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The Efficacy of Mindfulness-Based Therapies for Attention-Deficit/Hyperactivity Disorder: A Meta-analytic Review

Molly Cairncross
University of Windsor

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By

Molly Cairncross

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by

Molly Cairncross

APPROVED BY:

_____

E.A. Donnelly
School of Social Work

_____

D.L. Jackson
Department of Psychology

_____

C.J. Miller, Advisor
Department of Psychology

August 5th, 2015

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ABSTRACT

Mindfulness-based therapies (MBT) have been shown to be efficacious in treating internally-focused psychological disorders (e.g., depression), however it is still unclear whether MBT provide improved functioning and symptom relief for individuals with externalizing disorders, including ADHD. In order to clarify the literature on the efficacy of MBT in treating ADHD and to guide future research, an effect size analysis was conducted. A systematic review of studies published in PsycINFO, PubMed, and Google Scholar was completed from the earliest available date until December 2014. A total of eight studies were included in the analysis of inattention and the overall effect size was d= -.72. A total of seven studies were included in the analysis of hyperactivity-impulsivity and the overall effect was calculated at d= -.60. Findings related to changes in executive functioning pre- and post-intervention were equivocal. Results of this study highlight the possible benefits of MBT in reducing symptoms of ADHD.

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ABBREVIATIONS

ACT	Acceptance and Commitment Therapy
ADHD	Attention-deficit/Hyperactivity Disorder
APA	American Psychological Association
BPT	Behavioural parent training
CBT	Cognitive Behavioural Therapy
CD	Conduct Disorder
DBT	Dialectical Behaviour Therapy
MBT	Mindfulness-based therapies
MBCT	Mindfulness-based Cognitive Therapy
MBSR	Mindfulness-based Stress Reduction
ODD	Oppositional Defiant Disorder

I. LITERATURE REVIEW

Introduction

Attention-deficit/hyperactivity disorder (ADHD) is a highly prevalent disorder – one of the most common disorders of childhood (Centers for Disease Control and Prevention [CDC], 2015). Given that the symptoms of ADHD result in significant impairment in multiple areas of functioning, developing new treatments has important implications for the quality of life of individuals who suffer from ADHD. ADHD is most often treated with medication and/or psychosocial treatments, however in recent years, mindfulness-based therapies (MBT) have been introduced as a potential treatment for children and adults with ADHD (Hayes, 2004). Although research has demonstrated MBT to be a moderately effective treatment for internally-focused disorders (Khoury et al., 2013), it is still unclear whether MBT can provide improved functioning and symptom relief for individuals with externalizing disorders such as ADHD.

Using MBT as a treatment for ADHD offers a potentially successful psychotherapeutic treatment to be used in conjunction with medication therapy, or as an alternative treatment, which would be particularly important for individuals who suffer adverse side effects from ADHD medication, or for those who are unwilling to consider ADHD medications. The goal of the current study is to determine if individuals who have been diagnosed with ADHD and receive MBT experience positive outcomes, such as a reduction in ADHD symptoms (hyperactivity-impulsivity and inattention) and improved executive control; thus, determining the potential benefits of mindfulness-based intervention on individuals diagnosed with ADHD.

The purpose of this chapter is to review the literature on ADHD and the current treatments for individuals diagnosed with ADHD, to define mindfulness and how mindfulness-based therapies have been integrated in the treatment of psychological disorders, and lastly to present support for how mindfulness-based therapies may be effective in reducing ADHD symptoms and improve functioning in individuals diagnosed with ADHD.

Attention-deficit/Hyperactivity Disorder

Attention-deficit/hyperactivity disorder (ADHD) is a highly prevalent neurobehavioral disorder, which manifests as developmentally-inappropriate pervasive and persistent inattention, hyperactivity, and impulsivity that are impairing and present in at least two settings (American Psychiatric Association, 2013). ADHD impacts approximately 5-7% of children and adolescents worldwide and 4.4% of adults (APA, 2013; Polancyzk, de Lima, Horta, Biederman, & Rhode, 2007). Although symptoms are typically first noted in childhood, between 46% and 66% of these individuals continue to experience significant impairment into adolescence and early adulthood (Barkley, Fischer, Smallish, & Fletcher, 2002). Often, these symptoms result in significant difficulty in multiple areas of functioning, including education (Mannuzza, Klein, Bessler et al., 1993), employment (Mannuzza, Klein, Bessler et al., 1993), and strained romantic and familial relationships (Bagwell, Molina, & Pelham et al., 2001; Johnston & Mash, 2001). Furthermore, the symptoms commonly involve significant comorbid psychopathology (e.g. Cherkasova et al., 2013).

Despite the heterogeneity of symptoms expressed by children and adults diagnosed with ADHD, two primary symptom groups are diagnostic: inattention and poor

behavioural control, expressed as hyperactivity and impulsivity. The clinical presentation of an individual with ADHD changes across the lifespan and is largely dependent on the individual's current developmental stage (Cherkasova, Sulla, Dalena, Ponde, & Hechtman, 2013).

Difficulty sustaining attention occurs in tasks that require a large amount of self-regulation and task- or goal-directed persistence (Barkley, 1997). This difficulty sustaining attention is not a problem of processing information, rather an inability to inhibit and control external and internal stimuli that interfere with the executive functions that assist in self-regulated persistence (Barkley, 1997). Children with ADHD may be easily distracted, have problems with organizing tasks, and have difficulties completing schoolwork, especially when it requires a great deal of sustained mental effort.

Individuals diagnosed with ADHD may also have difficulties related to over-activity and poor impulse control (Barkley, 1998). Although the generalized overactivity often fades by adulthood, impulsive behaviour may remain stable (Moffitt et al., 2011). Children with ADHD may appear impatient, interrupt conversations/activities, and appear emotionally unrestrained. As a result of their difficulties with self-regulation, they may rush through schoolwork and make careless errors. Sitting still for long periods of time, fidgeting, and having trouble with quiet tasks are all hallmark behaviours associated with ADHD.

Symptoms of inattention and hyperactivity in early childhood are highly positively associated with one another. However, typically the symptoms associated with hyperactivity decrease with age, and symptoms of inattention tend to become more evident in their manifestation throughout the life span (Galera et al., 2012). For 50% of

preschool children with ADHD, the ADHD symptoms will persist into school age and approximately 50-70% of those persist across the lifespan into adulthood (Miller, Miller, Newcorn, & Halperin, 2008). ADHD in school-aged children interferes with academic performance, and peer and familial relationships (Barkley, 2006). During this time, symptoms of inattention continue to increase in severity, as hyperactivity decreases (Lahey et al., 2004). Generally, symptoms of inattention decline slower than hyperactivity and impulsivity in adolescence and adulthood ADHD (Biederman, Mick, & Faraone, 2000; Molina et al., 2009). A recent meta-analysis determined that while not all cases of ADHD will warrant a clinical diagnosis in adulthood, it is estimated that around 65% will continue to have impairments resulting from persisting symptomology (Faraone, Biederman, & Mick, 2006). Longitudinal studies investigating the persistence of ADHD into adulthood suggest that the proportion varies from 15% (Faraone, Biederman, & Mick, 2006) and up to 58% (Biederman et al., 2006).

Many factors contribute to the development of ADHD, and continue to predict ADHD persistence and impairment throughout the lifespan. Persistence of ADHD from childhood into adolescence and adulthood is predicted by severity of childhood ADHD symptoms and level of impairment in childhood; the presence of comorbid disorders (e.g. ODD, CD, anxiety disorders); intellectual functioning; level of behavioural problems; parental psychopathology; and familial factors, such as parenting style that affects the emergence of comorbid disorders such as ODD, CD, and problems with emotional adjustment (Barkley, et al., 2008; Biederman, Faraone, Milberger, Curtis, et al., 1996; Biederman, Petty, Clarke, Lomedico, & Faraone, 2011; Molina, et al., 2009; Swanson et al., 2007).

Etiology

While the etiology of ADHD continues to be studied by psychological and medical researchers, it is generally believed to be a result of the interaction of genetic and environmental factors (Nikolas & Burt, 2010). Behavioural genetic studies employing twin samples and adoption studies have been used to estimate the genetic influences on ADHD. These studies have implicated a high degree of heritability – up to 80% (Bobb, Castellanos, Addington, & Rapoport, 2006; Faraone & Biederman, 1998). Molecular genetic association studies have also shown that there are many genetic polymorphisms that contribute to the development of ADHD (Beaver, Nedelec, Rowland, & Schwartz,2012), including DRD4, DAT1, and DATI (genes involved in the dopaminergic system), HTR1B (a gene involved in the serotonergic system), and SNAP25 (a gene involved in the synthesis of a protein important for the development of axons, the release of neurotransmitters, and synaptic plasticity; Coghill & Banaschewski, 2009). Based on current studies, it is likely that multiple genes-of-risk are involved.

There are also neuroanatomical findings related to ADHD. Imaging studies of individuals with ADHD reveal dysfunctions in regions belonging to multiple neuronal networks involved in higher-level cognitive and sensorimotor functions (Cortese et al., 2012). Structural imaging studies show that individuals with ADHD commonly have cortical thinning and reduced dimensionality of the prefrontal cortex, caudate nucleus, corpus callosum, and cerebellar vermis (Valera, Faraone, Murray, & Seidman, 2007). Recent meta-analytic review of fMRI data revealed that children with ADHD had hypoactivation in the ventral attention and frontoparietal networks and hyperactivation in the ventral attention, somatomotor, and default mode network relative to comparison

subjects (Cortese et al., 2012). In adults with ADHD, hypoactivity occurred almost predominantly in the frontoparietal network (Cortese et al., 2012), an area of the brain imperative to attention (Ptak, 2012). The notion that ADHD is a disorder of dysfunctions in large brain networks has led to the idea that these alterations in brain structure and function may influence the diverse display of neurocognitive deficits that are demonstrated in children and adults with ADHD (Halperin, Bedard, & Curchack-Lichtin, 2012).

Beyond the genetic predisposition involved in the development of ADHD, certain prenatal and perinatal environmental factors increase the risk for ADHD. Maternal nicotine use (Linnet et al., 2003), alcohol use (Mick, Biederman, Faraone, Sayer, & Kleinman, 2002), and drug use during pregnancy (Accornero et al., 2007), as well as exposure to various chemicals/contaminants (Nigg, 2005) can increase the risk of the disorder. Further, maternal stress (Linnet, et al., 2003) and poor maternal nutrition during pregnancy (Vermiglio et al., 2004) can also increase the likelihood of developing the disorder. Not all children exposed to these environmental factors develop ADHD, thus genetics may predispose individuals to increased risk for poor outcomes. Postnatal environmental factors also exist, such as parenting style and socioeconomic status (Nigg, Nikolas & Burt, 2010).

Diagnosis

There is not a definitive test used to diagnose ADHD. Current diagnostic criteria for ADHD are from the Diagnostic and Statistical Manual of Mental Disorders (APA, 2013), which is currently in its fifth version (DSM-V). ADHD symptoms are divided into two domains – inattention, and hyperactivity-impulsivity. In order to qualify for a

diagnosis of ADHD children must endorse at least six symptoms from either or both of the categories listed in the DSM-V. The newest edition of the DSM clarifies the diagnostic criteria to be used in diagnosing adults with ADHD: individuals over the age of 17 only need evidence of five or more symptoms in at least one domain but symptom onset and evidence of impairment must be present prior to the age of 12 years. The assessment of ADHD requires the clinician to obtain rating scales from multiple informants (e.g., self-, parental-, and teacher-reports) that demonstrates impairment across multiple settings (e.g., home, school, work). Clinical interviews with the patient and informants can also provide important information, as well, when resources permit, a direct observation of the child and their behaviour is advantageous. Psychological testing is only indicated when there are concerns about comorbidities (Barkley, 2014).

Comorbid Conditions

Diagnosis of ADHD is often complicated by psychiatric and neurological comorbid conditions. Approximately 67-80% of children and 80% of adults diagnosed with ADHD also have at least one comorbid condition and up to 50% of these individuals will have more than one comorbid disorder (Barkley, Murphy, & Fischer, 2008). ADHD is highly comorbid with externalizing disorders such as ODD and CD, and internalizing disorders such as anxiety and depression (Jensen et al., 2001). Comorbid behavioural problems such as ODD and CD in childhood ADHD is a predictor of comorbidity in adulthood ADHD (Cherkosava et al., 2013) and are associated with social relationship problems and psychopathology such as substance use, and mood and personality disorders (Barkley, Murphy, & Fischer, 2008; Biederman, Faraone, Milberger, Guite et al., 1996; Biederman et al., 2008). Other common comorbid disorders include learning

disabilities, problems with academic achievements, motor coordination problems, sleep disorders, and substance abuse (Brown, 2009; Tomblin & Mueller, 2012). These comorbid conditions vary across the lifespan in individuals diagnosed with ADHD (Cherkosava et al., 2013). Like ADHD, these comorbidities are likely to persist into adolescence and adulthood (Kessler et al., 2006); furthermore, those with comorbid disorders are often more impaired (Cherkosava et al., 2013).

Adults who grew up with ADHD tend to have psychiatric comorbidities, relationship and marital problems, and poorer academic achievement, job rank and performance, and are more likely to engage in risky sexual behaviour and criminal behaviour (Barkley, Murphy, & Fischer, 2008; Biederman, Faraone, Milberger, & Guite, 1996; Biederman et al., 2006; Klein et al., 2012; Mannuzza, Klein, & Moulton, 2008; Molina, et al., 2009). Common psychiatric comorbidities in adulthood ADHD are antisocial personality disorders and substance misuse (Barkley, et al., 2008; Biederman, et al., 2006; Klein, et al., 2012; Mannuzza, et al., 1998; Molina, et al., 2009).

Treatment

Treatments available for children with ADHD aim to reduce symptoms and improve functioning across settings. The most commonly advocated treatments include medication, behavioural intervention, and parent training. Over the past four decades, psychostimulant medications have become among the most frequently prescribed medications for all childhood conditions, including antibiotics and asthma medications (Mayes & Rafalovich, 2007). Stimulant treatment has been reported to improve symptoms in individuals with ADHD; it is reported that 70-80% of children with ADHD experience improvements in their symptoms (DuPaul, Barkley, & McMurray, 1991;

Multimodal Treatment Study of Children with ADHD Cooperative Group: MTA, 1999). Further, research has shown that children diagnosed with ADHD who take psychostimulant medication score higher on neuropsychological measures of attention and verbal learning (Biederman et al., 2008). However, a small percentage of individuals who are prescribed medication to treat ADHD symptoms have adverse side effects such as sleep problems and loss of appetite (MTA, 1999; Graham & Coghill, 2008; Martin, 2007).

Often, adjunctive therapies such as behavioural interventions (e.g. antecedent-based strategies, contingency management techniques, social-skills straining), parent skills training, cognitive-behavioural therapy, and more recently mindfulness-based therapies are used in conjunction with psychostimulants. Combined treatment has been shown to reduce ADHD symptoms and improve other functional domains (e.g., externalizing and internalizing behaviours) more than behavioural treatment alone (MTA, 1999). Research has shown that combined medication and behavioral intervention provides the most effective symptom relief for individuals diagnosed with ADHD (Smith, Barkley, & Shapiro 2006). Thus, combined treatment is often utilized to provide improved symptom relief as well as improved overall functioning for children and adults with ADHD, particularly for adults who are less effectively treated with medication therapy alone (Spencer, Biederman, & Wilens 2000).

Behaviour therapy. Behavioural interventions for children with ADHD include antecedent-based strategies, contingency management techniques, and self-management strategies (DuPaul & Weyandt, 2006). Recent meta-analysis supports the effectiveness of behavioral based therapies for the treatment of ADHD (Fabiano et al., 2009).

Behavioural interventions for ADHD were developed from theories related to classical conditioning, operant conditioning, and social learning (Kolivas, Riordan, Gross et al., 2008). Because ADHD is often described as a developmental delay in internal self-regulation of behaviour and motivating goal-directed behaviour, these interventions work to provide externally represented information to guide behaviour, which enhances motivation (Mash & Barkley, 2006). Children with ADHD typically display symptoms in multiple settings. Thus, it is imperative that not only the parents but also the child's teacher incorporate these behavioural interventions; these interventions have been shown to improve the functioning of children with ADHD across multiple settings (e.g., home and school; Fabiano et al., 2009). Research has shown that, although behavioural interventions typically do not decrease core symptoms of ADHD, they often improve the child's overall functioning by decreasing disruptive behaviour and improve the social skills and relationships of the child (Roman, 2010).

Parenting training skills. Behavioural parent training (BPT) has been shown to be effective for children with ADHD (Chronis, Chacko, Fabiano, Wymbs, & Pelham, 2004; Sonuga-Barke, Daley, & Thompson, 2002; Sonuga-Barke, Daley, Thompson, Laver-Bradbury & Weeks, 2001). Most often, BPT consists of training parents in general contingency management strategies: providing reinforcements following appropriate behaviour and punishment following inappropriate behaviour (Mash & Barkley, 2006). One problem associated with BPT of children with ADHD is the high heritability of ADHD; thus, many parents who receive the training may have ADHD themselves and this may limit the success of the BPT for the child with ADHD (Sonuga-Barke et al., 2002).

Cognitive-behavioural therapy. Treatment of ADHD with cognitive-behavioural therapy (CBT) involves training individuals to self-instruct on how to approach a task, give themselves self-statements of evaluation, and self-reinforcement upon completion of a task (Mash & Barkley, 2006). CBT has previously shown some promise for children with ADHD (Kendall & Braswell, 1985; Meichenbaum & Goodman, 1971) but these effects were somewhat limited (Bloomquist, August, & Ostrander, 1991; Braswell et al., 1997). In contrast, meta-cognitive therapies, which employ cognitive behavioural strategies has been used in adults with ADHD effectively (Solanto, Marks, Wasserstein, Mitchell, & Abikoff, 2010).

Coaching. Coaching is an intervention that has recently increased in popularity for treating adults with ADHD. Coaching as an intervention focuses on goals, strategies for meeting goals, and emphasizes the accountability of the individual with ADHD (Knouse, Cooper-Vince, Sprich, & Safren, 2008). It uses psychoeducation to help adults and older adolescents with ADHD to improve functional skills to cope with the behavioral, emotional, and cognitive difficulties associated with ADHD (Kubik, 2010). Unlike in CBT, coaching takes a specific and action-oriented approach to meeting concrete goals (Knouse et al., 2008). The psychoeducation of potential negative outcomes associated with ADHD is integrated with developing and implementing new strategies to cope with these outcomes in everyday life.

Mindfulness interventions. Over the last fifteen years, mindfulness-based therapies (MBT) have been introduced to help with symptom relief of children and adults with ADHD (Hayes, 2004). In these mindfulness interventions, the internal experiences, thoughts, feelings, and bodily sensations of the individual have been integrated into the

intervention (Greco & Hayes 2008). Acceptance and mindfulness-based therapies seek to bring awareness to these internal processes in order to reduce their impact on the individual's functioning (Greco & Hayes, 2008). Recent research suggests that MBT may improve core symptoms of ADHD, with improvements in both attention and aspects of executive control, particularly in adults (Zylowska et al., 2008). Functional and structural imaging studies also suggest that patterns of hypoactivity in frontal regions of the brain were detected in individuals with ADHD (Dickstein, Bannon, Castellanos, & Milham, 2006), and activation of many of these regions can be enhanced in mindful meditators (Manna et al., 2010), suggesting a means by which MBT may successfully improve symptoms of ADHD (Grant et al., 2013).

Mindfulness

The concept of mindfulness, rooted in ancient Buddhist practice, has proliferated over that past 2,500 years in many Asian countries, but it was not until more recently that there has been an increased interest in mindfulness throughout the Western world (Langer & Moldoveanu, 2000). In the 1970's, Western practitioners adopted a particular interest in the utility of meditative and contemplative practices and their clinical applications, particularly for individuals with chronic pain disorders, high levels of stress, and chronic disease processes. Over the last several decades the clinical community has begun to adopt the concept into an integrative approach to healthcare and wellness promotion, which focuses on attitude, behaviour, and cognitive-affective processing and how this can affect functional outcomes, outside of a religious context.

The ancient Buddhist meditation techniques from which mindfulness originates facilitated individual insight, and promoted awareness to the present moment and to the

individual's psychological responses (Hart, 1987). In Buddhist tradition, mindfulness was developed as part of an individual's path to relieve personal suffering (Thera, 1962; Silananda, 1990). As a clinical component, mindfulness, which is the act of self-regulating attention in a non-judgmental way to the present moment (Zylowska et al., 2008), can lead to a greater sensitivity to the environment, openness to information, new ways of perceiving, and increased awareness (Langer & Moldoveanu, 2000). Clinical mindfulness training increases an individual's awareness and brings acceptance of experiences involving thoughts, emotions, physiological sensations, and events external to the individual (Baer, 2003; Cash & Whittingham, 2010).

In contemporary psychology, mindfulness has been used to increase awareness and teach the individual to identify and respond to the physiological and psychological processes that are involved in maladaptive behaviours and emotions (Bishop et al., 2004). Several researchers have attempted to conceptualize models of mindfulness. For example, some researchers believe that the emotional and attentional components of mindfulness create a unidimensional construct (i.e. Brown & Ryan, 2003). Whereas others have proposed a two-dimensional model that involves an attentional component and a second emotion regulation factor (Bishop et al., 2004). The two-factor model of mindfulness proposed that the ability to focus in the present moment experience and the act of doing so openly, and with curiosity and acceptance are separable factors that both contribute to mindfulness (Bishop et al, 2004). Bishop and colleagues (2004) proposed that mindfulness is composed of two components and operationalized as such:

(1) The first component involves the self-regulation of attention so that it is maintained on immediate experience, thereby allowing for increased

recognition of mental events in the present moment.

(2) The second component involves adopting a particular orientation towards one's experiences in the present moment, and orientation that is characterized by curiosity, openness, and acceptance (Bishop et al., 2004, p. 232)

Therapeutic Effects of Mindfulness

Due to the recent interest of mindfulness as a potential alternative therapy to a variety of different psychological disorders, several different MBT have been developed. The first therapy to introduce mindfulness into mainstream medicine was a program developed by Dr. Jon Kabat-Zinn, Mindfulness-based Stress Reduction (MBSR; 1990), at the University of Massachusetts. MBSR was originally developed as a program to manage chronic pain, but has since been validated for use with many different clinical and subclinical populations. MBSR is an 8-week psychoeducational program that consists of weekly 2.5-hour classes of guided mindfulness meditation. Participants are expected to do 45-60 minutes of home practice each day. There is also a day-long retreat between the 6th and 7th week of training. The therapy is led in a group format. Participants are taught meditation techniques that may be applied to tasks of daily living such as driving, eating, and interacting with others (Salmon et al., 2004). MBSR is not a goal-directed therapy; the purpose of MBSR is to teach the participant to be present and aware in their moment-to-moment life (Kabat-Zinn, 1982).

A strong interest in the clinical utility of mindfulness resulted from the development of MBSR. MBSR is now widely used and has been shown to effectively reduce stress and increase emotional well-being (William, Kolar, Reger, & Pearson, 2001), has effectively been used to treat emotional and behavioural disorders (e.g. Kabat-

Zinn, 1982; Teasdale et al., 2000), and reduce psychological problems often comorbid with medical illness (Reibel, Greenson, Brainard, & Rosenzweig, 2001; Speca, Carlson, Goodey, & Angen, 2000; Carlson, Ursuliak, Goodey, Angen, & Speca, 2001)

Various other programs have been developed based on modifications of the MBSR program, such as Mindfulness-based Cognitive Therapy (MBCT: Segal, Williams, & Teasdale, 2002), which utilizes mindfulness meditation in conjunction with cognitive therapy. It was designed to decrease relapse rate in individuals with recurrent depression (Teasdale et al., 2000). Mindfulness training is also a central component to therapies such as Dialectical Behaviour Therapy (DBT: Linehan, 1993, p. 114), which utilizes mindfulness meditation and has been shown to reduce suicidality and self-harm in patients with borderline personality disorder (Linehan, Armstrong, Saurez, Allmon, & Heard, 1991) and Acceptance and Commitment Therapy (ACT; Hayes, Strosahl, & Wilson, 1999), which promotes psychological flexibility by integrating mindfulness training into therapy and has been shown to be effective in treating disorders such as depression and anxiety (Forman, Herbert, Moitra, Yeomans, & Gellar, 2007). But, regardless of the specific protocol being used, each program's main focus is teaching the participants to become more mindful, accepting, and aware. Individuals are encouraged to be active participants in the process and take responsibility for their own outcomes (Kabat-Zinn, 1982).

Assessment of mindfulness

Several instruments have been created and psychometrically validated to measure the construct of mindfulness. Mindfulness is predominantly measured using self-report questionnaires. Most scales have been validated by means of confirmatory factor analysis

and have shown good psychometric properties (Sauer, Walach, Schmidt, Hinterberger et al., 2013). The current study will not explore the changes in mindfulness via meta-analysis; therefore a review of each existing mindfulness scale and the differences between them is beyond the scope of this paper (see Sauer et al., 2013 for a comprehensive review of each scale and each scales psychometric properties). The existing mindfulness scales are the most common process for assessing mindfulness, however, several alternatives to self-report measures exist.

Researchers have begun to use qualitative approaches to assessing mindfulness, although this approach is in its infancy. For example, some researchers have investigated the possibility of using qualitative interview data to acquire a more in-depth analysis of an individual's level of mindfulness and can be used as an explorative approach to complement quantitative analyses (Sauer et al., 2013). For example, Collins and colleagues (2009) developed a language-based measure of mindfulness by which mindfulness is assessed via the number of words that an individual uses that are related to the concept of mindfulness.

An individual's level of mindfulness can also be assessed through observation by an unbiased observer. This approach assumes that an individual's level of mindfulness can be assessed externally by a trained mindfulness expert on the bases of their own experiences and the trajectory of their own mindfulness development (Sauer et al., 2013). This approach has not been used within a research context; it is most commonly used in Buddhist practice (Sauer et al., 2013).

Lastly, cognitive tests such as standard tests of attention have also been investigated as a means of objectively assessing mindfulness (Fan et al. 2005; Jha,

Krompinger, & Baime, 2007; Tang and Posner 2009; Zeidan et al. 2010). Researchers have begun investigating the biological and neuronal correlates of mindfulness. Evidence exists that shows lower cortisol levels (Matousek, Pruessner, & Dobkin, 2011) and increased cortical thickness in areas active during meditation (Ott et al., 2011) in individuals who practice mindfulness. Although these variables are sensitive to mindfulness, they should not be equated. However, they do provide valuable insight into the nature of mindfulness.

Neurobiological Correlates of Mindfulness

Functional and structural imaging studies suggest that patterns of neural functioning and brain structure are altered by mindfulness training (Davidson et al., 2003; Ott et al., 2011; Holzel et al. 2008). Thus, the therapeutic effects of MBT could be a result of underlying neurobiological changes that occur following mindfulness training. Brain imaging studies have shown that cortical areas activated by mindfulness activities are actually larger in individuals who practice mindfulness compared to those who do not practice mindfulness (Ott et al., 2011). Furthermore, research has demonstrated greater cortical thickness (Lazar et al., 2005) and increased grey matter concentration in individuals who practice mindfulness meditation (Holzel et al., 2008).

Mindfulness and ADHD

Recent research suggests that MBT may improve core symptoms of ADHD, with improvements in both attention and executive control (Zylowska et al., 2008). Functional and structural imaging studies also suggest that patterns of hypoactivity in frontal regions of the brain were detected in individuals with ADHD (Dickstein et al., 2006), and activation of many of these regions can be enhanced in mindful meditators (Manna et al.,

2010), suggesting a means by which MBT may successfully improve symptoms of ADHD (Grant et al., 2013). However, some of this earlier work has been criticized due to small sample sizes and exploratory analyses.

Researchers have asked the question of whether ADHD and mindfulness overlap because sustained attention is imperative to mindfulness as well as positive outcomes related to ADHD (Smalley et al., 2009). Research has shown that mindfulness training improves attentional capacity (Lutz et al., 2009; Tang et al., 2007) and decreases impulsivity (Kozasa et al., 2012) in small samples, impairments typical in individuals with ADHD. Recent research has shown that participants trained in mindfulness can develop greater ability to focus and self-regulate. Research has also shown that individuals with ADHD score lower on measures of trait mindfulness than individuals who have not been diagnosed with ADHD (Smalley et al., 2009). Furthermore, in a study conducted on adults with ADHD, they noted the topic of mindfulness as important for their improved functioning (Philipsen, Richter, Peters, Alm, Sobanski et al., 2007).

Studies measuring changes in attentional capacity following mindfulness training report that changes in conflict attention occur quite rapidly (Tang et al., 2007), which is defined as attention that is important to self-regulation (Posner & Rothbart, 1998), and is involved in the inhibition of automatic responses. Studies report that individuals with ADHD have decreased conflict attention (Loo et al., 2007) and mindfulness training has been shown to increase this construct (Tang et al, 2007). Brain imaging studies of conflict attention show involvement of the prefrontal cortex (Posner & Rothbart, 1998) and imaging studies of ADHD and mindfulness both show involvement of the same prefrontal areas (Davidson et al, 2003; Giedd, Blumethal, Molloy, & Castellanos, 2001;

Holzel et al., 2011; Lazar et al., 2005). The aforementioned research suggests that mindfulness training may be effectively used to improve functioning and reduce symptomology in individuals with ADHD.

II. THE PRESENT STUDY

As previously described, ADHD is most often treated with medication and/or psychosocial treatments. However, in recent years, mindfulness-based therapies (MBT) have been introduced as a potential treatment for children and adults with ADHD (Hayes, 2004) because mindfulness training has been shown to increase attentional capacity (Zylowska et al., 2009). And although research has demonstrated MBT to be a moderately effective treatment for depression, stress, anxiety, and other psychological problems (Khoury et al., 2013), it is still unclear whether MBT can provide improved functioning and symptom relief for individuals with externalizing disorders such as ADHD.

A number of studies have begun to address this question, but samples are relatively modest. The results of these studies suggest that MBT reduces reported symptoms of ADHD and improves scores on measures of associated neurocognitive deficits. However, a recent study on adolescents with ADHD showed that although changes on parent-rated inattention occurred, on self-reported measures of ADHD symptoms no statistical significance was reported for inattention, and further, there was no statistically significant difference at pre- and post-intervention for hyperactivity-impulsivity ratings (Haydicky, 2013). In the same study, MBT was shown to significantly reduce parent-rated conduct problems and peer relational problems in adolescents with ADHD (Haydicky, 2013), demonstrating the therapies benefits to the psychosocial deficits often associated with ADHD.

Given that ADHD symptoms result in such significant impairment in multiple areas of functioning, developing new treatments has important implications for the

quality of life of individuals, and the families of individuals, who suffer from ADHD. Using MBT as a treatment for ADHD offers a potentially successful psychotherapeutic treatment to be used in conjunction with medication therapy, or as an alternative treatment, which would be particularly important for individuals who suffer adverse side effects from ADHD medication, or for those who are unwilling to consider ADHD medications. In order to address this question an effect-size analysis was conducted on studies investigating the effects of MBT on ADHD to determine the size of the treatment effect. To this author's knowledge, there are no published meta-analytic studies of MBT for individuals with ADHD.

Thus, the purpose of the present study was an investigation into the potential benefits of mindfulness-based interventions on individuals diagnosed with ADHD. In order to accomplish these research goals, a meta-analysis was conducted to determine if individuals who have been diagnosed with ADHD and receive MBT experience positive outcomes, such as decreased hyperactivity-impulsivity and increased attentional capacity that are examined by pre-post effects. Further, a qualitative review of how MBT may effect executive functioning in individuals diagnosed with ADHD was also conducted.

It was expected that individuals who have been diagnosed with ADHD and receive MBT would report a reduction in inattention and hyperactivity-impulsivity from pre- to post-intervention. It was also expected that individuals would report improvements in executive functioning from pre- to post-intervention. Several potential moderators were also investigated. Firstly, whether age of participants effects treatment success was assessed. It was hypothesized that MBT would be more effective in reducing ADHD symptoms in adults because as individuals with ADHD age, inattention increases

while hyperactivity-impulsivity decreases and research has more often provided evidence that MBT reduces inattention, rather than hyperactivity-impulsivity. Secondly, an analysis was conducted to determine whether self- and other-informant reported changes across these functional domains are consistent. It was hypothesized that self- and other-informant (e.g., parent or clinician) reports would differ because research has shown parents of children with ADHD to be more accurate reporters of symptoms than the child or adolescent.

Methods

Meta-analyses were used to summarize data across multiple quantitative studies (Lipsey & Wilson, 2001). This statistical technique provides a more systematic, detailed analysis of a particular intervention across studies than a more traditional qualitative review of the literature (Lipsey & Wilson, 2001). An effect size was calculated for each study, and these were pooled to obtain an overall effect size and confidence interval, which provided the magnitude of change associated with an intervention. The aim of this technique was to estimate the true effect size of the given intervention, rather than the effect size provided from a single study, which limits its generalizability.

Data Sources

Studies were collected by searching the following databases: PsychINFO and PubMed. The search terms attention-deficit/hyperactivity disorder, and mindfulness, or in combination with the abbreviations ADHD, MBSR, MBCT, MBT were used to identify studies. The search was performed from the first available date through December 2014. The author checked the databases systematically on several occasions to avoid accidental omissions. Following the search of the databases, Google Scholar was used to identify

any studies that may not have been identified on the databases. References cited in articles and dissertations on mindfulness-based therapies and ADHD were reviewed to determine if any studies were not identified in the search of the aforementioned databases. References cited in MBT reviews and meta-analyses were also searched to identify studies that fit inclusion criteria that may not have been identified.

Corresponding authors of each paper included in the meta-analysis and persons conducting research in this area were contacted to address issues of publication bias. The following researchers whose papers were included in the current study were contacted to request any unpublished data on mindfulness interventions and ADHD: Dr. Saskia Van der Oord, Dr. Susan Bogels, Dr. John Mitchell, Dr. Poppy Schoenberg, Dr. Lidia Zylowska, Dr. Jill Haydicky, Dr. Eva van de Weijer-Bergsma, and Dr. Andrew Roach. Most of the researchers did not have any unpublished data to provide. Two of the researchers, Dr. Susan Bogels and Dr. Poppy Schoenberg, reported several manuscripts in progress or in press investigating the effectiveness of MBT in large samples of adults and adolescents with ADHD, however neither were comfortable releasing the effect size data of the unpublished work. Several other researchers and institutes that specialize in mindfulness training were contacted for data: Dr. Susan Smalley (UCLA Mindful Awareness Research Center), Dr. Kimberly Schonert-Reichl (University of British Columbia), and The Centre for Mindfulness Studies (University of Toronto). No additional published or unpublished data were collected from these sources due to unavailability or reluctance to release unpublished data.

Inclusion and Exclusion Criteria

Studies examining the pre-post or controlled effects of MBT on individuals – both adults and children – diagnosed with ADHD are considered for the analysis. Studies were excluded if they (1) did not include a mindfulness-based intervention, (2) examined mindfulness as a component of another therapy (i.e. mindfulness was not the central component of the therapy), (3) did not aim to look at treatment effects, (4) examined the non-direct effect of mindfulness (e.g. effects of mindfulness on therapists or parents of children with ADHD), (5) reported no clinical outcomes, (6) reported insufficient information to compute effect size, (7) reported data that overlapped with previous studies, or (8) used protocols that involved other forms of meditation. Studies will be limited to those in the English language. The first author determined eligibility in a non-blinded standardized manner.

Data Extraction

Following the collection of all eligible studies the following information was extracted: (1) participant characteristics (e.g. mean age, gender distribution, diagnosis); (2) control group characteristics, if applicable (e.g. number of control participants, mean age, gender distribution, type of control, type of treatment); (3) treatment characteristics (e.g. type of mindfulness intervention, length of intervention, therapist qualification); (4) the study characteristics (e.g. date of publication, design, number of participants, outcome measure used, follow-up length); (5) and treatment effects on outcome measures of attention, hyperactivity-impulsivity, and executive functions (e.g., means and standard deviations). The treatment effects of MBT on ADHD symptomology were measured by the following outcome measures: attention and hyperactivity-impulsivity. A qualitative

review was also conducted to determine the effects of MBT on executive functioning in individuals with ADHD.

Summary Measures

Each study included in the meta-analyses measured changes in inattention, hyperactivity-impulsivity, and executive functioning using parental-, teacher-, and self-report ratings. Many of the studies used similar measures. A brief review of the measures used and their psychometric properties is reported below.

ADHD Symptoms: Inattention & Hyperactivity-Impulsivity

ADHD Rating Scale-IV. The ADHD Rating Scale-IV (ADHD-RS-IV, DuPaul et al. 1998) is a scale originally designed for children and adolescents, however has been employed in studies with adult samples. The scale is an 18-item informant-based scale that assesses the 18 symptoms from the DSM-IV used to diagnose ADHD. Each item is rated from 0 (*never or rarely*) to 3 (*very often*). The scale has been shown to have good internal consistency and high agreement between raters, with raters scoring individuals with the same total score 65% of the time (Adler et al., 2005).

The Behaviour Assessment System for Children, Second Edition (BASC-2)*. The BASC-2* **(**Reynolds & Kamphaus, 2004) consists of both parent and teacher ratings of behavioural and personality characteristics (e.g., attention problems, hyperactivity, activities of daily living). Chronbach's alpha revealed an internal consistency of .90 for the composite scales. Test-retest reliability correlations are between .80 and .89 for composite scores. The BASC-2 has strong correlations with other ADHD rating scales, such as the ABAS Child Behavior Checklist for Ages 1-5, the Conners' Parent Rating Scale- Revised, the Behavior Rating Inventory of Executive Functioning (BRIEF).

Child Behavior Checklist & Youth Self Report. The Child Behaviour Checklist (CBCL; Achenbach, 2001) is an informant-based rating scale of emotional and behavioural problems, social skills, and academic skills created for the assessment of children. The Youth Self Report (YSR; Achenbach, 2001), which is based off the CBCL, is a self-based rating scale used to assess internalizing and externalizing problems, and behavioural and emotional functioning. Both the CBCL and YSR have been shown to have good reliability and validity.

Conners 3rd Editiion. The Conners 3-P is used to screen for ADHD in both adolescents and children. Both the Conners 3-P, which is the parental-report and the Conners 3-SR, which is the adolescent self-report were used in the included studies. These measures assess ADHD symptoms (i.e. Inattention and Hyperactivity-Impulsivity), learning problems, aggression, oppositionality, and relationship problems. Reliability coefficients range from 0.85 to 0.97, test-retest correlations range from 0.72 to 0.98 for each scale (Conners, 2008).

Current ADHD Symptoms Scale. This measure of ADHD symptoms measures the 18 DSM-IV symptoms of ADHD, as well as 10 domains that could be affected by these symptoms in day-to-day functioning (Barkley & Murphy, 2006). Severity of symptoms is assessed on a four point likert scale from 1 (*not all or rarely*) to 4 (*very often*).

Disruptive Behaviour Disorder Rating Scale (DBDRS). The DBDRS (Pelham et al., 1992) is a 45-item scale that contains four subscales that assess inattention, hyperactivity-impulsivity, ODD, and CD. Each item is assessed on a likert scale ranging from 0 (*not at* all) to 3 (*Very* much). The scale has been shown to have good reliability

and validity (Massetti, Pelham, & Gnagy, 2005; Owens & Hoza, 2003; Pelham et al., 2005). Internal consistency reliabilities range from .94 to .97.

Swanson, Nolan, and Pelham Scale (SNAP-IV; adolescents). The SNAP-IV (Swanson, 1995) is a measure of severity of the 18 DSM-IV criteria of ADHD. It assesses inattention and hyperactivity-impulsivity, as well as symptoms of ODD. Each item is rated on a likert scale from 0 (*no, not at all*) to 3 (*much*). The SNAP-IV has been shown to have good internal consistency (Stevens, Quittner, & Abikoff, 1998). However, parental and teacher agreement has been reported as poor (Swanson et al., 2001).

Executive Functioning.

Behavioural Rating Inventory of Executive Function (BRIEF). The BRIEF (Goia et al., 2000) is an 86-item measure that consists of eight scales that measure different aspects of executive functioning: inhibit, shift, emotional control, initiate, working memory, plan/organize, organization of materials, and monitor. The eight scales provide two index scores: Metacognition and Behavioural Regulation. The scale has good internal consistency for parent and teacher reports (alpha level of .93 to .97) and adequate test-retest reliability (r = .74 to .95). Parent test-retest correlation across the scales was .81 (Goia et al., 2000).

Conners 3rd Editiion. The Conners 3-P is a parental rating scale of ADHD symptoms that includes a scale assessing executive functioning, which was used for one of the included studies for the evaluation of changes in executive functioning. See above for review of psychometric properties.

Analyses

Following the collection of all published and unpublished data that met the inclusion criteria, the data were synthesized to estimate the overall effect size. Effect sizes (Cohen's *d*) were computed using the means, standard deviations, sample size and correlation of the pre- and post-measures for each outcome and informant, for each of the individual studies in order to compare the magnitude of change associated with mindfulness-based interventions. The standardized difference in means was computed using the following formula:

$$d = \frac{Y_{diff}}{S_{within}} = \frac{Y_1 - Y_2}{S_{within}}$$

The standard deviation within groups was computed from the standard deviation of the difference, using the following formulas:

$$S_{\ within} = \frac{S_{diff}}{\sqrt{2(1-r)}}$$

where the standard deviation of the difference scores (S_{diff}) was calculated as:

$$S_{diff} = \sqrt{SD_1^2 + SD_2^2 - 2 \times r \times SD_1 \times SD_2}$$

where r is the the pretest-posttest correlation. In within-group analyses the correlation between pre- and post- measures was taken into account when calculating effect sizes because the two groups were not independent. When the correlations between the pre- and post-treatment measures were not available a conservative estimate, recommended by Rosenthal (1993), was used (r = .7). The standard deviation of the difference scores was used to calculate the standard deviation within because if the sample displays a wide range of symptoms before treatment the calculated effect size would be lower if just the

pretreatment standard deviation is used to calculate effect size. If the pretreatment standard deviation is low and symptoms have low variability than the effect size may be overestimated. Using the standard deviation of difference rather than the standard deviation of pretreatment scores changes the focus from pre-treatment variability to the variability in how much change clients experience over the course of the treatment (Siedel, Miller, & Chow, 2013). The variance was calculated as:

$$V_d = \left(\frac{1}{n} + \frac{d^2}{2n}\right) 2(1 - r)$$

where n is the sample size of the study. The previously mentioned formulas were used to calculate effect size and variance for both attention and hyperactivity-impulsivity, for each informant reported by each study.

Next, the primary analyses were conducted examining the overall effects of MBT on ADHD symptomology separately (i.e. attention and hyperactivity-impulsivity). Effects based on more than one informant (e.g., self and parent) were combined (or averaged) to obtain a single effect size estimate to be used in the full model. A composite effect size was computed for each study that included more than one informant report using the following formula:

$$d_{composite} = \frac{1}{2}(\mathrm{d}_1 + d_2)$$

Thus each study only contributed a single effect size to the primary analysis. The variance for the composite effect size was computed taking into account both the individual informants variance and the correlation between informant reports using the following equation:

$$V_{d\ composite} = \frac{1}{4}(V_{d1} + V_{d2} + 2r\sqrt{V_{d1}}\ \sqrt{V_{d2}})$$

Because the correlation between these outcomes is not often reported within the studies, the conservative value of 1.00 will be used, which may overestimate variance and underestimate precision. After calculating the composite Cohen's *d* and its associated variance for each individual study and each outcome of interest, these effect size estimates were aggregated to obtain an overall (or summary) effect size with its associated 95% CI, Z, and p value.

Because the participants and interventions differed across studies, a random effects model was applied in order to take into account the between study and within study variability when aggregating the effect sizes (Hunter & Schmidt, 2004). In a random effects model it is assumed that variation occurs from two sources: sampling variation that occurs because each study used a different sample of participants and random variation that occurs because the effect sizes contributed from each study are sampled from a population of effect sizes. Whereas, in a fixed-effect model it is assumed that each effect size is the estimate of one true population effect and the effect sizes contributed from each study only differ due to sampling error. In this analysis, a fixed effect model would not be justified because the goal was not to estimate one true effect size; rather the goal was to estimate the mean distribution of effect sizes across studies with various participant and intervention characteristics (Borenstein et al., 2010). Further, in a fixed effect model large studies are given a much higher relative weight in the analysis because it is assumed that these studies provide more information about the true effect size because all studies are presumed to be the same. In a random effects model the relative weight assigned to each study is in a more narrow range because the relative weight of each study is less affected by sample size. Thus, using a random effects model

allows the meta-analyst to make generalizations that extend beyond the samples used in the specific analysis (Hunter & Schmidt, 2004).

After aggregating the effect sizes, a test of homogeneity was conducted to determine if the overall effect size is a result of the intervention or if other possible factors have influenced the relationship. Heterogeneity was assessed using the I^2 and chi-squared statistic (Q). The Q test informs the researcher whether heterogeneity is present. The I^2 describes the percentage of variation across studies that is due to real differences between the studies (e.g., methodology) and is not affected by low statistical power (Higgins and Thompson, 2002; Higgins et al., 2003). If significant heterogeneity is found, the relationship between the variables may be influenced by moderating variables. Higgens et al. (2003) suggests an I^2 of 25%, 50%, and 75% would indicate low, moderate, and high homogeneity, respectively, and the Q test produces a p value to indicate the presence of significant heterogeneity. All statistical analyses were conducted using Comprehensive Meta-analysis Software (CMA).

Subgroup analysis

Many of the studies reported both self and other informant ratings for ADHD symptoms; other ratings refer to ratings obtained from the participant's parents or teacher. Thus, in addition to calculating the effect size of the composite scores across informant ratings, a subgroup analysis was conducted for self- versus other-ratings to determine if effect sizes differ across informant type and if type of informant contributed to any heterogeneity found within the analysis.

Another variable that may have contributed to heterogeneity between the studies was age because individual studies included both child and adult populations. However, a

subgroup analysis was not conducted for child versus adult populations to determine if effect sizes differ across age group, or to determine if age of participants contributes to any heterogeneity found within the analysis because only one study included in the analysis (Mitchell et al., 2013) measured the effects of MBT in an adult sample. The subgroup analysis was also conducted using CMA.

Publication bias

One limitation of conducting meta-analyses was the risk of publication bias, which is the misleading bias of published data due to the fact that studies with significant, positive results are more likely to be published. This can be problematic for systematic reviews and meta-analyses because the reviews will be inherently biased if the studies used are unrepresentative of all the existing literature. In order to address the possibility of publication bias, individuals conducting research in this field were contacted in order to collect any unpublished datasets that may be available. Following these efforts, publication bias was assessed by statistical analyses. As recommended by Sterne, Egger, & Smith (2001), funnel plots were created to statistically test for publication bias. The funnel plot included the measure of treatment effect on the horizontal axis and the standard error on the vertical axis, which allowed the researcher to determine the region in which the points should fall if publication bias is not present. An asymmetric funnel indicates potential publication bias because it would show most studies falling into one side of the funnel with either positive or negative EF. Given that the previous method can perform poorly with small and heterogeneous samples, 'fail-safe-N' was also be calculated. This statistic estimates the number of studies with null results required to reduce the effect size to non-significance.

Further, to address concerns of publication bias, the 'trim and fill' method was used to correct asymmetry caused by publication bias in the funnel plots (Taylor, 1998, Duval, 2000). This method removes small studies that are causing asymmetry in the plot and creates a new funnel plot using an iterative process to replace omitted studies around the center of the funnel plot to estimate the true center of the plot. This technique provides an estimate of the number of missing studies and an adjusted effect size based on the imputed values.

III. RESULTS

The literature search of PsycINFO produced 45 studies and the search of PubMed produced 18 studies, including 8 dissertations and 8 books. Upon immediate evaluation 29 publications were eliminated (8 books, 4 reviews, 5 qualitative studies, 1 collection of abstracts, and 11 duplicate studies). After reviewing the abstracts of the 34 remaining studies, 24 studies were eliminated (4 reviews, 1 qualitative article, 5 journals with no MBT, 5 studies with no ADHD group, 5 studies with neither an ADHD group or a MBT, 1 study that did not measure core symptoms of ADHD, 1 study examining trait mindfulness, 1 study examining indirect effects of MBT, and 1 sample that overlapped with another study). This process resulted in 10 studies that met the inclusion criteria. From these 10 studies that met inclusion criteria, two were excluded from the analysis. One study (Sheckler, 2013) was excluded from the analysis because sufficient information was not provided in the paper to calculate effect sizes and the researchers did not respond to email requests for the information necessary to calculate effect sizes. A second study (Schoenberg, 2014) was excluded because it was the only study that examined the controlled effects of MBT on ADHD symptoms and therefore could not be included in the meta-analysis of pre- and post- intervention designs or in a separate meta-analysis of controlled effects.

ADHD Symptoms: Inattention and Hyperactivity-impulsivity

Eight studies measured the effects of MBT on inattention and combined ratings across 74 self-reports and 93 observer-reports of inattention for a total of 167 ratings. The overall effect size was calculated at d= -.72 (95% CI [-1.066, -0.373], Z = -4.066, p < .001) (see Figure 1). The test of homogeneity of effect size was significant (Q = 26.81, df

= 7, p <.001). The I^2 statistics indicated high heterogeneity (73.89%), suggesting high between study variability.

Seven studies measured the effects of MBT on hyperactivity-impulsivity and combined ratings across 64 self-reports and 83 observer-reports of hyperactivity-impulsivity for a total of 147 ratings. The effect size of MBT on hyperactivity-impulsivity in individuals diagnosed with ADHD at the end of the intervention was calculated at *d*= -.59 (95% CI [-.871, -.311], Z = 4.14, p<.001) (see Figure 2.). The test of homogeneity was significant (Q = 13.45, p<.001) indicating the presence of heterogeneity. The I^2 statistic indicates heterogeneity and was in the moderate range (55.46%).

Subgroup analysis

A subgroup analysis was conducted for self - versus observer-ratings for inattention (see Figure 3). Seven studies (Carboni, 2012; Haydicky et al., 2013; Mitchell et al., 2013; Ryznack, 2011;Van de Weijer-Bergsma et al. 2012; van de Oord et al., 2012; Worth, 2013;) reported other observer ratings and five studies reported self-ratings (Haydicky et al., 2013; Mitchell et al., 2013; Ryznack, 2011; van de Weijer-Bergsma et al., 2012; Zylowska et al., 2008). Effect sizes were calculated for each type of report separately. The effect size for self-report (*d* = -0.71, 95% CI [-1.190, -0.233], *z*= -2.917 *p* < .01) and other informant report (*d* = -1.00, 95% CI [-1.433, -0.567], *z*= -4.530, *p* < .001) subgroups were both significantly different from 0. However, given that the effect sizes were similar no moderation was observed. Both the self-report (I^2= 81.04) and other informant report continued to demonstrate significant heterogeneity (I^2=73.08). The test

of homogeneity was significant for both self (Q = 21.096, $p< .001$) and other-ratings (Q = 22.284, $p <.01$) indicating the presence of heterogeneity.

A subgroup analysis was calculated for self- versus observer-ratings for hyperactivity-impulsivity (see Figure 4). Six studies (Carboni, 2012; Haydicky et al., 2013; Mitchell et al., 2013; Ryznack, 2011; van de Oord et al., 2012; Worth, 2013) reported other observer ratings (i.e. parental and teacher) and four studies reported self-ratings (Haydicky et al., 2013; Mitchell et al., 2013; Ryznack, 2011; Zylowska et al., 2008;). Effect sizes were calculated for each type of report separately. The effect size for both self-report (d = -0.68, 95% CI [-1.121 to -0.244], Z=-3.050, p<.005) and other informant report (d = -0.634, 95% CI [-1.010 to -0.258], Z=-3.307, p<.005) were significant. However, given that the effect sizes were similar no moderation was observed. The test of homogeneity was not significant for other-informant (Q = 8.584 p = .127), demonstrating only moderate heterogeneity (I^2= 41.751). The test of homogeneity was significant for self-ratings (Q = 17.813, $p <.01$) indicating the presence of heterogeneity. The self-report (I^2= 83.158) overall effect size estimate continued to show significantly high heterogeneity. This could indicate that self-report accounts for more of the between study variance.

A subgroup analysis was not conducted for adults versus children for either outcome of inattention or hyperactivity-impulsivity due to limited data. Only one pre/post design study reported findings in a homogenous adult sample; one study reported findings from both adult and children together and the remaining studies investigated the effects of MBT on children with ADHD. Thus, the question of whether the efficacy of

MBT differs in children and adults with ADHD remains unaddressed in the present analysis.

Publication bias and sensitivity analysis

The funnel plots, which graphically represent publication bias, did not indicate any substantial concerns, however they are difficult to interpret with a small number of studies. One study (Mitchell, 2013) within each of the primary analyses was located outside of the funnel, with a large negative effect size. The trim and fill technique for inattention results in a mean effect size of -.46 (95% CI -0.832 to -0.093) with three studies missing. For hyperactivity-impulsivity the trim and fill technique results in a mean effect size -0.45 (95% CI -0.769 to -0.122) with two studies missing. Although both effect sizes were reduced, they both remained within the moderate range.

For the studies investigating inattention and hyperactivity-impulsivity a fail-safe N of 110 and 65 studies, respectively, was indicated. This indicates the number of studies with non-significant effect size that would be needed to render the current overall estimates non-significant. Thus, it is not likely that unpublished data would nullify the results of the current meta-analysis.

Due to one study of concern displayed on the funnel plot, the researcher conducted a sensitivity analysis to determine how the effect size of the overall model of attention and hyperactivity-impulsivity would be affected by the removal of that single study. To accomplish this the analysis was run multiple times after the removal of each single study from the analysis and this produced only marginal differences in effect size. However the removal of the study located outside of the funnel (Mitchell et al., 2013) did produce some differences for the overall effect size estimate of inattention (d = -0.53,

95% CI [-0.763, -0.302], z= -4.53 p < .001) and hyperactivity-impulsivity (d = -0.45, 95% CI [-0.626, -0.264], z= -4.83 p < .001). Although the overall effect size decreased for both outcomes, both remained within the medium size range and significance levels were not affected (Cohen, 1992). Of noteworthy change, the heterogeneity for the primary analysis of inattention was no longer significant (Q = 10.219, df = 6, p > 0.05) and the I^2 statistic was reduced from 73.89% to 41.29%. Thus, after removal of this single study, the between study variance reduced considerably. Similarly, the heterogeneity for the primary analysis of hyperactivity-impulsivity was no longer significant (Q = 3.28, df = 5, p > 0.05) and the I^2 statistic was reduced to from 62.84% to 0%. Thus, in the remainder of the studies included in the meta-analysis there was no observed heterogeneity caused by between study variance. It is important to note that this was the only study in the meta-analysis that consisted of an adult sample. Thus, as per the original hypothesis, it is possible that the effect size for adults with ADHD who receive MBT is much higher, however as aforementioned, the current limited data does not allow for further investigation. The implications of these findings will be discussed below.

Executive Functioning

Four of the studies that met inclusion criteria for the current study reported the effects of MBT on executive functioning; however, a meta-analysis was not conduced because each study measured executive functioning with a combination of different subscales and scales from the BRIEF. Researchers were contacted to obtain the total BRIEF scores for each study, but this was unsuccessful, for this reason a qualitative review was conducted. The aim of this qualitative review is to evaluate the evidence of

the efficacy of mindfulness-based therapies in improving executive functioning in individuals with ADHD.

Haydicky et al., (2013) conducted a non-controlled quasi-experimental design, in which 18 adolescents (13 males, $M = 15.5$; $SD = 1.58$) diagnosed with ADHD and 17 of their parents participated in an 8-week mindfulness therapy, MYmind. MYmind is a program adapted from MBCT for use with children and adolescents with ADHD. The intervention was lead by two doctoral level child clinical psychology graduate students who trained in a 12-week mindfulness course for mental health professionals and reported their own mindfulness meditation practice. The executive functioning subscale on the Conners-3 Parental report were used to measure executive functioning. Parental reports of executive functioning were completed by the mothers of the children, with the exception of one father report. Participants were assessed at four-time points: baseline, pre-intervention, post-intervention, and 6-week follow-up. Results of a one-way repeated measures ANOVA demonstrated a significant time effect in executive functioning, however post-hoc pairwise comparisons between pre- and post-intervention scores on executive functioning were non-significant ($p = .527$, $d = 0.36$).

The study was limited by small sample size and a non-randomized uncontrolled design. Further, research has suggested that parental involvement in treatment can increase reported improvements,, thus the involvement of parents in the intervention could affect results (Chronis et al., 2006). The researchers noted that 78% of the adolescents had a comorbid disorder and 61% of the adolescents were taking medication for their ADHD.

Van de Weijer-Bergsma et al., (2012) conducted an uncontrolled trial involving 10 adolescents aged 11-15 (M = 13.4) diagnosed with ADHD, 19 parents, and 7 tutors, investigating the efficacy of an 8-week mindfulness-training program on reducing behavioural and attentional problems. The intervention was lead by a cognitive-behavioural therapist who also had unspecified mindfulness training. Executive functioning was assessed with the Behavior Rating Inventory of Executive Function (BRIEF; Gioia et al., 2000). The researchers reported the metacognition and behavioural regulation scales of the BRIEF separately. Results showed that behavioral regulation did not improve significantly according to parents or tutors, however at 8-week follow-up fathers reported significant reductions in behavioural regulation. No significant changes in metacognition were reported post-intervention by parents or tutors. However, similarly to behavioural regulation, at 8-week follow-up fathers reported a significant reduction in meta-cognitive problems.

This study was also limited by a small sample size and non-randomized design. It is important to note that only one adolescent participant was receiving stimulant treatment during the course of this intervention. Parents of this study also received a Mindful Parenting intervention, and as aforementioned the involvement of parents in the intervention could affect results (Chronis et al., 2006). The fathers reported a reduction in parenting stress following the Mindful Parenting intervention, and this could have affected their reports of improved executive functioning at 8 week follow-up, because research has shown that parental stress can affect parent ratings of disruptive behaviours (Langberg et al., 2010).

Mitchell et al. (2013) conducted an 8-week randomized within-in wait-list control study investigating the efficacy of mindfulness treatment for improving symptoms of ADHD, executive functioning, and emotional functioning in a homogenous adult sample, aged 18-50. Eleven participants were in the treatment group and nine participants were in the waitlist control group. The intervention conducted was Mindful Awareness Practices (MAPs), a mindfulness program developed by Zylowska et al., (2008) for individuals with ADHD. The intervention was administered by a PhD-level clinical psychologist. Executive functioning was assessed with the BRIEF-Adult version (Roth, Isquith, & Gioia, 2005) and the Deficits in Executive Functioning Scale (DEFS; Barkley, 2011) self and clinician report. Further, participants completed a short battery of laboratory tasks to measure components of executive functioning. Results demonstrated that scores on the self-reported BRIEF-A ($p = .003$, $d = 1.55$), self-reported DEFS ($p = .005$, $d = 1.45$), and the clinician-rated DEFS ($p < .001$, $d = 2.67$) were statistically significant with large effect sizes. The researchers conclude that this may indicate that executive functioning in the treatment group improved relative to the waitlist control group. However, there was no significant difference between the treatment and control group of performance on laboratory tasks measuring executive functioning.

This study was limited by small sample size, however the use of the waitlist control group was an advantage. The study was strengthened by the addition of the laboratory tasks to measure executive functioning, however the researchers speculate that the discrepancy between findings on self-report improvements and laboratory tasks is that the neuropsychological tasks may not capture the executive functioning difficulties that these individuals are having in their day-to-day life.

Carboni (2012) conducted a multiple baseline across participant's design to determine the effects of mindfulness on executive functioning. Four eight-year old males who had been diagnosed with ADHD participated in the study. The intervention was one-on-one mindfulness training for 30-45 minutes, twice per week. An interventionist with mindfulness training provided the intervention. The researcher used the parent and teacher reports of the BRIEF (Gioia et al., 2000) to assess executive functioning in the children. The Reliable Change Index (RCI) was calculated to for the Inhibit, Initiate, and Monitor scale of the BRIEF to determine if the pre- to posttest change were greater than what would be expected just from measurement error. Parent ratings on the inhitbit scale of the BRIEF were significantly improved across all participants. Parent ratings on the initiate and monitor scales were also significantly improved for participants 3 and 4. On teacher ratings of the BRIEF scales, participant 1 demonstrated no significant changes, whereas participant 2 had statistically significant improvements on all three scales. Teacher reports on the monitor scale of the BRIEF indicated that Participant 3 and 4 had clinically significant decreases, further participant 4 had clinically significant improvements on the inhibit scale of the BRIEF. Thus, results were variable, however changes noted in pre- and posttest ratings suggests that mindfulness based interventions may be effective in improving some aspects of executive functioning in children.

Executive functions are described as a set of processes involved in maintaining information in working memory; initiating, planning, organizing, executing and monitoring activities and behaviors; and regulating behaviour and emotional responses to situations. Given the impact that deficits in executive functioning have on normal functioning it has been suggested that executive functioning deficits in individuals with

ADHD are related to functional impairment in these individuals (Barkley, 1997). Barkley (1997) describes the difficulties individuals with ADHD experience in sustaining attention are related to deficits in the executive functions that assist in self-regulation. This difficulty in self-regulation can manifest as being easily distracted and having problems with organizing tasks. Further, deficits in executive functioning can also manifest as difficulties controlling impulses. These individuals may rush through tasks, or speak and act without thinking. Thus, an intervention that targets these executive functions may help individuals with ADHD improve daily functioning and quality of life.

IV. DISCUSSION

The purpose of the current study was to investigate the effects of mindfulness therapies on ADHD symptoms (inattention and hyperactivity-impulsivity) using meta-analysis. Results from the first meta-analysis, which included eight studies, demonstrated that MBT significantly reduced inattention in individuals diagnosed with ADHD. The subgroup analysis investigating differences between self- and observer-ratings demonstrated that MBT reduced inattention in individuals diagnosed with ADHD irrespective of reporter. The second meta-analysis included seven studies and demonstrated that MBT significantly reduced symptoms of hyperactivity-impulsivity in individuals diagnosed with ADHD. Similarly, the subgroup analysis investigating differences between self- and observer- ratings found that MBT reduced symptoms of hyperactivity-impulsivity in individuals diagnosed with ADHD, irrespective of reporter. Thus, it appears that MBT is effective in reducing the core symptoms of ADHD.

However, results must be interpreted with caution given the significant heterogeneity across the studies included. Potential causes of heterogeneity were first investigated via the aforementioned subgroup analyses. These subgroup analyses were conducted to determine if the type of informant would make a significant contribution to the studies heterogeneity. The first subgroup analysis revealed that the heterogeneity for inattention was not affected by informant type. The second subgroup analysis for informant type revealed that heterogeneity for hyperactivity-impulsivity was still significant for self-informant reports and the I^2 statistic indicated high heterogeneity (83.16%). Although, heteroegenity was not longer significant for other-informant reports the I^2 statistic indicated only moderate heterogeneity (41.75%), suggesting self-reported

hyperactivity-impulsivity contributed more heterogeneity to the primary analysis. Research has shown that parent-reports of impairment across several domains were more predictive than self-reports of actual impairment (Barkley, Fischer, Smallish, & Fletcher, 2002), thus, perhaps other individuals are more accurate reporters of ADHD symptoms and therefore less heterogeneity is contributed by these other-informant reports.

The second potential source of heterogeneity that was hypothesized at the outset of the study was age of participants. It was predicted that adults would have a greater reduction in ADHD symptoms following MBT. However, only one study investigated the effectiveness of MBT for reducing ADHD symptoms in homogenous adult sample, thus a subgroup analysis was not possible. The sensitivity analysis that was conducted by removing each study from the analysis one at a time to determine if the overall effect size was significantly affected by any one study revealed that one study in particular (Mitchell et al., 2013) had a significant impact on overall heterogeneity in both of the primary analyses; this was the only study included in the analyses with an all-adult sample. Following removal of this study, heterogeneity was reduced for both inattention, from an I^2 value of 77.18% to 46.77%, and hyperactivity-impulsivity, from 62.84% to 0%. Thus, removal of this study reduced heterogeneity of the primary analysis of inattention from high to moderate levels, and reduced heterogeneity to non-significance in the primary analysis investigating hyperactivity-impulsivity, which could indicate a difference in the effectiveness of MBT in treating ADHD symptoms in adults and children.

The effect size for reduction in inattention and hyperactivity-impulsivity in this study of adults was considerably larger than the other studies. A possible explanation for the larger effect of MBT in adults with ADHD could be influenced by how the symptoms

of ADHD change over developmental periods. Specifically, as individuals with ADHD get older, symptoms of inattention become more prominent and hyperactivity-impulsivity tends to decrease, and there is much more literature to support increased attentional capacity following mindfulness training in healthy participants (Lutz et al., 3009; Tang et al., 2007) than decreased hyperactivity-impulsivity. Further, adults who are more inattentive may find environmental supports and modifications for those problems more readily than children and benefit more from mindfulness training than children. The findings that the effect size of MBT in reducing ADHD symptoms was larger in the study with adult participants and was causing a large amount of the heterogeneity provide preliminary support for the hypothesis that MBT may be more effective in reducing symptoms of ADHD in adults. Another possible explanation for the larger effect size in adults could be a result of adults having more insight into their symptoms and reduction in symptoms following treatment. As aforementioned, parental-reports of child ADHD symptoms and impairment is more predictive of actual impairment than the child's self-reported symptoms and impairment, and research shows that adult self-reported symptoms of ADHD were found to correlate significantly with observer reports (Murphy & Schachar, 2000). Thus, adults may have more insight into their symptoms and as a result report more reductions in symptoms following treatment. Given the limited data on adults in the current literature, a subgroup analysis could not be conducted and the hypothesis could not be tested. Although, the researcher attempted to account for heterogeneity with a sensitivity analysis, it is difficulty to determine whether age of participants was the exact source of heterogeneity produced by the study. Further

investigation into the effectiveness of MBT in adult versus childhood ADHD is warranted.

The aforementioned findings of the efficacy of mindfulness based interventions in improving executive functioning in individuals diagnosed with ADHD is mixed. The studies were limited by small sample sizes and nonrandomized, uncontrolled designs. Further investigation into the effectiveness of this intervention in improving executive functioning is warranted. Future research would be improved by conducting controlled studies and including laboratory tasks of executive functioning, as well as self- and observer-reports.

Surprisingly few studies measured pre- and post-intervention levels of mindfulness (van der Weijer-Bergsma et al., 2012 & Worth, 2013), thus a meta-analysis of effect size was not conducted. Given that only two studies reported mindfulness pre- and post-intervention the researcher cannot determine whether there were increases in mindfulness, whether increases in mindfulness moderated the effects of MBT in reducing ADHD symptoms, and thus whether the effectiveness of the therapy is a result of the mindfulness component. However, preliminary research has shown support for the mindfulness component of MBT as a mechanism of change (Khoury et al., 2013). In future investigations of ADHD and MBT it will be important for researchers to assess pre- and post-intervention levels of mindfulness to further explore the relationship between mindfulness and observed decreases in ADHD symptoms.

One study also measured the impact of parental mindfulness training on pre- and post-intervention levels of mindfulness of parents who have children with ADHD who were receiving MBT to treat the child's ADHD. It is possible that if parental mindfulness

training is successful in increasing levels of mindfulness this could affect parental reports of the child's ADHD symptoms. Effect sizes for parental report on inattention and hyperactivity-impulsivity in this study were not largely different from the overall effect size reported by other studies in which the parents did not receive the mindful parent training, suggesting in this particular study that parental mindfulness training did not largely influence observer ratings of children with ADHD. However, it would be important to investigate possible influences of parental mindfulness training on ADHD symptom reports.

The present study is, of course, not without limitations. First, there is a risk of publication bias when conducting meta-analysis, which is a misleading bias of published data due to the fact that studies with significant, positive results are more likely to be published. Although the tests used to detect publication bias did not show evidence of significant publication bias, they tend to perform poorly in small samples. However given a high 'fail-safe N' it is not likely the effect size would be effected by a small number of unpublished non-significant studies and although the effect size was reduced by the trim and fill techniques, intervention effects were still moderate in size. Another limitation of the present study was that the researchers were unable to examine the controlled effects of MBT on ADHD symptoms given the limited number of studies with this methodological rigor that met inclusion criteria. Lastly, the sample size was small, reducing the power of the meta-analysis. However, a meta-analysis can be conducted on as few as two studies (Valentine, Pigott, & Rothsein, 2010). Further, several goals can be accomplished with meta-analyses; a meta-analysis can be used to determine the magnitude of an effect, investigate whether current literature is homogenous, and lastly,

if there is heterogeneity what variables can account for this variation and moderate the effects (Huedo-Medina, Sánchez-Meca, Marín-Martínez, & Botella, 2006). Thus, despite the small sample size the analysis suggested preliminary findings in support of MBT as a treatment for reducing ADHD symptoms and can be used to guide future research in this area.

The present study provides preliminary evidence for the efficacy of MBT in ADHD by providing a quantitative review of the current research. The present study can help to guide future research, by bringing attention to the need for more methodologically rigorous experimental studies to provide more evidence for the use of MBT in individuals with ADHD. Further research would allow for investigation into the variables and characteristics that moderate the effectiveness of MBT in reducing symptoms of ADHD and to address whether this treatment is more effective for individuals with ADHD at different developmental stages or with different subtypes of ADHD.

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Table 1
Characteristics of Studies Included in Analysis

Author	Carboni, 2012	Haydicky et al., 2013	Mitchell et al., 2013	Rynczak, 2011	van de Weijer-Bergsma et al., 2012	van der Oord et al., 2012	Worth, 2013	Zylowska et al., 2008*
Research Design	Multiple baseline across participant's pre-post test design	Pre- and post-test research design	Wait-list pre-post-follow-up design	Pre- and post-test research design	Pre- and post-test research design	Wait-list pre-post-follow-up design	Pre- and post-test research design	Pre- and post-test research design
Age of Participants	8 y/o	13-18 y/o (M = 15.5)	18-50 y/o (M = 40.55, SD = 6.83)	12-15 y/o (M =13)	11-15 y/o (M = 13.4)	8-12 y/o (M = 9.67)	11-15 y/o	Adolescents (M =15.6, SD = 1.1), Adults (M = 48.5, SD =10.9)
N	4	18 adolescents, 17 parents	11	12	10	18	17	25
% Males	100%	72%	45.5%	67%	50%	72%	71%	38%

Table 1 (*continued*)

Author	Carboni, 2012	Haydicky et al., 2013	Mitchell et al., 2013	Rynczak, 2011	van de Weijer-Bergsma et al., 2012	van der Oord et al., 2012	Worth, 2013	Zylowska et al., 2008*
Dx	Previous diagnosis of ADHD (DSM-IV)	Previous diagnosis by qualified health professional and current ADHD status as confirmed by the DSM –IV & ADHD subscales of the Conners-3P	Childhood ADHD symptom Scale- Self Report, CAARS-Self-Report, Conners Adult Diagnostic Interview for DSM-IV to assess diagnostic criteria by clinical Psychologist	Diagnosis on intake at clinic where the study was being conducted	Previous diagnosis of ADHD (DSM-IV)	DSM IV diagnosis established with parent and child version of the ADIS-C by trained clinical psychologist	71% of participants had previous diagnosis by physician, 23% had previous diagnosis by psychologist, 6% have diagnosis from unknown source	Previous diagnosis of ADHD (DSM-IV)
ADHD Subtype	n.r.	C: 67%, IN: 28%, HI: 6%	C: 27.3%, IN: 72.7%	n.r.	C: 50% IN: 40% HI: 1%	C: 56%, IN: 33%, HI: 11%	C: 47%, IN: 6%, HI: 18%, Unknown: 29%	Adolescents: C: 62%, IN: 38%, HI: 0% Adults: C: 50%, IN:62%, HI: 8%

Table 1 (*continued*)

Author	Carboni, 2012	Haydicky et al., 2013	Mitchell et al., 2013	Rynczak, 2011	van de Weijer-Bergsma et al., 2012	van der Oord et al., 2012	Worth, 2013	Zylowska et al., 2008*
Medication Status	100%	61%	54.5%	n.r.	10%	33%	71%	Adolescents: 67%, Adults: 63%
Comorbid Disorders	n.r.	78% (67% previous learning disability, 22% depressive disorder, 6% anxiety disorder	54.5%	n.r.	n.r.	17% comorbid ODD	n.r.	Adolescent: 75%, Adults: 92%
Intervention	One on one mindfulness training adapted from an MBSR course for children	MYmind, based on MBCT	MAPs for ADHD	Mindfulness techniques adapted from DBT	Mindfulness program developed for children with ADHD and their parents (van de Oord et al., 2012) and parallel mindful parent training	Mindfulness treatment based on MBCT and MBSR and parallel mindful parenting	MAPs for ADHD	MAPs for ADHD

Table 1 (*continued*)

Author	Carboni, 2012	Haydicky et al., 2013	Mitchell et al., 2013	Rynczak, 2011	van de Weijer-Bergsma et al., 2012	van der Oord et al., 2012	Worth, 2013	Zylowska et al., 2008*
Intervention Characteristics	30-45 min, twice per week, for 8 sessions	1 1.5 h sessions per week, for 8-weeks, adolescents and their parents participated in parallel training	8-week, 2.5 hour sessions per week, for 8 weeks and at-home practice	50 min once per week for 4 weeks	1.5 h sessions weekly, for 8-weeks, homework. Mindful parenting consisted of CD and at home practice	90-mins per week, for 8-week	0.5 h daily for 8-weeks	2.5 hr once per week, for 8-week, daily at home practice
Therapist Characteristics	Interventionist with training in mindfulness, extensive experience working with children	Clinical Psychology Doctoral students, attended 12 week mindfulness course, practice mindfulness meditation regularly	PhD level clinical psychologist	Researcher familiar with protocol	Experienced cognitive-behaviour therapists who were experienced mindfulness practitioners and attended mindfulness training	Cognitive behaviour therapists, extensive mindfulness experience, mindfulness training by experts in the field	School counselor who received training on protocol	Experienced mindfulness instructor and ADHD researchers

Table 1 (*continued*)

Author	Carboni, 2012	Haydicky et al., 2013	Mitchell et al., 2013	Rynczak, 2011	van de Weijer-Bergsma et al., 2012	van der Oord et al., 2012	Worth, 2013	Zylowska et al., 2008*
Informants	Parent and Teacher	Parental and Self	Self	Parental and Self	Parental and Self	Parental	Teacher	Self
Measurement of ADHD Symptoms	BASC-2	Conners-3P, Conners 3-SR	Current ADHD Symptoms Scale	Conners Hyperactivity-Impulsivity Scale, YSL/CBCL	YSR/CBCL	DBDRS	Conners-3T	ADHD Rating Scale IV and SNAP-IV

Note. *Zyloska et al., 2008 participant characteristic from initial sample, not reported for final N in statistical analysis; IN = inattentive subtype, HI = Hyperactive-Impulsive Subtype, C= Combined Subtype; n.r. = not reported.

Figure 1. Primary Analysis of Inattention

Study name	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Carboni, 2012	-0.810	0.455	0.207	-1.702	0.082	-1.780	0.075
Haydicky et al., 2013	-0.470	0.200	0.040	-0.862	-0.078	-2.350	0.019
Mitchell et al., 2013	-2.420	0.465	0.216	-3.331	-1.509	-5.207	0.000
Rynczak, 2011	-0.900	0.272	0.074	-1.433	-0.367	-3.309	0.001
van de Weijer-Bergsma et al., 2012	-0.360	0.167	0.028	-0.688	-0.032	-2.151	0.031
van der Oord et al., 2012	-0.800	0.346	0.120	-1.479	-0.121	-2.309	0.021
Worth, 2013	-0.790	0.215	0.046	-1.210	-0.370	-3.683	0.000
Zylowska et al, 2008	-0.096	0.195	0.038	-0.478	0.286	-0.493	0.622
	-0.719	0.177	0.031	-1.066	-0.373	-4.066	0.000

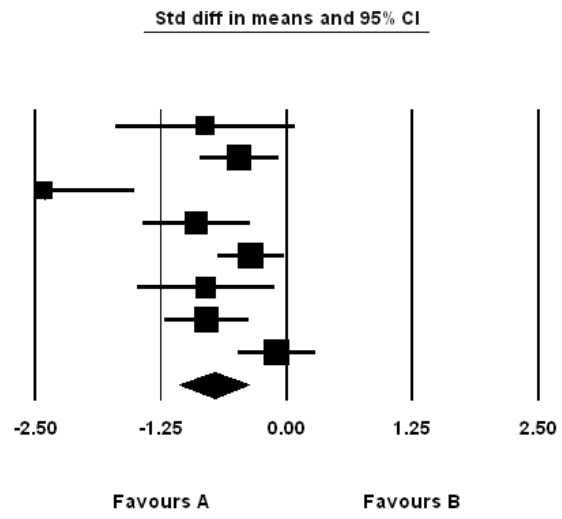


Figure 2. Primary Analysis of Hyperactivity-Impulsivity

Study name	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Carboni, 2012	-0.760	0.441	0.194	-1.623	0.103	-1.726	0.084
Haydicky et al., 2013	-0.270	0.190	0.036	-0.642	0.102	-1.423	0.155
Mitchell et al., 2013	-1.620	0.356	0.127	-2.319	-0.922	-4.546	0.000
Rynczak, 2011	-0.690	0.249	0.062	-1.178	-0.202	-2.771	0.006
Worth, 2013	-0.290	0.192	0.037	-0.667	0.087	-1.508	0.132
van de Oord et al., 2012	-0.560	0.346	0.120	-1.239	0.119	-1.617	0.106
Zylowska et al., 2008	-0.520	0.173	0.030	-0.860	-0.181	-3.002	0.003
	-0.591	0.143	0.020	-0.871	-0.311	-4.140	0.000

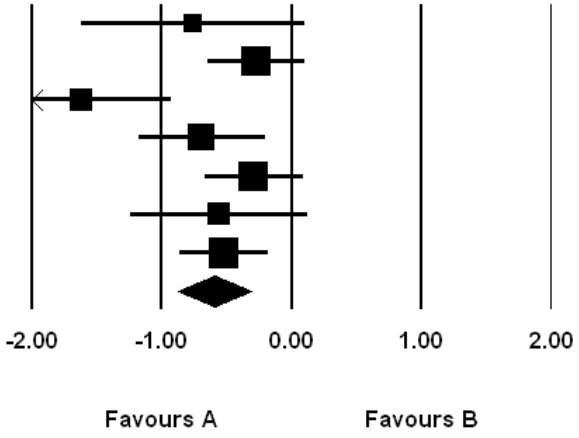


Figure 3. Inattention by Informant Report

Group by Subgroup within study	Study name	Informant	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Other	Carboni, 2013	Other	-0.810	0.455	0.207	-1.702	0.082	-1.780	0.075
Other	Haydicky et al., 2013	Other	-0.780	0.215	0.046	-1.200	-0.359	-3.634	0.000
Other	Mitchell et al., 2013	Other	-2.944	0.539	0.291	-4.001	-1.887	-5.458	0.000
Other	Ryznack, 2011	Other	-1.360	0.310	0.096	-1.968	-0.752	-4.384	0.000
Other	van de Weijer-Bergsma et al., 2012	Other	-0.320	0.255	0.065	-0.820	0.180	-1.255	0.209
Other	van der Oord et al., 2012	Other	-0.800	0.346	0.120	-1.479	-0.121	-2.309	0.021
Other	Worth, 2013	Other	-0.794	0.216	0.046	-1.216	-0.372	-3.685	0.000
Other			-1.000	0.221	0.049	-1.433	-0.567	-4.530	0.000
Self	Haydicky et al., 2013	Self	-0.157	0.184	0.034	-0.517	0.204	-0.852	0.394
Self	Mitchell et al., 2013	Self	-1.889	0.390	0.152	-2.653	-1.125	-4.847	0.000
Self	Ryznack, 2011	Self	-0.427	0.234	0.055	-0.885	0.031	-1.829	0.068
Self	van de Weijer-Bergsma et al., 2012	Self	-0.440	0.257	0.066	-0.944	0.064	-1.713	0.087
Self	Zylowska et al., 2008	Self	-0.960	0.195	0.038	-1.342	-0.577	-4.917	0.000
Self			-0.712	0.244	0.060	-1.190	-0.233	-2.917	0.004

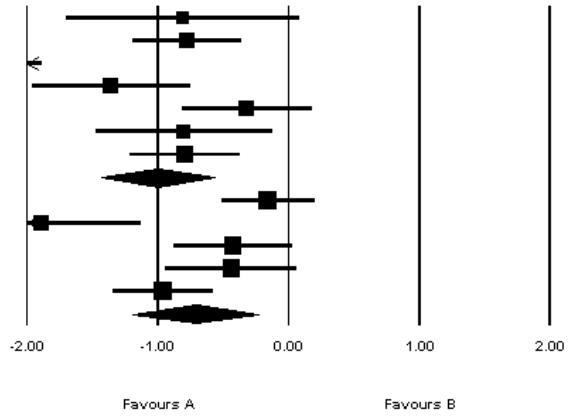


Figure 4. Hyperactivity by Informant Report

Group by Subgroup within study	Study name	Informant	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Other	Carboni, 2012	Other	-0.760	0.441	0.194	-1.623	0.103	-1.726	0.084
Other	Haydicky et al., 2013	Other	-0.420	0.195	0.038	-0.802	-0.038	-2.155	0.031
Other	Mitchell et al., 2013	Other	-1.320	0.319	0.102	-1.946	-0.694	-4.133	0.000
Other	Rynczak, 2011	Other	-0.680	0.249	0.062	-1.168	-0.192	-2.731	0.006
Other	van de Oord et al., 2012	Other	-0.560	0.346	0.120	-1.239	0.119	-1.617	0.106
Other	Worth, 2013	Other	-0.290	0.192	0.037	-0.667	0.087	-1.508	0.132
Other			-0.634	0.192	0.037	-1.010	-0.258	-3.307	0.001
Self	Haydicky et al., 2013	Self	-0.116	0.184	0.034	-0.477	0.245	-0.629	0.529
Self	Mitchell et al., 2013	Self	-1.910	0.392	0.154	-2.679	-1.141	-4.867	0.000
Self	Rynczak, 2011	Self	-0.690	0.249	0.062	-1.178	-0.202	-2.771	0.006
Self	Zylowska et al., 2008	Self	-0.520	0.173	0.030	-0.860	-0.181	-3.002	0.003
Self			-0.683	0.224	0.050	-1.121	-0.244	-3.050	0.002

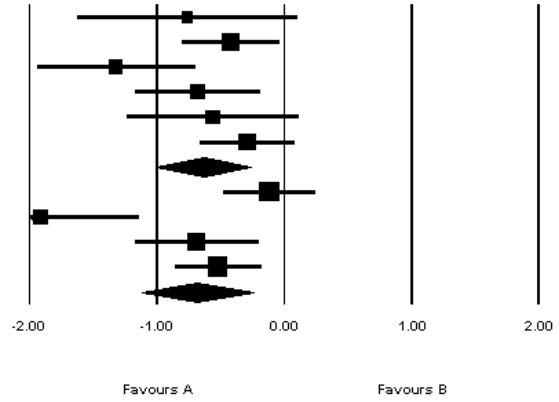


Figure 5. Publication Bias in Inattention Studies

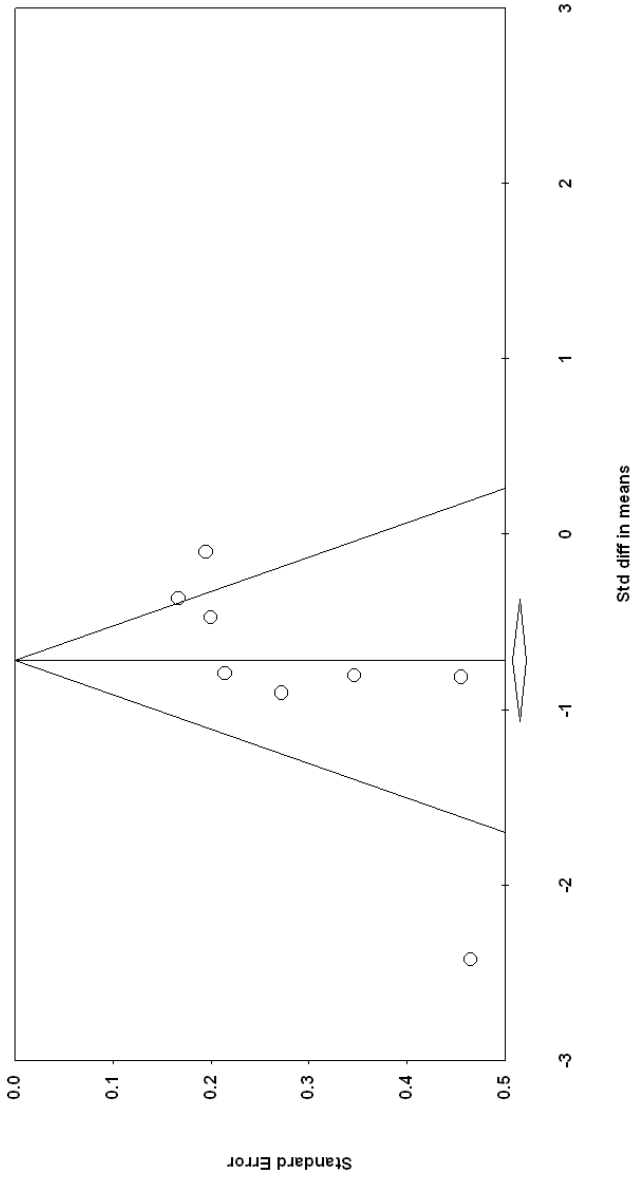


Figure 6. Publication Bias in Hyperactivity-Impulsivity Studies

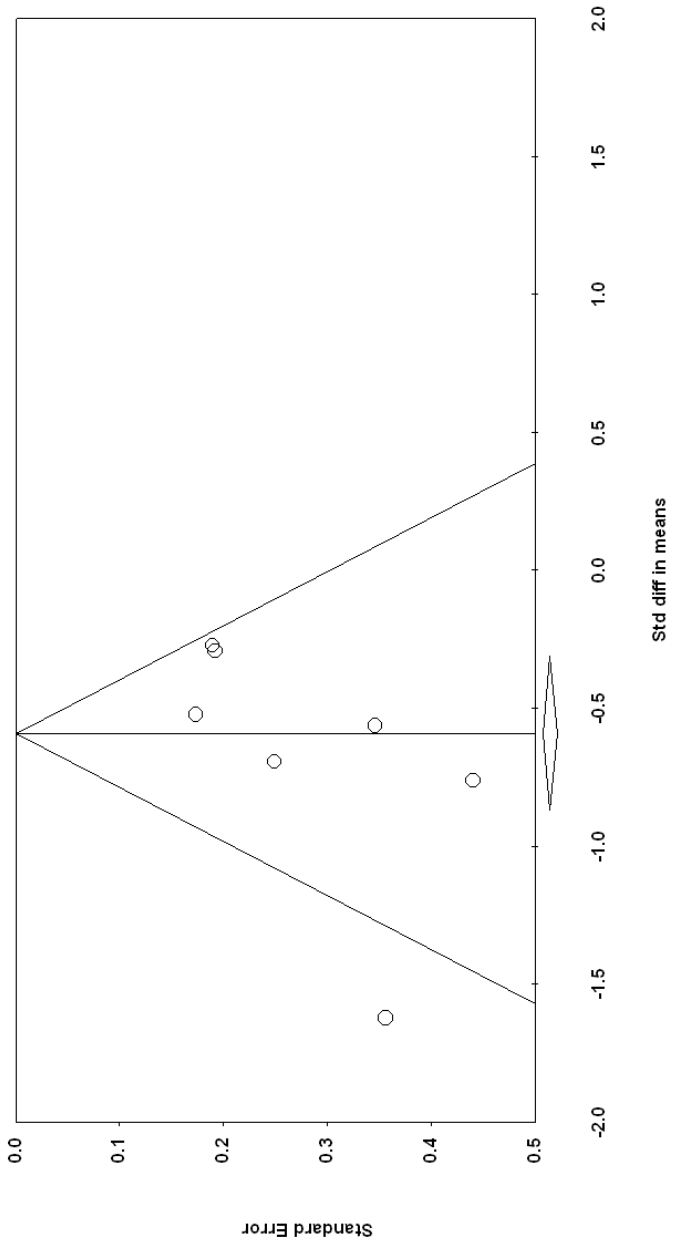


Figure 7. Trim and Fill Funnel Plot for Inattention Studies

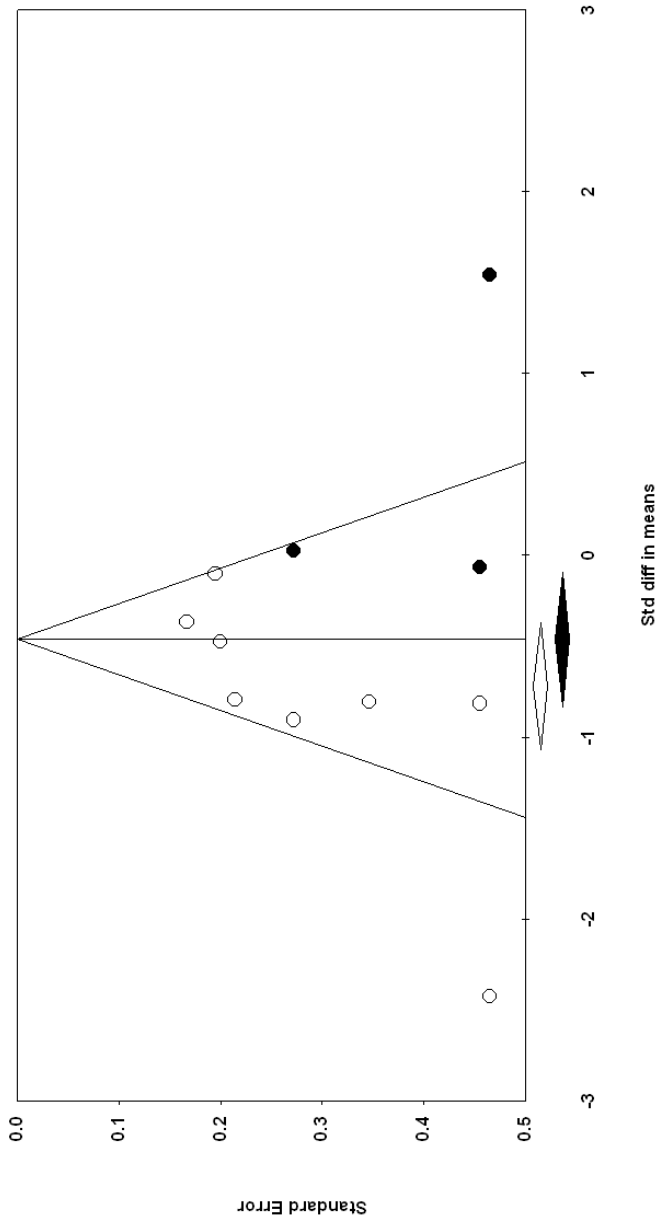
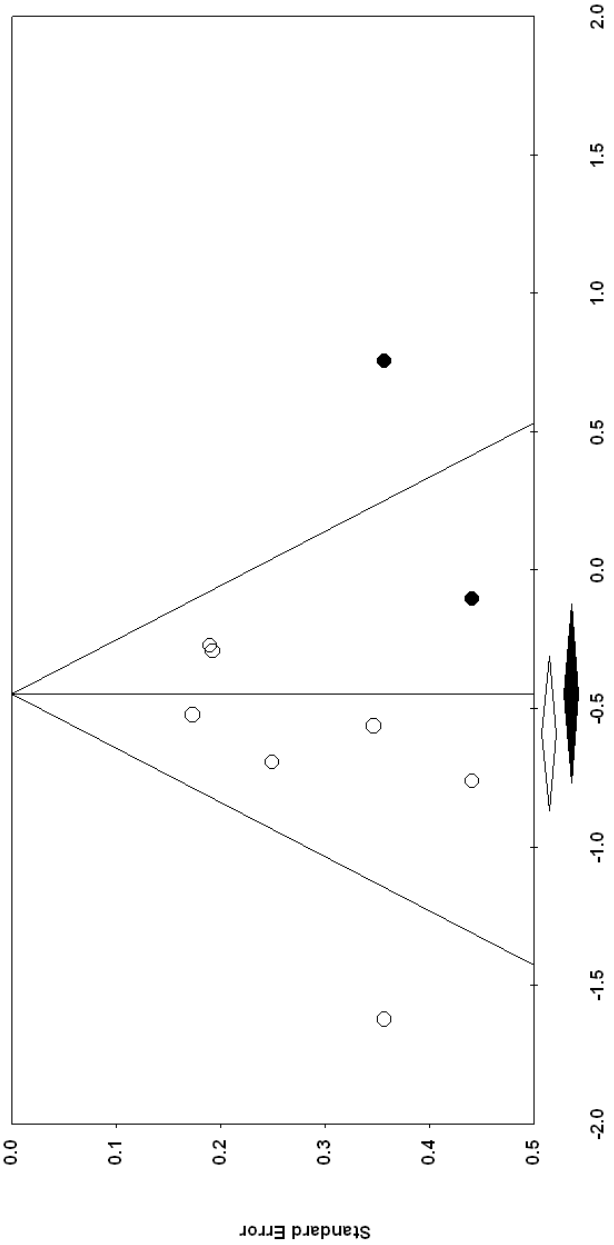


Figure 8. Trim and fill Funnel Plot for Hyperactivity-Impulsivity Studies



VITA AUCTORIS

Molly Cairncross was born in Windsor, Ontario, Canada in 1989. Shortly thereafter, her family moved to London, Ontario. Molly graduated with distinction from the University of Western Ontario in 2012, obtaining a Bachelor of Science with Honors Specialization in Psychology. She is currently a graduate student in the Clinical Neuropsychology program at the University of Windsor. Following the completion of her Masters degree in 2015, she will continue toward her Ph.D. in Clinical Neuropsychology.