, suggesting that both mindfulness and time management interventions could lead to improvements in depressive symptoms. These improvements could be related unique mechanisms of each intervention, or to similar common factors. However, MBE participants showed significantly lower levels of depressive symptoms than TMS participants following the intervention, despite no significant differences between groups at baseline. Thus, although the interaction effect reached only a trend towards significance, results suggest that mindful breathing may be more effective at reducing depressive symptoms than a time management intervention. This finding is interesting as it suggests that even in a sample with primarily subclinical depression levels, the MBE still appeared to have a positive effect on reducing depressive symptoms. Power to detect statistical
significance may have been limited by the small sample size, as medium effect sizes were observed for both posttest group differences and the interaction of group and time on depressive symptoms.

In individuals with clinical levels of depressive symptoms at baseline, only MBE participants showed a significant decrease in depressive symptoms, and the posttest group comparison reached a trend towards significance, with MBE participants reporting lower depressive symptoms than TMS participants. These results suggest that mindful breathing may be especially beneficial in those with clinical levels of depressive symptoms.

Results from this study replicate earlier findings that mindfulness interventions (e.g., MBSR and MBCT) can reduce depressive symptoms in college students (Regehr et al., 2013), and in non-clinical (Khoury et al., 2015) and clinical samples (Goyal et al., 2014). Research with Chinese college students has shown improvements in depression following short, intensive mindfulness training delivered in a group format over 5 consecutive days (Tang et al., 2007). The present study extends this prior research by demonstrating that mindful breathing, a single component of these interventions, delivered with minimal training, and practiced individually online for only three weeks, could lead to significant improvements in depressive symptoms (even among those below clinical thresholds). College students are at higher risk for depression due to their age group and academic stressors, and even subclinical symptom levels have substantial negative impacts on functioning (Cuijpers, de Graaf, & van Dorsselaer, 2004). Current results provide evidence that brief online mindful breathing interventions can effectively reduce depressive symptoms in college students with both sub-clinical and clinical levels of
symptoms, which could be critical to improving psychological well-being and decreasing the risk of full depressive episodes.

**ADHD Symptoms**

The mindful breathing intervention appeared superior to the time management intervention in improving ADHD symptoms, as MBE participants showed a significant decrease in ADHD symptoms as measured by the Adult ADHD Self-Report Scale Screener (ASRS), whereas there was no significant change in TMS participants. Interestingly, the ASRS measure of ADHD originally was included to screen and potentially control for differential intervention responses between individuals with and without ADHD, as treatment of ADHD symptoms was not a primary aim of the current study. This study supports earlier research showing the efficacy of mindfulness-based interventions in treating ADHD, especially for reducing symptoms of inattention (Cairncross & Miller, 2016). The findings of the present study suggest that mindfulness training may have advantages over other behavioral skills training interventions for ADHD, given that engagement in the time management practice control intervention did not lead to significant reduction in ADHD symptoms.

**Mindfulness**

There were no group differences or significant within-group changes from pretest to posttest for self-reported mindfulness as measured by the Five Facet Mindfulness Questionnaire (FFMQ). As baseline levels of self-reported mindfulness were high across participants, ceiling effects may have limited the ability to detect intervention-related changes in mindfulness. In addition, the brief length of the intervention may not have provided an adequate dose to produce changes in self-perceived trait mindfulness.
Although the groups did not significantly differ in mindfulness change, several significant associations were observed in the full sample between changes in mindfulness and other relevant measures. Improvements in mindfulness were associated with decreased depressive symptoms, which aligns with previous findings (Brown & Ryan, 2003; Kumar, Feldman, & Hayes, 2008). Improvements in mindfulness were also associated with decreases in rumination, as in prior research (Deyo, Wilson, Ong, & Koopman, 2009). Finally, increased mindfulness was associated with increased self-reported attentional control across participants. This supports previous findings that attentional control, as assessed by self-report measures of attention symptoms, improved in young adults with ADHD following MBIs (Zylowska et al., 2008).

Other Effects

Worry, rumination, and perseverative thinking are maladaptive cognitive-affective processes involving difficulties with attention, which can contribute to and maintain depression. Results showed a beneficial effect of mindful breathing on reducing worry as measured by the Penn State Worry Questionnaire (PSWQ), with a trend towards a significant decrease in worry among MBE participants. There was a large effect size for this decrease, suggesting that the result might reach statistical significance in a larger sample. The interaction between group and time on worry also showed a trend towards significance, which appeared to be driven by the trend towards a significant decrease in worry among MBE participants, and lack of change among TMS participants.

MBE participants showed significant decreases in rumination as measured by the Ruminative Response Scale (RRS), and perseverative thinking as measured by the Perseverative
Thinking Questionnaire (PTQ). However, the TMS group also showed significant decreases in rumination and perseverative thinking, with no evidence of a differential effect based on group intervention. These observed changes may have been due to factors unrelated to the study (e.g., maturation, time of semester), common factors of the interventions (e.g., positive expectancy, consistent practice of new skills), or unique factors that impacted outcomes similarly, but perhaps by different mechanisms.

There were no significant group differences or changes over time for other self-report outcome variables, including state positive and negative affect as measured by the Positive and Negative Affect Schedule (PANAS), difficulties with emotion regulation as measured by the Difficulties with Emotion Regulation Scale (DERS), and attentional control as measured by the Attentional Control Scale (ACS). While caution in interpreting non-significant findings is warranted, various factors could have contributed to the observed outcomes. For instance, the PANAS is designed to measure state mood, and thus might be affected more by daily events than the intervention. For attentional control and emotion regulation, it is possible that changes in these trait measures would not be observable with a brief intervention.

**Changes in Attention**

An important aim of the present study was to explore the role of changes in attention on depressive symptoms following a mindfulness intervention. Attention deficits have been consistently observed during and after depressive episodes (de Raedt & Koster, 2010; Hasselbalch et al., 2011), with some prospective studies suggesting that attention deficits may be a cognitive marker of vulnerability to depression (Weiland-Fiedler et al., 2004). Mindfulness interventions have been shown to lead to improvements in attention (Chiesa et al., 2011; van der
Velden et al., 2015), although many intervention studies have relied on subscales of self-report mindfulness measures to measure attention (Baer et al., 2008). To improve on earlier methodologies, researchers have increasingly incorporated cognitive tasks to measure attention behaviorally (Moore et al., 2012). Findings on the impact of mindfulness on different aspects of attention have been mixed, indicating the need for additional research (Lao et al., 2016). Given the importance of attention deficits in contributing to and maintaining depressive symptoms, it is important to clarify the effects of mindfulness on specific attention processes.

In the current study, different aspects of attention were examined using a multi-method, multi-measure approach. As described above, a self-report measure of ADHD symptoms (ASRS) was used to assess difficulties with inattention and hyperactivity/impulsivity. Attentional control was assessed by a self-report measures (ACS), which has a two-factor structure including subscales for focusing attention and shifting attention (Judah, Grant, Mills, & Lechner, 2014). Previous research has suggested that difficulties with shifting of attention are related to depression (Ólafsson et al., 2011), whereas problems with focused attention may be uniquely related to trait anxiety (Derryberry & Reed, 2002). Moreover, deficits in attentional control have shown associations with worry and rumination (Armstrong, Zald, & Olatunji, 2011), which are cognitive processes that contribute to depression. Two cognitive behavioral tasks were included to assess attention, allowing for an objective measure of attention performance and clarification of effects on multiple components of attention.

**Sustained Attention to Response Task (SART).** The Sustained Attention to Response Task (SART) is a go/no-go task that assesses sustained (i.e., focused) attention (Robertson et al., 1997). Individuals with better ability to focus their attention over a period of time will tend to
have faster reaction times and make fewer errors than those with poor ability to focus attention. In addition, greater number of errors (omission and commission), longer reaction times, and greater reaction time variability are characteristic of individuals with ADHD (Advokat, Martino, Hill, & Gouvier, 2007; Epstein et al., 2003).

The primary result from the analyses of the sustained attention task (SART) was an increase in reaction time variability (as measured by the coefficient of variation of mean reaction time), over time in all participants with a medium effect size. This is particularly surprising as higher RT variability is considered a robust neuropsychological marker of increased attention deficits in ADHD (Tamm et al., 2012) and other disorders. Therefore, one might have predicted that, at least among MBE participants who had a decrease in self-reported ADHD symptoms over time, there would be a concomitant decrease in reaction time variability. Future work should examine the effects of mindfulness interventions and reaction time variability more closely. Other SART results indicated that there were no significant differences for overall accuracy or mean reaction time. Because high overall accuracy and fast reaction times were observed across participants at baseline, ceiling effects could have limited the possibility of detecting changes related to the intervention. Similarly, floor effects may have limited detection of change for the number commission errors, as there were no significant differences between groups or within groups over time on this outcome.

**Attention Network Test (ANT).** The Attention Network Test (ANT) was also employed in the present study because it assesses three independent networks of attention: alerting, orienting, and executive control, which each contribute to adaptive functioning. Faster reaction times typically indicate greater flexibility to attend appropriately to relevant information, which
is associated with healthier psychological functioning. Effect scores for each network can be calculated as differences in reaction time in response to various cueing conditions. Results of this study suggest that mindful breathing may contribute to changes in specific components of attention, including alerting and orienting networks.

A primary result was the observation of a trend towards a significant interaction of group and time on the alerting effect, which appeared to be driven by a greater alerting benefit at posttest for MBE participants than for TMS participants. This result suggests that mindful breathing may lead to improvements in the alerting network, reflecting increased speed in directing one’s attention after alerting cues.

The orienting effect as measured by the ANT can be split into two effects: moving + engaging and disengaging attention. The moving + engaging effect reflects the reaction time benefit associated with valid spatial cues to enhance the ability to direct attention towards a target. The disengaging effect reflects the reaction time cost associated with invalid spatial cues from which one must disengage attention in order to appropriately attend to a target stimulus.

There was a significant interaction of group and time on the moving + engaging effect, which appeared to be driven by both a trend towards group differences at pretest, and a trend towards a significant decrease in moving + engaging in the MBE group. This result is counterintuitive to the hypothesis that mindfulness improves attention, as it indicates that MBE participants had decreased ability to engage their attention on a target when given spatial orienting cues after the intervention. For the disengaging attention effect, participants in both groups showed significant improvements from pretest to posttest, with no group differences, which may reflect a practice effect of the task. Prior research has shown mixed findings for
changes in orienting attention following MBSR or MBCT (Isbel & Mahar, 2015; Lao et al., 2016). One study found that changes in orienting attention were related to open monitoring mindfulness practice, but not to focused attention practice (Tsai & Chou, 2016). In the present study, the lack of improvement in either orienting component attributable to the MBE intervention specifically may align with this prior finding that focused attention practices such as mindful breathing do not uniquely improve orienting attention.

However, in the full sample, improvements in both moving + engaging and disengaging scores were associated with decreases in ADHD symptoms and depressive symptoms. These results may indicate that aspects of orienting attention are important markers of changes in attention difficulties associated with ADHD and depression, but that the mindful breathing exercise in this study did not affect these components in predicted ways. Future studies should continue to examine the effects of different types of mindful practices on the orienting network, to determine whether results from the current study represent a true effect or type II error.

Results for both disengaging attention and the conflict effect showed significant improvements in reaction time from pretest to posttest for all participants, with no group differences. It is likely that these findings reflect a practice effect. Alternatively, these results could indicate that mindfulness practice and time management training provide similar benefits in orienting and executive control of attention. Current findings should be considered in the context of prior meta-analyses in which a majority of studies have not found evidence for changes in orienting or executive attention following mindfulness interventions (Chiesa, et al., 2011; Lao et al., 2016).
Difficulties with disengaging attention and executive control of attention are theoretically relevant to repetitive thinking processes such as rumination, worry, and perseverative thinking. Given that these cognitive processes involve negative affect, it is possible that changes in these aspects of attention would only be captured by attention tasks that included emotionally-relevant stimuli (de Raedt & Koster, 2010), which was not the case for the SART or ANT tasks used in this study. Thus, future mindfulness research should examine changes in components of attention by directly comparing attention tasks using both emotional and non-emotional stimuli.

Accuracy did not differ between groups or over time, which was likely due to ceiling effects. Mean reaction time on the ANT decreased significantly over time with no group differences, suggesting change due to practice effects.

**Mediation**

Given the significant changes in ADHD and depressive symptoms, we employed measures of these constructs (ASRS and BDI-II) in the mediation model to test the hypothesis that changes in attention mediated the effect of the mindfulness intervention on change in depressive symptoms. Tests of this simple mediation model were not significant, and thus the hypothesis was not supported by results in the present study. However, the model suggests that after controlling for change in ADHD symptoms, the association between the mindful breathing intervention and decrease in depressive symptoms was stronger.

**Support for Hypotheses**

Taken together, results of the present study provide partial support for study hypotheses. The first hypothesis, that experimental participants would show greater improvements in mindfulness and depressive symptoms than the control group, was partially supported by results.
There were no significant changes in mindfulness, but the mindfulness group showed significantly lower depressive symptoms at posttest.

The second hypothesis predicted that, due to the attention training involved in mindful breathing practice, the mindfulness intervention would lead to greater improvements in attention as assessed by self-report and behavioral measures of attention. This prediction was partially supported by study results. While there were no changes in self-reported attentional control, the mindful breathing intervention was associated with improvements in ADHD symptoms. On cognitive measures of attention, the MBE group showed better alerting at posttest than the TMS group, although the interaction between group and time on alerting only reached a trend towards significance. Counterintuitively, the MBE group showed a decrease in orienting attention from pretest to posttest, although there were no group differences in orienting performance at posttest. Results for sustained attention, disengaging of attention, and executive control of attention revealed no significant differences between groups.

Results of the present study differ from at least one study of mindfulness training in college students, which showed improvements in executive control of attention but no changes in alerting or orienting networks (Tang et al., 2007). However, meta-analytic reviews have revealed mixed findings for changes in sustained, alerting, orienting, and executive attention following mindfulness interventions (Chiesa et al., 2011; Lao et al., 2016).

Several factors may be related to these variable findings. First, different types of meditation practice appear to differentially affect changes in attention networks (Tsai & Chou, 2016). For instance, experts in open monitoring meditation demonstrate better orienting attention than focused attention experts and controls (Tsai & Chou, 2016). Chan and Woollacott (2007)
found that expert meditators showed better executive control (as measured by a Stroop task) compared to controls, but were not better at orienting attention (as measured by a Global-Local letters task).

Second, several studies have used cross-sectional designs that compared existing differences in attention performance between experienced and novice or non-meditators (Chan & Woollacott, 2007; Tsai & Chou, 2016). In the study by Tsai and Chou (2016), experts in both focused attention and open monitoring showed better performance on different components of attention than controls at baseline, but all groups improved on executive control after practicing focused attention meditation.

Third, executive attention comprises multiple cognitive processes, and various measures of executive attention (e.g. ANT, attentional blink, Stroop, etc.) may capture different aspects of this complex construct. For instance, Slagter and colleagues (2007) found that mindfulness meditation practice was related to greater improvement in executive attention using an attentional blink measure, but did not include tasks such as the ANT to assess changes in orienting or alerting attention.

Fourth, it is possible that the dose, timing, and structure of MBE practice may be related to the results observed in the current study. Existing research suggests that behaviorally measured changes in attention can be observed after as few as five days of intensive meditation training (Tang et al., 2007). However, how practice is conducted may affect changes in attention. For instance, Chan and Woollacott (2007) found that amount of time meditating per day was related to improvements in executive attention whereas total number of lifetime hours practicing was not, suggesting that frequency of practice may be most important. There may be a more
optimal way to engage in practice to see changes in the variables of interest (or larger changes for those constructs that did significantly change). For instance, engaging in the MBE for longer sessions, more frequently, or over a longer period of time could be required before changes in cognitive attention measures would be evident. Conversely, perhaps very brief practice (2-3 minutes) multiple times per day might be required to alter attention processes.

Many well-validated cognitive measures of attention, such as the SART and ANT, use visual stimuli to measure basic networks of attention, including alerting, orienting, and executive control. Current theories suggest that these attention networks are distinct but interdependent (Fan et al., 2009). While mindfulness practices may take both external and internal objects as the foci of attention, the mindful breathing exercise requires participants to attend primarily to internal stimuli (i.e. physical sensations of breathing) and thoughts that arise in awareness. It is possible that cognitive attention processes differ in response to internal vs. external stimuli. Thus, behavioral measures using reaction time as the outcome and requiring attention to external visual stimuli may not accurately capture aspects of attention that change as the result of mindful breathing practice (Isbel & Mahar, 2015).

Common therapeutic factors (Luborsky et al., 2002) may have affected outcomes in both intervention groups. An aim of this study was to try to elucidate the specific effect of mindful breathing on outcome variables, and thus an active control group was a critical aspect of the study design. However, given that both groups improved on several measures, common factors such as positive expectancy may have led to the improvements that were observed in both groups on some variables. For behavioral measures, both groups may have improved over time due to practice effects of repeating the attention tasks. Alternatively, different specific factors of the two
interventions could have led to similar changes in attention outcome variables. Both common therapeutic factors and unique intervention factors could have led to improvements in both groups, which would limit the ability to detect group differences in outcomes.

The third hypothesis of the present study was that improvements in attentional measures would be correlated with decreases in depressive symptoms and increases in mindfulness, and this hypothesis was partially supported by results. Decreases in depressive symptoms were associated with improvement in the orienting network of attention in the full sample. There were no significant correlations between improvement in depressive symptoms and other measures of attention, including self-reported attentional control, ADHD symptoms, or sustained, alerting, or executive attention.

Increases in mindfulness were strongly associated with increased self-reported attentional control in both the full sample and in the MBE group. While the comparison of correlations did not show group differences, the relationship between increased mindfulness and increased attentional control was only significant in the MBE group. Changes in mindfulness were not significantly associated with changes in sustained, alerting, orienting, or executive attention as measured by the SART or the ANT tasks. Results indicated that increased mindfulness was not associated with changes in ADHD symptoms in either the MBE group or the full sample. This finding was somewhat unexpected, as change in ADHD symptoms was the only statistically significant difference between groups, and thus changes in mindfulness would be expected to correlate with this change among MBE participants. Taken together, the lack of significant associations between changes in mindfulness and changes in all but one of the attention measures
may reflect a difficulty detecting correlations due to a small range of changes in mindfulness across the study.

Results did not support the fourth hypothesis that changes in attention would mediate the effect of the mindful intervention on depressive symptoms. The test of mediation did not support a model in which change in ADHD symptoms is a significant mediator of the effect of a mindfulness exercise on changes in depressive symptoms. However, given the greater improvements in both ADHD and depressive symptoms for mindfulness participants compared to controls, mindfulness interventions may have independent beneficial effects on these symptom clusters.

Limitations

The present study has several limitations. First, the small sample size (30–40 participants per group in each analysis) could be related to inadequate statistical power to detect true group differences, as well as mediators of change for outcome variables. Second, demographic characteristics of the sample may have been related to ceiling effects for certain variables. For instance, young adults are at a developmental stage that is characterized by generally good attention as measured by cognitive and neuropsychological assessments. College students may also be used to engaging their attention during daily academic activities in ways that match the demands of these behavioral attention tasks. This could allow them to demonstrate higher attentional performance on these tasks specifically, making it harder to detect changes in attention. Similarly, a majority of the sample had some prior mindfulness experience (e.g., yoga, meditation) with about 16.25% of the sample reporting more than 1 year of mindfulness practice. This prior experience might have made it harder to detect changes in mindfulness during this
brief intervention period than in a sample of mindfulness-naïve participants. Third, it is likely participants engaged in the online practice in variable ways. Although the study tracked participants’ responses and completion of the 10-minute online sessions, there was no direct measure of participants’ engagement in the intervention. For instance, some individuals may have been more motivated to engage in the exercise as intended (i.e., attempt to accurately observe the focus of their attention), whereas others may have been distracted or indifferent and only given minimal effort to complete the exercises. Finally, the sample included young adults with varying levels of psychological symptoms, but the majority had subclinical levels of depressive and ADHD symptoms. Thus, current findings could be generalized to a non-clinical population, but may not be generalizable to individuals with more severe depression, non-college students, or older individuals.

**Summary and Future Directions**

Results suggest that a single training session in mindful breathing, followed by an online mindful breathing intervention comprising short, frequent practice sessions over a 3-week period, could lead to improvements in ADHD and depressive symptoms. Online mindfulness interventions offer flexibility, minimal time commitment, and do not require highly trained clinicians. Given these advantages, online mindful breathing interventions could help improve the accessibility of MBIs for college students and lead to improvements in depressive symptoms in this high-risk population.

This study makes an important contribution to the literature by comparing a brief online mindful breathing intervention to a strong active control intervention to elucidate specific effects of mindfulness interventions on outcomes such as depression, worry, and attention difficulties.
While standard MBIs include multiple components that may lead to beneficial effects, it is valuable to study the effects of a single component (mindful breathing), practiced individually in an online format, to better understand its specific effects on psychological outcomes of interest. Results of the current study indicate that mindful breathing can lead to reductions in symptoms of depression and ADHD. In addition, this study used behavioral attention measures to explore changes in specific components of attention following mindful breathing in college students with a range of depressive symptoms. This study showed that changes in alerting and orienting networks of attention were affected by mindful breathing, and that improvements in orienting functions were associated with improvements in ADHD and depressive symptoms across all participants. Although current results did not provide evidence that change in attention mediates the effect of mindful breathing on change in depressive symptoms, study limitations (sample size, attention measures used) may have prevented the detection of a true relationship between these constructs. As prior studies have suggested that changes in attention may be an important cognitive-affective process targeted by mindful breathing, future research should further explore changes in specific components of attention following MBIs to further clarify factors moderating these relationships, as well as to test the conditions under which attention changes might mediate changes in depression.

The online mindful breathing intervention was found to be feasible and effective, and thus should be tested in other samples, such as college students with higher baseline depressive symptoms or prior depressive episodes. The significant decrease in ADHD symptoms following the mindful breathing exercise suggests that the intervention could be tested in university students with ADHD diagnoses. Future work could also test the effects of online mindful
breathing in a more severe, clinical sample of depressed individuals, as the MBE intervention was helpful for participants above the clinical cutoff for mild depression.

It would be important for future studies using online mindful breathing to assess aspects of motivation and engagement, as the quality of practice may be related to changes in outcomes. Anecdotally, participants who expressed having noticed improvements in their concentration and mood tended to have said that they were motivated to practice the exercise and expected positive outcomes.

Another future direction would be to examine MBE practice data to explore individual patterns of change. With longitudinal data, insight could be gained into ways that various aspects of attention change during the acquisition of mindfulness skills. For instance, as participants practice the MBE, they might build greater ability to notice mind-wandering and thus increase un-cued reports of their attention being off the breath. With even greater experience, participants may be able to maintain focused attention on their breathing for longer periods, resulting in a subsequent decrease in both cued and un-cued responses of attention being off the breath.

The current study extends the literature on mindfulness-based interventions by exploring the effects of a brief, online mindful breathing intervention on changes in depression, attention, mindfulness and related psychological variables in college students with a range of depressive symptoms. Important findings are that significant improvements in depressive and ADHD symptoms were observed in mindful breathing participants with just under 3 hours of total practice during a 3-week period. Low attrition rates suggest that the intervention was feasible and acceptable. Individual practice of mindful breathing, with an online interface to support accountability, could be an optimal way to enhance accessibility and deliver an effective
treatment for depressive and ADHD symptoms in college students. Results from behavioral measures of attention indicate that brief mindful breathing may lead to improvements in the alerting network of attention in particular. Study limitations may have prevented the detection of a significant mediating role of changes in attention on improvements in depressive symptoms following a mindful breathing intervention. Future research should test ways of measuring attention behaviorally that may be most relevant to capturing the effects of mindfulness training in order to further explore attention as a mechanism of change.
Appendix A. Recruitment Flyer

THE CATHOLIC UNIVERSITY OF AMERICA

VOLUNTEERS WANTED!

Earn all 10 research credits for PSY 201!

Short-term Changes in Cognition and Emotion

Description: CUA researchers are seeking volunteers to participate in a research study consisting of questionnaires and computer-based tasks. It requires 2 lab visits (1.5 and 1 hours each) and 15 web-based home sessions (10 minutes each). Participation requires a total of 5 hours of participation over a 3-week period.

Eligibility: Volunteers must be at least 18 years old, currently enrolled in PSY 201 at CUA, and have access to a personal computer with internet.

Study participants will receive all 10 research points for PSY 201 (1 research point for every half hour of participation).

For more information about this study, or to volunteer, please contact:

email@cua.edu

Cognitive and Affective Neurosciences (CAN) Laboratory,
Dept. of Psychology, CUA
Appendix B. Consent Form

THE CATHOLIC UNIVERSITY OF AMERICA
COMMITTEE FOR THE PROTECTION OF HUMAN SUBJECTS (CPHS)

RESEARCH CONSENT FORM

_________________________  ________________________
Subject Name                        Date

Short-term Changes in Cognition and Emotion

Title of Study
Katherine McMorran, M.A., and Nancy E. Adleman, Ph.D.

Principal Investigators

FWA00004459

INVITATION TO PARTICIPATE
We invite you to participate in a research study by Dr. Nancy Adleman, Katherine McMorran at
the Catholic University of America (CUA). Before you decide whether or not to participate, we
want you to know why we are performing the study and what you will be asked to do. This form
gives you information about the study and you may ask any questions that you may have, after
which we will ask you to sign this form to show that you understand and are agreeing to
participate. It is important to know that taking part in this research is entirely voluntary; you do
not have to participate. You also may change your mind and drop out of the study at any time.

PURPOSE
The purpose of this study is to examine short-term changes in cognitive processes and emotions.

DESCRIPTION OF THE PROCEDURES
Your participation involves completing questionnaires and computer tasks, presented in a varied
order, during two study visits and during at-home practice sessions. Participation in this study, as
well as any information collected throughout the study, will be kept confidential. Participation
requires a total of 5 hours over a 3-week period. Participation requires 2 lab visits (1.5 and 1
hours each) in which you will complete questionnaires and computer tasks, as well as 15 practice
sessions at home in which you will complete computer tasks (10 minutes each, 5 times per week
for 3 weeks). The questionnaires will ask you to indicate some background information about
yourself and information related to your mood and abilities. You are welcome to skip any of
these questions if you do not feel comfortable answering them. Additionally, you will be asked
to complete computer tasks that involve responding to visual cues, and practicing certain skills.
The home practice sessions will require you to have internet access and to use your personal
computer with keyboard and headphones/earbuds. During the 10-minute home practice sessions, you will complete computer tasks to practice skills. As previously stated, all of these tasks are completely voluntary. If you decide you no longer wish to participate in the research at any time, please let us know.

**DISCOMFORTS AND RISKS**
There are no known risks associated with filling out standard psychology questionnaires. You may, however, experience some mild psychological discomfort while answering questions about your mood and feelings. You may also be asked questions relating to suicidality, which may cause some psychological discomfort. As indicated below, your study records are kept confidential and your data will not be identified by name. However, you are free to skip any questions that make you feel uncomfortable.

**CONFIDENTIALITY**
We will keep all study records as confidential as possible to the extent of the law. This means that we will not tell anyone you are in the study. You will be given a subject identification number so that the results of the questionnaires are tagged with this confidential number and not your name. Your signed informed consent form will be kept separate from your questionnaire responses. All records will be kept in a locked file cabinet or password protected computer file, and they will be available only to the research personnel. Only aggregate findings will be shared in any report of the results, and the names of participants will never be identified in presentations and publications.

**RISKS DURING PREGNANCY**
There are no expected risks during pregnancy from participating in this study.

**EXPECTED BENEFITS**
While we hope that you find the study tasks interesting, there are no expected benefits from participating in this study.

**WITHDRAWAL FROM THE STUDY**
You may choose to withdraw from the study at any time without repercussion. In order to ensure the quality of our study, we ask that you please do not discuss the study with fellow students.

**COSTS AND PAYMENTS**
As a General Psychology (PSY 201) student, you will receive one research point for each half hour of participation. This study will take approximately five hours to complete, for a total of ten research credits. If you decide to withdraw from the study, you will receive research credits for your time (1 point for each half hour of participation). Aside from the earning of research credits, understand that your class standing or grades will not be affected by your decision to participate in or withdraw from this study. Participation in this study is strictly voluntary. There will be no cost to you for participating in this research.
CONTACTS
If you have any problems or questions about this study or about your rights as a study participant, you may contact the Principal Investigators: Dr. Nancy Adleman (email@cua.edu), or Katherine McMorran (email@cua.edu).

RESEARCH SUBJECT RIGHTS: I have read or have had read to me all of the above.

__________________________ has explained the study to me and answered all of my questions.
I have been told of the risks or discomforts and possible benefits of the study.

I understand that I do not have to take part in this study, and my refusal to participate will involve no penalty or loss of rights to which I am entitled. I may withdraw from this study at any time without penalty or loss of benefits to which I am entitled.
I understand that any information obtained as a result of my participation in this research study will be kept as confidential as legally possible.
The results of this study may be published, but my records will not be revealed unless required by law.

NOTE:
If I have any questions about the conduct of this study or my rights as a subject in this study, I have been told I can call The Catholic University of America, Office of Sponsored Programs (202) 319-4495.

I understand my rights as a research subject, and I voluntarily consent to participate in this study. I understand what the study is about and how and why it is being done. I will receive a signed copy of this consent form.

☐ I confirm that I am 18 years of age or older.
☐ I confirm that I am not currently enrolled in any courses taught by Dr. Nancy Adleman or Katherine McMorran, M.A.

<table>
<thead>
<tr>
<th>Signature of Subject</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature of Subject’s Representative*</td>
<td>Date</td>
</tr>
<tr>
<td>Signature of person obtaining consent**</td>
<td>Date</td>
</tr>
</tbody>
</table>

*Only required if subject is not competent. **Only required if not investigator.
Appendix C. Demographic and Background Questionnaire

Please enter your participant ID number.

What is your age (in years)? ______________________

What is your gender?
  o  Female
  o  Male
  o  Transgender / Non-binary

Have you ever been diagnosed with and/or received treatment for a psychiatric, psychological or neurological condition?
  o  Yes
  o  No

If yes, what was the diagnosis and/or treatment? ______________________

Do you currently take any prescription medications for a psychiatric, psychological or neurological condition?
  o  Yes
  o  No

If yes, which medication(s)? ________________________________
Appendix D. Mindful Breathing Exercise Training Script

Introduce the MBE
“Now we are going to have you do a mindful breathing exercise. Have you heard of mindfulness before?” If yes, “How would you describe it?” After participant responds, “I’m going to explain a bit more about the way we’re defining it for our study.” If no, “Let me explain it.”

Describe mindfulness
“Mindfulness is a technique that can be practiced to improve psychological well-being. To practice mindfulness means to pay attention to your moment-to-moment experience, and to have an accepting, non-judging attitude towards this experience.

In other words, it means noticing what’s happening in your awareness during the present moment without labeling it as good or bad, or saying ‘I like this or I don’t like this.’ Typically, when something is pleasant, we often cling to it, and when we experience something unpleasant, we try to get rid of it somehow. When we practice mindfulness, we try to accept the present moment just as it is.

To pay attention to the present moment, we focus our awareness on what is happening right now, rather than being caught up in thoughts about the past or future. This might mean being aware of internal experiences, such as thoughts, bodily sensations or emotions. Or it could mean being aware of external experience such as sounds and sights around you. For this exercise, we will narrow it down to one area, which is internal body sensations. Specifically, we will ask you to be aware of the internal physical sensations of breathing.”

Teach participant how to do the MBE
“Now let’s practice a mindful breathing exercise. To begin, sit upright in your chair and allow yourself to relax. It helps if your back can be straight without being strained or arched. You may close your eyes or leave them open, whichever is more comfortable for you. Rest your hands in your lap and see if you can notice the sensation of your feet making contact with the floor.

Next, let’s locate the breath in your body. Notice where it’s easiest for you to be aware of your breath coming in and out. Is it at the nostrils and throat, the chest, or the belly? [Pause for participant response.] “Ok, then rest your attention lightly in this area. Now take just one full breath, and feel all the sensations in this area from the beginning, through the middle, to the end of the out-breath. As much as possible, try to feel your breath moving in and out, rather than thinking about your breath.

It is inevitable that your attention will wander from your breath to various thoughts and feelings that arise in your awareness. Whenever your attention wanders, simply make a mental note that thoughts or feelings have arisen, and then gently return your attention to the sensations of breathing. If you find yourself caught up in a stream of thoughts, or get lost in a story about the past or the future, that’s perfectly ok. The mind naturally wanders, so there is no need to criticize
yourself when this happens. In fact, the practice of mindfulness is simply about seeing more clearly how your mind works. So, whether your mind wanders or not, as long as you keep coming back to the breath, you are doing it correctly.”

**MBE practice and initial session using online interface**

“Next we will have you practice making responses on the computer about the focus of your attention as you do mindful breathing.” [Use participant ID to log in to MBE online interface. Give instructions for making responses.] “For now, let your eyes rest gently on the fixation cross in the center of the screen. Rest your hands on the keyboard, with your left index finger over the “F” key and your right index finger over the “J” key. These keys correspond to the two options shown on the screen “Breath” and “Other.” You will use these 2 keys to give responses, based on the focus of your attention. There are two situations in which you should give responses. First, you will hear a tone at intermittent points during the exercise. When you hear it, notice if your attention was on your breathing sensations or if you were lost in thought. If your attention was on your breath, press the key shown for “Breath.” If your attention was caught up in thoughts, press the key shown for “Other.” After making any response, return your attention to mindfully observing your breathing sensations.” [Ask the participant to repeat back the instructions in their own words to confirm understanding.]

“There is NO right or wrong here. We simply want to understand what happens during the mindful breathing exercise. Even if your mind wanders 100 times, that’s perfectly alright, and even quite natural. All that matters is that you respond as accurately as possible, and that you keep returning your attention to your breath as best you can. Do you have any questions?” [Answer any questions.]

“Now let’s do a short practice round for one and a half minutes. When you hear a gong sound, that signals the start of the session and you should begin mindful breathing. Leave your fingers resting on the keyboard. You may keep your eyes open or closed. If open, keep your gaze softly on the cross in the center of the screen, rather than looking around the room. If you choose to close your eyes, remember that you can open them if you need a reminder of which key to press. Again, any time you notice your attention wandering, either after a tone or when you notice it on your own, press the key corresponding to “Other.” If you hear a tone and you are focused on your breathing, press the key corresponding to “Breath.” When you hear the gong again, that signals the end of the session, and you can stop doing the mindful breathing.”

[After participant completes the practice trial, ask the following questions.] “Were you able to engage in the Mindful Breathing Exercise? How did it go? Were you able to respond when you heard the tone? Were there any times you noticed your mind wandering without the tone and made a response?” [Give feedback to clarify questions or correct the practice as needed.]

“Now you will do the Mindful Breathing Exercise for a full 10 minutes. This is the same way you will do it when you practice at home between study visits.” Participant completes a 10-minute session of the MBE.
Appendix E. Mindful Breathing Exercise (MBE) Online Intervention

Instructions
(displayed before each session)

Login Screen
Field to enter Participant ID number

Welcome
For each 10-minute online session, you will practice the Mindful Breathing Exercise, just as you did at the first study visit.

Mindful Breathing Exercise Instructions
When you begin the session, bring your awareness to the sensations of your breathing, and then keep your attention on your breathing as best you can.

Each time you notice that you have become caught up in your thoughts, press the Other key to indicate that your mind has wandered. Then, without judging yourself, gently return your attention to your breathing.

Each time you hear a tone, press the appropriate key to indicate where your attention was at that moment - either on your breath (Breath) or on other thoughts (Other). After responding, return to mindful awareness of your breathing.

Important Note
If you close your web browser before the session has ended, your responses will NOT be submitted. You will be able to restart the session that same day if you wish.

Ready to start the session?
Rest your hands on the keyboard with your left index finger over the “F” key and your right index finger over the “J” key. These keys correspond to “Breath” or “Other” as shown on your screen. Press the appropriate key whenever you notice your mind wandering OR whenever a tone plays.

During the session, you may keep your eyes open or closed. If open, allow your eyes to softly focus on the cross in the center of the screen.

Next, PRESS THE “J” KEY to BEGIN today’s session.
Visual Display for Mindful Breathing Exercise (MBE) Online Sessions

Version 1
(Counterbalanced presentation for Participants with Odd ID numbers)

Version 2
(Counterbalanced presentation for Participants with Even ID numbers)
Appendix F. Time Management Skills (TMS) Online Intervention

Instructions
(displayed before each session)

Login Screen
Field to enter Participant ID number

Welcome
During today’s session, complete the time management exercise on the following page. Each session will last 10 minutes, and you should complete as much as you can during this time. You will be reminded when there is 1 minute left in the session. After 10 minutes, a new page will load with questions and your responses will be submitted.
Time Management Skills (TMS) Exercises

Time Log
(home sessions 1, 6, & 11)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Yesterday</th>
<th>2 Days Ago</th>
<th>3 Days Ago</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class Hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study Hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sleep</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meals/Tasting</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exercise</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family/Friends</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Media or Internet</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TV, Movies, Videos</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work/Job</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Miscellaneous Recreation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commuting/Travel</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In what areas did you spend the most time? In what areas did you spend the least time? Did the pattern change greatly from one day to another?

What do you notice about the ways in which you’ve spent your time over the last few days? Does anything surprise you? Were any areas difficult to estimate? If so, which ones?
Understanding How You Manage Your Time

What do you notice about the ways in which you’ve spent your time over the last few days?

Thinking about the past week, what was a major goal you had in one of these areas?

Did you procrastinate on working towards this goal? If so, how did you procrastinate?

What else might be keeping you from working on what you need to?

What could you do to remove the problem or obstacles?

What would partial progress look like on this goal? What will the end result look like?

Distractions and disruptions (e.g., illness) are inevitable, but planning for setbacks is a good way to keep yourself on track. How could you plan ahead for potential disruptions that may occur in the coming week?
Urgency & Importance
(home sessions 3, 8, & 13)

Urgency and Importance

The Difference Between Urgent and Important

“What is important is seldom urgent and what is urgent is seldom important.”
— Dwight D. Eisenhower

Many of us fall into the trap of believing that all urgent activities are also important. When we are constantly reacting to urgent demands, this can prevent us from having time to make progress towards longer-term goals that we value. The following exercise will help you identify which of your activities are urgent and/or important. Review the chart below.

The Urgency/Importance Quadrants (by Steven Covey)

<table>
<thead>
<tr>
<th>Urgent</th>
<th>Not Urgent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Important</td>
<td>Quadrant 1: Crises, problems, and deadlines (e.g., paper due tomorrow) When you spend most of your time in Q1 activities, you may feel stressed, panicked, negative, or reactive. Many of us spend time on urgent tasks that are not truly important, simply because they demand our attention. This could lead to burnout!</td>
</tr>
<tr>
<td>Not Important</td>
<td>Quadrant 2: Weekly and long-term planning, advance planning: exercise or recreation, learning a new skill: spending time with friends and family Activities in Q2 don’t have a pressing deadline, but nonetheless help you achieve your important personal, school, and work goals. When we focus on important but not urgent, activities we operate in a proactive mode, which helps us remain calm, rational, and open to new opportunities. Time spent in Q2 creates balance and a sense of control over what’s ahead.</td>
</tr>
<tr>
<td>Important</td>
<td>Quadrant 3: Interruptions, distractions, spontaneous invitations (e.g., most calls/invitations from others) If you spend a lot of time in Q3, you may feel busy and productive, but everything has a short-term focus, and isn’t connected to your big picture goals. Many Q3 tasks are interruptions from other people and often involve helping them fulfill their own priorities. Many people spend most of their time on Q3 tasks, all the while thinking they’re working in Q1.</td>
</tr>
<tr>
<td>Not Important</td>
<td>Quadrant 4: Time wasters, busy work, procrastination (e.g., checking social media, watching TV, playing video games) If you’re spending a lot of time in Q4, you’re not taking responsibility for things that need to get done. As a result, you may find it hard to achieve academic success, or to balance healthy relationships, wellness, work and other commitments. Q4 activities can be helpful when you need to relax or decompress, but try to limit them to about 5% of your available time.</td>
</tr>
</tbody>
</table>

In which quadrant do you think you currently spend the majority of your time?

List your 10 most common daily activities.

| Daily Activity 1 |
| Daily Activity 2 |
| Daily Activity 3 |
| Daily Activity 4 |
| Daily Activity 5 |
| Daily Activity 6 |
| Daily Activity 7 |
| Daily Activity 8 |
| Daily Activity 9 |
| Daily Activity 10 |
Urgency & Importance (continued)

For each activity, how important is it? How urgent is it? Fill in the chart below by assigning each activity to the appropriate quadrant.

<table>
<thead>
<tr>
<th>Important</th>
<th>Urgent</th>
<th>Not Urgent</th>
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</thead>
<tbody>
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<tr>
<td>Not Important</td>
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</table>

Time management experts recommend spending the most time in Q1 & Q2 and minimal time in Q3 & Q4 for greater productivity and satisfaction. By planning ahead, some Q4 activities can be shifted to Q2. What might allow you to spend more time on Q2 activities? List up to 3 ways.

Reducing the amount of time you spend on Q1, Q3 and Q4 activities is another way to improve your time management. What might help you to spend less time on these activities? List up to 3 ways.
Setting Goals
(home sessions 4, 9, & 14)

Setting Goals

Generating goals and writing out steps to accomplish them can help you manage your time. Use the acronym SMART when working towards your goals. Identify steps that are: Specific, Measurable, Action-oriented, Relevant, and Time-oriented.

Write down 3 goals that you have for the upcoming week (e.g., accomplishing specific projects or moving towards broader goals such as improving your fitness).

Select one goal from above and break it into smaller steps. Each step should be specific, measurable, action-oriented, relevant, and time-oriented.

Goal 1

<table>
<thead>
<tr>
<th>Step</th>
<th>Time Needed</th>
<th>Target Completion Date</th>
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</thead>
<tbody>
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</table>

Now, repeat this process for your remaining 2 goals

Goal 2

<table>
<thead>
<tr>
<th>Step</th>
<th>Time Needed</th>
<th>Target Completion Date</th>
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<tbody>
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Goal 3

<table>
<thead>
<tr>
<th>Step</th>
<th>Time Needed</th>
<th>Target Completion Date</th>
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</tbody>
</table>
### Scheduling Priority Tasks and Activities

Identifying top priorities and scheduling specific days and times to accomplish tasks can be a helpful way to manage your time.

Write down one major goal that you would like to accomplish during the upcoming week (e.g., writing a paper or planning an extracurricular event):

Now, identify 6 smaller actions that will help you reach this goal:

Using the calendar below, fill in your regular daily commitments (job, classes, extracurricular, exercise, meals, breaks, etc.). Next, choose specific dates and times for your goal-oriented actions. It may be helpful to schedule these steps into 30-60 minute blocks of time.

<table>
<thead>
<tr>
<th>Time</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
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</table>
Appendix G. Previous Mindfulness Experience Questionnaire

Please indicate any experiences you've had learning or practicing mindfulness PRIOR to your participation in this study.

Prior to this study, have you ever learned about or practiced mindfulness?
  o Yes
  o No
  o Unsure

If yes, which types of mindfulness? Select all that may apply.
  o Yoga
  o Tai Chi / Qigong
  o Meditation
  o Mindfulness-Based Stress Reduction
  o Other

What was the format of your experience? Select all that may apply.
  o Formal class or course
  o Informal instruction by someone you know
  o Workshop
  o Book
  o Audio or Video-guided
  o Participation in a research study
  o Other

How many total YEARS of mindfulness practice have you done prior to this study?
If less than one year, please indicate number of months. __________________________

Approximately how many total HOURS of mindfulness practice have you done prior to this study? Please give your best estimate. ________________________________
Appendix H. Debriefing Information
(Given to study participants at the end of study visit 2)

Short-term Changes in Cognition and Emotion
Debriefing Information

PURPOSE
The purpose of this study is to evaluate whether a brief mindful breathing intervention leads to changes in aspects of attention, and whether these changes mediate the beneficial effects of mindfulness interventions on changes in psychological symptoms. Participants were assigned to either a mindful breathing intervention or a time management intervention that served as an active control. We are investigating whether participants who do mindful breathing demonstrate significant changes in attention, over and above those who practice time management exercises. We are also investigating how attention changes may be related to and/or mediate changes in rumination, worry, mindfulness, mood, and depressive symptoms.

BACKGROUND
Deficits in certain aspects of attention may be a cognitive marker of vulnerability to depression and may contribute to rumination and perseverative thinking. Mindfulness-based interventions (MBIs) have demonstrated positive outcomes in depressed individuals, and research suggests that mindfulness practice leads to changes in attention. These changes might mediate improvements in mood. Because various components of MBIs have been shown to affect changes in mood, individual differences may determine whether changes in attention are most critical to observed outcomes. Thus, there is a need for new research to test the potential mediating role of attention changes following mindfulness-based interventions.

CONFIDENTIALITY
Participant confidentiality is very important at The Catholic University of America. We plan to publish the findings of this study but will not include any information that would identify you
personally. To keep your information safe, we have assigned a numerical code to your data. Your name will not be associated with the data collected in this study.

**FINAL REPORT**

If you are interested in obtaining a copy of the final report of this study, contact either Dr. Nancy Adleman (email@cua.edu) or Katherine McMorran (email@cua.edu).

**CONTACT**

If you have any questions regarding this study, its purpose or procedures, please feel free to contact Dr. Nancy Adleman or Katherine McMorran at the emails provided above. If you have questions about your rights as a research participant, or wish to obtain information, ask questions or discuss any concerns about this study with someone other than the researcher(s), please contact the Catholic University of America, Office of Sponsored Programs and Research Services Institutional Review Board, McMahon Hall 213, 620 Michigan Ave., NE, Washington, DC, 20064, (202) 319-4495, CUA-OSP@cua.edu.

**IMPORTANT**

It is very important that you do not discuss this study with anyone else until the study is complete. Our efforts will be compromised if participants come into this study knowing what it is about. So please do not discuss the details of this study with anyone else until at least the end of this academic year.

**FURTHER INFORMATION**

If you would like to receive the alternate intervention (either mindfulness training or time management), please contact us so that we can email you information.
References


Cuijpers, P., Sijbrandij, M., Koole, S.L., Andersson, G., Beekman, A.T., & Reynolds III, C.F. (2013). The efficacy of psychotherapy and pharmacotherapy in treating depressive and


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