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THE EFFECTS OF A SINGLE MINDFULNESS MEDITATION PRACTICE ON SELF-REGULATION IN CHILDREN AND ADULTS

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ABSTRACT

The present thesis assesses a core component of mindfulness training, experiential mindfulness meditations, on one of the primary targets of mindfulness training, self-regulation. The research presented here explores the effect of a single mindfulness meditation practice on self-regulation on novice meditators of all ages, with a special interest in children and adolescents. This thesis offers a distinct contribution to the literature on mindfulness, by two main methods: (a) systematically reviewing, meta-analysing and synthesising experimental investigations of single session mindfulness meditation practices on self-regulation, and (b) exploring the potential effects of a single session mindfulness meditation practice on self-regulation in children in two novel studies.

The findings provide preliminary support that mindfulness meditation practice may be an active component of mindfulness training for self-regulation in children from age 7 years. Furthermore, there is evidence for all ages of a direct short-term effect of a single mindfulness meditation practice on self-regulation by impacting on attention and emotion regulation. The thesis presents an original theoretical model for the short-term effects of mindfulness meditation practice on self-regulation based on the thesis findings.

The thesis offers a novel contribution to an emerging area of research within the domain of mindfulness, and highlights the need for (a) more understanding of the age at which mindfulness meditation practice may contribute to the effects of mindfulness training, and (b) further investigation of processes through which self-regulation is affected by mindfulness meditation practice. By investigating the effect of mindfulness meditation practice on self-regulation there is potential for further understanding of the processes of change of mindfulness training and theory development.

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AUTHOR'S DECLARATION

I, Anna Leyland, confirm that the Thesis is my own work. I am aware of the University's Guidance on the Use of Unfair Means (*www.sheffield.ac.uk/ssid/unfair-means*). This work has not previously been presented for an award at this, or any other, university. Where information has been derived from other sources, I confirm that this has been indicated in the thesis. The research was supported by a research studentship awarded by the Department of Psychology at The University of Sheffield.

The data in chapters three and four were collected with the assistance of four undergraduate students at the University of Sheffield, who between them collected around a third of the data. The data collected by the undergraduates for chapter three formed the sample for their Psychology BSc dissertations. The data collected by the undergraduates was in its raw form when analysed by Anna Leyland for the purposes of this thesis. The quality of included studies in the systematic review and meta-analysis of chapter two was assessed with the aid of a fellow Postgraduate Research Student in the Department of Psychology at the University of Sheffield. The protocol and guidance for this process was devised by the author Anna Leyland, and the author offered quid pro quo for this assistance. All remaining aspects of research design, data collection, analysis and the contents of the thesis were the sole work of the author, with guidance from the supervisory team.

Chapters two and three have been published in peer-reviewed journals and chapter four has been submitted for peer review. Where chapters are published, they appear in the thesis in the preprint form, with a brief introductory section added ahead of the preprint paper. Some formatting changes were made to the preprints (such as table numbering, line spacing and section headings) for consistency. Furthermore, the findings from chapter three and four have been presented at academic conferences.

Publications arising from the thesis

Leyland, A., Rowse, G., & Emerson, L. M. (2019). Experimental effects of mindfulness inductions on self-regulation: Systematic review and meta-analysis. *Emotion*, 19(1), 108.

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GENERAL INTRODUCTION

> *"Sometimes our mind is thinking of one thing and our body is doing another, and [our] mind and body are not unified. By concentrating on our breathing, "In" and "Out," we bring body and mind back together, and become whole again. Conscious breathing is the bridge… [which] helps us stop thinking so much and stop being possessed by sorrows of the past and worries about the future. It enables us to be in touch with life, which is wonderful in the present moment."*
>
> Thich Nhat Hanh (pg. 9-11, 1991)

The present thesis explores the effect of a single mindfulness meditation practice on self-regulation. It aims to do this through secondary analysis of empirical investigations with people of all ages and by conducting two novel empirical trials with children. This chapter has three sections. The first section will define and conceptualise mindfulness and mindfulness meditation practice and explore the theoretical and empirical evidence for the potential mechanisms of mindfulness. The second section focuses on research evidence for mindfulness with children and adolescents. The third and final section focuses on self-regulation, and the current understanding of the potential for an effect of mindfulness and mindfulness meditation practice on self-regulation. The foundation of the present thesis is the understanding that greater self-regulation offers benefits to children and adults (Moffitt et al., 2011, see section 1.3.3 of this chapter) and as such it is critical to grow knowledge of the mechanisms through which self-regulation can be enhanced. Specifically, the present thesis will further test whether in the short-term mindfulness meditation practices can enhance self-regulation and through what mechanisms. Through this investigation the present thesis aims to contribute to the growing understanding of the mechanisms

through which mindfulness and mindfulness meditation practice may elicit short- and long-term change in self-regulation.

1.1 Mindfulness

The focus of this section of the chapter is to consider how mindfulness is defined and conceptualised, what the benefits are of greater trait mindfulness and the potential effects of mindfulness training. The section then moves to consider mindfulness meditation practice as a component of mindfulness training and as a method through which trait mindfulness can be enhanced.

1.1.1 How is mindfulness defined and operationalized?

In this present thesis mindfulness is defined as the "*open and receptive attention to and awareness of ongoing events and experience*" (Brown & Ryan, 2003, pg. 245)[1]. The term mindfulness dates back thousands of years and originates in texts and practices from Eastern spiritual traditions including Buddhism, the Vedic traditions and Yoga (Brown, Ryan, & Creswell, 2007; Desikachar, 1999; Kang & Whittingham, 2010). In the last half century, the term has been adopted by and adapted for Western psychology; however, there remains no singular agreed upon definition of mindfulness (see for example Grossman, 2011).

One of the most cited definitions describes mindfulness as "*paying attention in a particular way: on purpose, in the present moment, and non-judgementally*" (Kabat-Zinn, 1994, pg. 4). Another popular definition states that mindfulness is the "*non-judgemental observation of the ongoing stream of internal and external stimuli as they arise*" (Baer, 2003, pg. 125). There are many more definitions of mindfulness in western Psychology (for overview see Krägeloh et al., 2019). When these collective definitions have been summarised two essential elements of mindfulness have been highlighted: awareness of present-moment experience and the non-judgemental acceptance of experience (Keng, Smoski, & Robins, 2011). Definitions of mindfulness can be applied to how one typically displays the qualities of mindfulness in their day-to-day life (trait (of) mindfulness) or how the qualities of mindfulness are being demonstrated in the present moment (state (of) mindfulness). There are also distinct definitions of state mindfulness such as *an active and open mode of attention to current experience in the present moment* (Lau et al., 2006).

[1] In chapter two (page 40) mindfulness is described as "*non-judgemental attention and acceptance of present moment experience*" from a later manuscript from Brown & Ryan (2004).

This thesis uses the definition offered by Brown and Ryan (2003) and a two-component operationalization that proposes that mindfulness is the self-regulation of attention to attain non-elaborative awareness, and a particular orientation to experience that is open, curious and accepting (Bishop et al., 2004). The choice of this definition and conceptualisation is pragmatic based on a primary intention of providing a definition and operationalization that contain the two aspects of mindfulness for which there appears to be some agreement amongst scholars, namely attention and awareness. Although it is also recognised that researchers and scholars in the field are still in the process of arriving at a 'definitive definition', and as such some may view any or all of the current definitions sceptically or with ambivalence.

1.1.2 How is mindfulness measured?

There are numerous measures of trait mindfulness for adults (for overview see Quaglia, Brown, Lindsay, Creswell, & Goodman, 2015) that are often associated with one or more of the definitions of mindfulness (Grossman et al., 2011). For example, a widely used measure based on a review of other measures is the Five-Facet Mindfulness Questionnaire (FFMQ; Baer et al., 2008), which has facets of: *observe* (noticing or paying attention to experience), *describe* (labelling experiences with words), *acting with awareness* (attending to present moment activities), *non-judgement of inner experience* (not evaluating thoughts or feelings), and *non-reactivity to inner experience* (allowing thoughts and feelings to pass without getting caught up in them). Another popular measure is the Mindful-Awareness and Attention Scale (MAAS) based on the definition by Brown and Ryan (2003), which has a single factor of attention to and awareness of experiences in daily life (Brown & Ryan, 2003).

More recently measures of trait mindfulness have been developed and validated for children and adolescents. There are now at least seven measures available for ages 9-18 years, although many are yet to be widely used (Goodman, Madni, & Semple, 2017). The two most widely used measures form a single factor for trait mindfulness, namely the Child and Adolescent Mindfulness Measure (CAMM; Greco et al., 2011) and two adaptations to the MAAS for children or adolescents (de Bruin, Zijlstra, van de Weijer-Bergsma, & Bögels, 2011; Lawlor, Schonert-Reichl, Gadermann, & Zumbo, 2014). As an example of one of the newer multifactor measures of trait mindfulness, The Comprehensive Inventory of Mindfulness Experience (CHIME-A) has eight factors: *awareness of internal experiences, awareness of external experiences, acting with awareness, accepting* and *non-judgemental orientation, decentering* and *nonreactivity, openness to*

experience, relativity of thoughts, and *insightful understanding* (Johnson, Burke, Brinkman, & Wade, 2017).

There are several self-report measures of state mindfulness for adults, with some forming a one-dimensional measure of mindfulness, such as the 5-item MAAS (Brown & Ryan, 2003), and the Daily Mindful Responding Scale (Lacaille, Sadikaj, Nishioka, Flanders, & Knäuper, 2015). Other measures are multidimensional such as The Toronto Mindfulness Scale (TMS), which is formed of two subscales: *decentering* (reduced personal identification with thoughts and feelings) and *curiosity* (desire to learn about own experience; Lau et al., 2006). Similarly, the State Mindfulness Scale (SMS) is formed of two scales: *mindfulness of the body* and *mindfulness of the mind* (Tanay & Bernstein, 2013). Presently there are no equivalent measures of state mindfulness for children and adolescents.

1.1.3 What are the benefits of greater mindfulness?

Systematic reviews of cross-sectional evidence provide strong support for the benefits of greater trait mindfulness on a range of adaptive correlates. For example, trait mindfulness is positively associated with adaptive cognitive processes (e.g., less rumination, pain catastrophizing), emotion regulation, and self-esteem (Randal, Pratt & Bucci, 2015; Tomlinson, Yousaf, Vittersø, & Jones, 2018). In the workplace, trait mindfulness is positively associated with greater job satisfaction and reduced work burnout (Mesmer-Magnus, Manapragada, Viswesvaran, & Allen, 2017). Furthermore, an individual's trait mindfulness may also be of benefit to others, as greater trait mindfulness is associated with increased prosocial behaviour (Donald et al., 2019). Lastly, trait mindfulness in adults is associated with engaging in more healthy behaviours, such as physical activity, healthy eating, and sleep, and negatively associated with substance misuse (Karyadi, VanderVeen, & Cyders, 2014; Sala, Rochefort, Lui, & Baldwin, 2020). Conversely adult trait mindfulness is negatively associated with perceived life stress and psychopathological symptoms and disorders (e.g., depressive symptoms, depression), and positively associated with life satisfaction (Mesmer-Magnus et al., 2017; Tomlinson et al., 2018). Empirical research also reports that greater state mindfulness is associated with enhanced well-being (Brown & Ryan, 2003; Lacaille et al., 2015; Snippe et al, 2015), and can reduce negative state affect (Weinstein, Brown, & Ryan, 2009).

Similar associations have been reported for children and adolescents. For example, greater trait mindfulness in children and adolescents is positively associated with higher academic

achievement (Caballero et al, 2019), improved resilience to the effects of peer victimisation, less social exclusion (Clear, Zimmer-Gembeck, Duffy, & Barber, 2020), and enhanced psychological health (Tan & Martin, 2016). Although not an indicator of causality, there is strong evidence demonstrating that trait mindfulness is positively associated with a range of desirable personal characteristics and outcomes. Proponents of mindfulness present that it is the degree to which one is high or low in trait mindfulness that generates the effects on other areas of functioning and wellbeing.

There is a small but growing body of theoretical and empirical evidence that supports the notion that the association between trait mindfulness and other traits is not linear but rather is an inverted U shape, where there is an optimal range of trait mindfulness that infers the most benefits. In this way there is a potentially detrimental effect of low or high levels of trait mindfulness (for discussion see Britton, 2019). For example, high scores of mindful attention are associated with higher mental health symptoms; however, greater non-judgemental awareness coupled with greater mindful attention guards against this negative affect (Eisenlohr-Moul, Walsh, Charnigo, Lynam, & Baer, 2012; Sahdra et al., 2017). This fine-grained analysis of trait mindfulness is of increasing interest in the field; however, presently there is little evidence of the potential limits of mindfulness. As such, the common understanding is that increasing trait mindfulness will infer benefits to individual wellbeing.

1.1.4 Mindfulness training to enhance trait mindfulness

Mindfulness-based interventions (MBI) are one method through which trait mindfulness can be enhanced (Carmody & Baer, 2008).[2] The founding mindfulness-based intervention (MBI) came from Kabat-Zinn (2013) in the form of the 8-week (~2 hour sessions per week) Mindfulness Based Stress Reduction (MBSR), with a later notable variant of the course being Mindfulness Based Cognitive Therapy (MBCT; Segal et al., 2018). In addition, two other intervention programmes, Acceptance and Commitment Therapy (ACT; Hayes, Strosahl, & Wilson, 2009) and Dialectical Behaviour Therapy (DBT; Linehan, 1987), contain a substantial mindfulness component and have also received broad research and clinical interest.[3]

[2] A systematic review reported that 30 of 69 non-mindfulness interventions (including exercise, time spent in nature and psychotherapy) significantly increased trait mindfulness (Xia, Hu, Seritan, & Eisendrath, 2019).
[3] In this chapter and across the thesis the terms mindfulness-based programme (MBP) and mindfulness-based intervention (MBI) are used interchangeably to mean any manualised programme based on the prototypical MBSR course and the descriptions of MBPs as set out by Crane and colleagues (2017). A broader term,

The core components of MBIs have been proposed as three formal experiential mindfulness meditation practices (body-scan, movement, sitting), an inquiry process, and integrated home practice (Crane et al., 2017). In addition, MBIs include education, informed by ideas from contemplative traditions and areas of science, to support individuals to form a new relationship with experience. Specifically, the new relationship with experience is characterised by a focus on the present moment, decentering from thoughts and emotions, and approach rather than avoidant coping strategies (Crane et al, 2017). For example, decentering would allow more cognitive distance from challenging thoughts and emotions that can increase the opportunity for an objective stance on experience. This objectivity can lessen the impact of the thought or emotion, supporting an individual to approach rather than avoid an experience. A systematic review and meta-analysis of mediation trials reported that gains in trait mindfulness following mindfulness training is one of the significant mediators of positive change to psychological functioning and wellbeing (Gu, Strauss, Bond, & Cavanagh, 2015). Notwithstanding, the theoretically proposed benefits of MBIs extend beyond enhanced trait mindfulness to include greater self -regulation and enhanced compassion, wisdom and equanimity (Crane et al, 2017).

There are a range of mindfulness training programmes available for children and adolescents, often resulting from adaptations made to the prototypical adult mindfulness-based programmes (MBPs), such as MBSR for children (MBSR-C; Saltzman & Goldin, 2008) and Dot Be (Kuyken et al, 2013). Comparatively, others have further evolved the content or format of sessions for their specific population or context, such as the Inner Kids programme for younger children (Flook et al, 2010) or MYmind for children with ADHD (Bögels, Hoogstad, van Dun, de Schutter, & Restifo, 2008). There is evidence from meta-analyses that compared to controls participating in an MBP can significantly enhance trait mindfulness in children and adolescents d = .24 (Dunning et al., 2019). In addition, greater trait mindfulness is a strong moderator of the positive effects of mindfulness training on mental health and wellbeing (Carsley et al., 2018).

One component of mindfulness training that may be actively involved in enhancing trait mindfulness is mindfulness meditation practice. Theoretically it is thought that repeatedly engaging with mindfulness meditation practice, which induces a state of mindfulness, enhances trait mindfulness (e.g., see Davidson, 2010; Vago & Silbersweig, 2012). This is supported by

mindfulness training is used to mean any programme containing specific training in mindfulness, including MBPs, other novel mindfulness training programmes, ACT and DBT.

empirical evidence reporting that mindfulness meditation practice and the associated state of mindfulness, lead to increased trait mindfulness during and following mindfulness training (Kiken, Garlan, Bluth, Palsson, & Gaylord, 2015). Notwithstanding, the same authors identified different trajectories for change in state mindfulness over time between individuals, suggesting that the pathway between mindfulness meditation practice, state mindfulness and trait mindfulness may not be the same for everyone. Nevertheless, a systematic review and meta-analysis (k = 18) reported significant effects of repeated mindfulness meditation practice (without the other components of mindfulness training) on anxiety g = .39 and depression g = .41 (Blanck et al., 2018). As such this evidence gives support for mindfulness meditation practice as an active component of mindfulness training.

There is then theoretical and empirical reason to view mindfulness meditation practice as an active component of mindfulness training. Furthermore, mindfulness meditation practice is a core component of mindfulness training, and it has been identified as the most frequently included component of mindfulness training for children and adolescents (Crane et al., 2017; Maynard, Solis, Miller, & Brendel, 2017). This is pertinent in a research and clinical field where fidelity and adherence of mindfulness training programmes is poor (Gould, Dariotis, Greenberg, & Mendelson, 2016; Meiklejohn et al., 2012; Tan, 2016). The next subsections further describe mindfulness meditation practices and present additional theoretical and empirical evidence for the potential contribution of mindfulness meditation practice to the beneficial effects of mindfulness training.

1.1.5 What is mindfulness meditation practice?

Mindfulness meditation practice is a core component of mindfulness training and a method through which trait mindfulness can be enhanced (Quaglia, Braun, Freeman, McDaniel, & Brown, 2016; Shapiro, Brown, Thoresen, & Plante, 2011). Erisman and Roemer (2012) describe this process:

> *Mindfulness is a skill that can be cultivated through repeated practice, such as through mindfulness meditation, in which individuals continually bring attention to their breath while maintaining an open and gentle awareness of the present moment* (p. 31).

The quote is describing a typical meditation practice called mindfulness of breathing, with other common practices being mindful movement, mindful eating and the body-scan (for descriptions see Kabat-Zinn, 2013). In a mindfulness of breathing practice, the instructor guides participants to sit in a comfortable but alert posture, placing the focus of their attention on to the movement and flow of the breath, observing their experience non-judgementally moment-by-moment.

Participants of all experience levels will notice the focus of their mind inevitably wandering from their breath, and the instructor guides them to observe and notice this activity of the mind, each time returning their attention to the breath while maintaining a kind and compassionate attitude toward the self. Mindfulness meditation practices engage several cognitive functions, including attention regulation, working memory and meta-cognition, as well as processes of self-awareness and self-compassion.

Mindfulness meditation practice enables an individual to enter a state of mindfulness, referred to as state mindfulness (Lau et al., 2006). State mindfulness can also be cultivated toward and during everyday activities such as brushing teeth or taking a shower (Hanley, Warner, Dehili, Canto, & Garland, 2015; Kabat-Zinn, 2013). As previously mentioned, state mindfulness can be operationalised as being formed of decentering and curiosity (Lau et al., 2006). Decentering is where the connection between a perceived object (e.g., an experience or stimulus) and the emotion or thought that is generated in response to the object is weakened or distanced. In relation to state mindfulness curiosity is described as the desire to learn more about one's experiences, which may be likened to an openness to experience (Lau et al., 2006).

There are challenges in practicing mindfulness meditation, particularly for novice meditators. Buddhist scholars often refer to the mind of a non-meditator as an *untrained* mind, likening the activity of the mind to that of a monkey or puppy moving from one thought to the next (e.g., Gyatso, 2013; Kornfield, 2002). Mindfulness meditation can also cause unwanted thoughts, emotions and sensations to arise (Baer, Crane, Miller, Kuyken, 2019; Lomas, Cartwright, Edginton, & Ridge, 2015). Theorists have proposed that one reason that meditation may elicit negative effects is that the increased attention and awareness toward the activity in the mind may increase self-criticism (Shapiro et al., 2006; Werner, Tibubos, Rohrmann, & Reiss, 2019). These potential adverse outcomes have meant that mindfulness meditation has been contraindicated for some clinical groups (for example see Dobkin, Irving, & Amar, 2012). Although many more people may find mindfulness meditation practice challenging without experiencing adverse effects. Much like in other approaches the short-term discomfort of mindfulness meditation practice is part of a therapeutic process that ultimately leads to treatment gains (e.g., exposure therapy; Olatunji, Deacon, & Abramowitz, 2009).

1.1.6 What are the direct effects of mindfulness meditation practice?

Mindfulness meditation practice and the state of mindfulness reached through a mindfulness meditation practice can lead to short term behavioural, emotional, physiological and cognitive changes. These effects can be measured using experimental designs where participants are randomly assigned to follow the instructions of a mindfulness meditation practice or comparison activity before completing the outcome measure.[4] In adults a single mindfulness meditation practice can enhance state mindfulness (Feldman, Greeson, & Senville, 2010; Johnson, Gur, David, & Currier, 2013; Mahmood, Hopthrow, Randsley de Moura, 2016;), reduce smoking behaviour over a one week follow up period (Bowen & Marlatt, 2009), reduce emotional reactivity to emotional slides (Arch & Craske, 2006), produce a positive effect on heart rate variability following a cognitive stressor activity (Azam et al., 2015), and enhance memory recall (Alberts & Thewissen, 2011).

Two systematic reviews have summarised the evidence for the effects of a single mindfulness meditation practice on cognition and emotion. [5] A systematic review and meta-analysis reported that a single mindfulness meditation had a significant small effect across all cognitive domains (Gill, Renault, Campbell, Rainville, & Khoury, 2020). Although subgroup meta-analyses found a significant effect for higher-order cognitive functions (e.g., decision making), but no effect for attention, executive function, or memory (Gill et al., 2020). Similarly, a second systematic review and meta-analysis synthesised evidence for an effect of brief forms of mindfulness training, from a single mindfulness meditation to two weeks of training, on negative affectivity (Schumer, Lindsay, & Creswell, 2019). The authors reported a significant effect of mindfulness training on negative affectivity where negative affect was induced (referred to as a distress paradigm) but no effect where affect was not manipulated (Schumer et al., 2019). The authors also commented that the largest effect sizes appeared immediately after the mindfulness meditation practice, although the meta-regression for the effect of time was not significant. This preliminary evidence indicates that the effects of a single mindfulness meditation may be short-term, although there is currently little theoretical or empirical evidence to support understanding of

[4] Mindfulness meditation practices investigated as standalone practices in experimental settings can be referred to as mindfulness inductions (as in chapter two).

[5] The publication of two relevant systematic reviews (Gill et al., 2020; Schumer et al., 2019) occurred after the publication of the systematic review presented in chapter two (Leyland, Rowse, & Emerson, 2019). Furthermore, the point of publication of these two systematic reviews was during the final stages of writing of the PhD and as such was not available to inform the design of empirical methods or the interpretation of findings of chapters two or chapter three.

this assertion. One theoretical explanation is that the repeated practice of experiential mindfulness meditations is likened to exercising a muscle, whereby more practice equates to greater and longer lasting effects (Kabat-Zinn, 2013).

1.1.7 How may mindfulness meditation practice contribute to the mechanisms of change of mindfulness?

Over time the brain activation resulting from repeated mindfulness meditation practice can lead to changes in brain structure and function (Tang, Hölzel, & Posner, 2015). Specifically, eight brain areas are associated with changes relating to mindfulness meditation practice and these areas are involved with self-regulatory processes including meta-awareness, body awareness, emotion and behavioural regulation, executive attention and inter-hemispheric communication (Fox et al., 2014). These structural changes mirror the theoretically proposed mechanisms of trait mindfulness, which include gains in the self-regulation of attention and self-awareness, greater use of decentering, and a change in perspective of the self or self-transcendence (Vago & Silbersweig, 2012). This subsection will briefly describe these theoretical mechanisms of change, presenting empirical evidence where available, and proposing how mindfulness meditation practice may theoretically be implicated in each mechanism.

Greater self-regulation of attention is theoretically proposed as a mechanism though which mindfulness elicits its effects on other outcomes (Grabovac, Lau, & Willet, 2011; Hölzel et al., 2011). The self-regulation of attention is the volitional control of attention that is in accord with an overarching goal, and as such it is beneficial to the pursuit of long-term goals (see Kaplan & Berman, 2010). Self-regulation of attention may offer other benefits as an adaptive emotion regulation strategy and to enhance cognitive control (Baer, 2003; Garland, Gaylord, & Park, 2009; Ochsner & Gross, 2005). A review of brain imaging studies identified brain areas activated during mindfulness meditation practice that are associated with attention control (Tang, Hölzel, & Posner, 2015). Mindfulness meditation practice necessitates the use of attention regulation and introspective awareness, specifically as one is asked to notice the activity of the mind and repeatedly regulate or direct attention toward a nominated stimulus, such as the breath. The dynamic nature of attention during a mindfulness mediation practice was revealed through functional magnetic resonance imaging which identified four phases of a mindfulness meditation practice each with distinct brain activation areas: mind-wandering, awareness of mind-wandering,

shifting attention towards the breath, and sustained attention on the breath (Hasenkamp, Wilson-Mendenhall, Duncan, & Barsalou, 2012).

Decentering is one of the most consistently proposed mechanisms of mindfulness (Baer, 2003; Grabovac et al., 2011; Kabat-Zinn, 2013; Segal, Williams, & Teasdale, 2018; Shapiro et al., 2006; Vago & Silbersweig, 2012). Decentering is proposed as an adaptive emotion regulation strategy offering greater opportunity to notice the nature of primary cognitive appraisals and generate less emotive secondary cognitive appraisals (Garland et al., 2009; Shapiro et al., 2006). Consequently, enhanced mindfulness is associated with greater approach to rather than avoidance of experience (e.g., exposure) given that experiences elicit a diminished and more tolerable emotional reaction (Baer, 2003; Shapiro et al., 2006). Furthermore, fewer negative appraisals and greater emotion regulation reduces rumination and negative reactivity, and subsequently enhances acceptance of experience (Baer, 2003; Grabovac et al., 2011; Kabat-Zinn, 2013; Segal et al., 2018; Shapiro et al., 2006; Vago & Silbersweig, 2012). Mindfulness meditation practice instructions often direct individuals to notice and observe the activity and content of their mind without elaboration or attachment. This instruction is coupled with the format of a mindfulness meditation practice (e.g., sitting still in a quiet space with eyes closed) that reduces external distraction and opportunities to avoid present moment experience. Mindfulness meditation practice offers an opportunity to directly apply the principles of decentering, where one is aware of an emotion or thought and aware of the reaction to the emotion or thought but this awareness is non-elaborative. In a review of brain imaging studies mindfulness meditation practice was associated with activation of brain regions that are implicated in emotion regulation processes (Tang et al., 2015).

A further mechanism of mindfulness is greater self-awareness, in particular greater awareness of the body and mind, which in turn can lead to greater clarification of personal values and goals (Baer, 2003; Brown, Ryan, & Creswell, 2007; Hölzel et al., 2011; Shapiro et al., 2006; Vago & Silbersweig, 2012). Mindfulness meditation practice may enable greater self-awareness by creating the conditions where external distractions are removed so that attention can be focused on the activity of the mind and the sensations arising in the body. This process enables one to become more aware of habitual thought patterns and the content of thoughts. A review of brain imaging studies found that mindfulness meditation practice was associated with activity in brain regions linked to self-awareness (Tang et al., 2015).

Greater trait mindfulness is thought to facilitate self-transcendence, an existential understanding or view that there is no true or static sense of 'I' or 'me' and that all things (e.g., beings, events) are connected (Hölzel et al., 2011; Vago & Silbersweig, 2012). Although more difficult to operationalise, self-transcendence is associated with reduced cognitive biases in the processing of self-relevant information (e.g., more objective evaluation of one's performance in a task; Hölzel et al., 2011; Vago & Silbersweig, 2012). Furthermore, self-transcendence may be associated to greater compassion and acceptance towards the self and others (Baer, 2003; Grabovac et al., 2011). Mindfulness meditation practice facilitates a separation of or greater distance from one's primary cognitive, behavioural and emotional reactions to stimuli. This distance allows an individual to increase their self-awareness and reduce their habitual patterns of thought and behaviour, allowing them to explore or question more aspects of their thoughts, emotions and behaviours. In mindfulness training programmes there is often a group inquiry process after a mindfulness meditation practice that facilitates the exploration of these experiences. Mindfulness meditation practice and the inquiry process may contribute to the process of self-transcendence as it facilitates individuals to question and explore their self-identity. For example, the extent to which they identify as their thoughts, emotions or behaviours. Furthermore, mindfulness meditation practices such as the loving kindness meditation (also known as Metta Bhavana) may directly enhance a sense of connection as the instructions guide practitioners to develop compassion and connectedness with other beings.

1.1.8 What are the broader implications of applying an experimental method to mindfulness research?

The experimental method has great potential in the domain of mindfulness research to contribute to theory development and understanding of the mechanisms of mindfulness (Keng et al., 2011; Creswell, 2017). In particular this method can provide greater understanding for the processes of change of mindfulness training by testing the active contribution of the mindfulness meditation component of training. Experimental designs offer a greater degree of precision relative to intervention studies and more stringent methodological processes, such as randomisation to active comparison groups and controlled environments (Levin, Hildebrandt, Lillis, & Hayes, 2012). Furthermore, experimental designs support the testing of components that may not be ethical or appropriate in larger intervention trials, such as advising rumination exercises (Levin et al., 2012). Nevertheless, there is reason to be cautious in the application of experimental designs within the domain of mindfulness research.

There is growing criticism and concern for the extraction of mindfulness from its spiritual and ethical origins and there is a need for researchers and clinicians to uphold and not further diminish the integrity of mindfulness education and practice within Western psychology (McCaw, 2020). Experimental studies that seek to understand the effect of a single component of mindfulness training may inadvertently be contributing to the further commodification or oversimplification of mindfulness. For example, applying mindfulness meditation practice as a technique to reduce employee stress in a highly stressful occupational setting (e.g., Arch & Craske, 2006), as an alternative to more comprehensive support or changes to working environments. Furthermore, there is evidence that mindfulness meditation practice can have adverse effects for some individuals and these deleterious effects are not well understood in adults and are under researched for children and adolescents (Baer et al., 2019). There is little discussion in the existing literature of the potential negative contribution the experimental method may make to the integrity of mindfulness, or how to overcome or prevent any deleterious consequences.

Notwithstanding, there is reason to persist in the use of the experimental method as it can contribute helpful evidence to the understanding of mindfulness and mindfulness training. Given this position it is pertinent that researchers consider the potential for over simplified interpretations of results and ensure that their own results are presented and interpreted so findings are not exaggerated, extrapolated or overgeneralised. Overall, there is theoretical and empirical evidence that mindfulness meditation practices are an active component of mindfulness training and that they elicit short-term effects on a range of outcomes. Furthermore, mindfulness meditation practice contributes to enhancing trait mindfulness, which is associated with a wide range of benefits to functioning and wellbeing.

1.2. Mindfulness for children and adolescents

The focus of the chapter in the following subsections moves to consider the application of mindfulness and mindfulness meditation practice for children (4-12 years) and adolescents (13-17 years). This section will relate mindfulness to child development and present a critical overview of theoretical and empirical evidence in this domain.

1.2.1 The normative development of trait mindfulness in childhood

There is currently not a clear consensus on the normative development of trait mindfulness through childhood. There is some evidence to suggest that some facets of mindfulness have a linear association with age. Specifically, the facet of non-reactivity demonstrates a linear increase

in adolescence and is associated with the development of emotion regulation (Galla, Tsukayma, Park, Yu, & Duckworth, 2018). Whereas there are differential findings as to the development of the facet of acting with awareness through childhood, with positive (e.g., de Bruin et al., 2011), negative (e.g., Warren, Wray-Lake, & Syvertson, 2018) and no (Warren, Wray-Lake, & Shubert, 2020) associations with age reported. Other evidence suggests that development of mindfulness may result from a dynamic interaction with an individual's social environment (Warren et al., 2020). Specifically factors such as the extent to which an environment is supportive and nurturing, and free from discrimination can positively impact on the development of trait mindfulness (Warren et al., 2020). In this respect, the environments that are conducive for all healthy child development are also the contexts within which trait mindfulness is enhanced.

1.2.2 At what age can children engage with and benefit from mindfulness training and mindfulness meditation practices?

There is little consensus about the developmental stage from which children can begin to access and engage with mindfulness training and mindfulness meditation practices. Based on the Piagetian framework it could be assumed that children may need to have passed into the formal operation stage (around age 12), whereby they can engage in abstract and hypothetical reasoning (Piaget, 1952; Wagner, Rathus, & Miller, 2006). There is however evidence to suggest that younger children in the concrete operation stage (7-11 years) can engage well with and benefit from mindfulness training programmes (e.g., Flook, Goldberg, Pinger, & Davidson, 2015). Furthermore, mindfulness training programmes are available for children and adolescents for an almost full range of ages, with examples of school-based studies from 4-18 (e.g., Flook et al., 2010; Johnson, Burke, Brinkman, & Wade, 2016) and children involved in family based studies from infancy (Potharst, Aktar, Rexwinkel, Rigterink, & Bögels, 2017).

There are several areas of development that occur across childhood that are relevant to how an individual may relate to the practices and ideas within mindfulness training. These areas include the maturation of meta-cognitive and introspective abilities, increased executive function capacity, use of more adaptive emotion regulation strategies, self-control, and attention regulation (Black, 2015; Shonert-Reichl & Lawlor, 2010). Although, the way in which these maturational changes impact accessibility of mindfulness training may not always be positive. For example, increases in self-evaluation and self-consciousness in adolescence may impede an individual's ability to put into practice some of the instructions of mindfulness meditation practices, for example non-judgemental acceptance of experience (Schonert-Reichl & Lawlor, 2010). To add complexity

somewhat, there is also evidence demonstrating that mindfulness training can enhance the very functions that may be considered a prerequisite of training. For example, mindfulness training can enhance meta-cognition, executive function, attention regulation, and self-control in children and adolescents (Black & Fernando, 2014; Flook et al., 2010; Felver, Tipsord, Morris, Racer, & Dishion, 2017; Vickery & Dorjee, 2016).

1.2.3 How does child development impact on the potential outcomes of mindfulness training?

Evidence from systematic reviews further elucidates on the association between participant age and the effects of mindfulness training. Specifically, mindfulness training may offer greater overall benefits to adolescents relative to children (Carlsey, Khoury, & Heath, 2018). However, specific effects may differ depending on age, for example with evidence for greater behavioural changes in children relative to adolescents; but greater benefits to executive function in adolescents relative to children (Dunning et al., 2019). There is further evidence to suggest that the children and adolescents that may benefit from mindfulness training are those that have higher or lower than the age-average baseline measurements on a particular characteristic or construct. For example, those who at baseline had lower than average performance on executive function measures or those with clinically high levels of depression or anxiety gained more from mindfulness training than those who at baseline scored closer to the group mean (Flook et al., 2010; Kallapiran, Koo, Kirubakaran, & Hancock, 2015; Zoogman et al., 2015). Notwithstanding in research and practice it is a popular option to deliver mindfulness training to community-based children and adolescents rather than targeting training at subgroups.

1.2.4 What is the current state of the evidence of mindfulness for children and young people?

There is consistent evidence across systematic reviews and meta-analyses for a positive effect of mindfulness training for psychological wellbeing and mental health in children and adolescents (for examples see Carsley, Khoury, & Heath, 2018; Dunning et al., 2019) There is however less clear empirical support for the effects of mindfulness training on child and adolescent cognitive function (for conflicting evidence see Dunning et al., 2019; Mak, Whittingham, Cunnington, & Boyd, 2018) and little empirical support for changes in behaviour and academic achievement (for review see Maynard et al., 2017). Notwithstanding, there is political support in the UK for mindfulness training to be delivered in schools. In 2015 a UK Mindfulness All-Party Parliamentary Group made recommendations for mindfulness training to be delivered in education

settings. The report stated that mindfulness had "*a lot to contribute*" in meeting the three key policy challenges in education to enhance academic achievement, children's mental health, and non-academic skills and capabilities (Mindfulness All-Party Parliamentary Group, 2015). This political support has been accompanied by a growth in research activity in the field in the UK and internationally (For review see Semple & Burke, 2019) and more recently growth in the rigour and size of mindfulness intervention studies for this population (For example see Chan et al, 2018; Kuyken et al., 2017).

Despite the growth in the evidence base reviews of the literature consistently highlight high heterogeneity and low methodological quality of published empirical research (for example see Burke, 2010; Semple & Burke, 2019). The high clinical heterogeneity across research papers presents challenges for evidence synthesis and interpretation (for example see Mak et al., 2018; Dunning et al., 2019). Furthermore, reviews of the evidence also highlight other methodological limitations such as a lack of independence of observations (Semple & Burke, 2019), use of non-active or no control comparison groups (Dunning et al., 2019), reliance on third party reported outcomes, and the absence of valid measurement tools for trait mindfulness in children under 9-years and state mindfulness (see Goodman et al, 2017). In addition, even though measures of trait mindfulness for children over 10 years have been available for around a decade, they are often not used or not reported in empirical research papers (For review see Mak et al., 2018).

There are other limitations within the empirical evidence around the fidelity of mindfulness training programmes for children and adolescents. Reviews of the evidence report that the content of interventions are often poorly described in research reports or there is low adherence to the core components of mindfulness training (Crane et al., 2017; Maynard et al., 2017). Furthermore, theoretical and empirical understanding of when (at what age) and how (through what processes) mindfulness training may be effective is less well developed for children and adolescents.

1.2.5 What is the theoretical evidence for the mechanisms of mindfulness for children and adolescents?

There are several theoretically proposed mechanisms through which mindfulness may elicit effects on children and adolescents. One such proposal is that greater trait mindfulness may lead to a change in self-awareness, to be more experiential and less ruminative and self-critical, which results in greater academic motivation and performance (Vago & Silbersweig, 2012; Roeser &

Peck, 2009). Another theoretical proposal is that mindfulness might be of benefit to children as it improves their ability to sustain attention and manage their emotions (Harnett & Dawe, 2012).

A recent theoretical model has been proposed by adapting and combining adult theoretical models. The Conceptual Framework of Mindfulness groups theoretical components in to three domains: cognition (attention, awareness, and executive function), attitude (acceptance, curiosity, non-judgment), and ontology (related to all aspects of being; Dawson, Clinton, Quach, & McKenzie, 2019). It is an issue for debate as to whether theoretical and empirical evidence for adults can be applied to children and adolescents, and currently this framework has not been empirically supported for this population.

Others have proposed theoretical models by adopting a neurocognitive or neurodevelopmental approach. Zelazo & Lyons (2012) present three interrelated components of self-regulation: executive function, emotion regulation, and perspective taking that are enhanced following mindfulness training along with greater trait mindfulness. This change is said to be associated with enhanced cognitive functions (e.g., executive function) and greater modulation of bottom-up influences (e.g., emotional arousal) to enhance self-regulation. In a similar model, the integrative neurodevelopmental framework proposed by Kaunhoven and Dorjee (2017) proposes that greater trait mindfulness may modulate bottom-up automatic and top-down volitional control of self-regulation, improving attention and reducing mind wandering. These proposed models highlight the potential importance of mindfulness to effect change in self-regulation for children and adolescents, and that this may confer benefits in other areas of cognitive functioning and wellbeing.

1.3 Mindfulness and Self-regulation

The focus of the chapter in the following section moves to consider self-regulation. This section focuses first on a describing self-regulation, the development of self-regulation and the benefits of self-regulation for wellbeing. The section then progresses to present an overview of research pertaining to mindfulness and self-regulation, including observational, theoretical and empirical evidence. This section places shared emphasis on evidence relating to children, adolescents and adults.

1.3.1 What is self-regulation?

In the present thesis the term self-regulation is used to refer to the interrelated activity of executive function, attention, emotion regulation and the regulation of behaviour, to support the on-going pursuit of a goal (Hofmann, Scmeichel, & Baddeley, 2012; Karoly, 1993). Self-regulation is effortful, for example giving in to temptations is easier than resisting them or reacting automatically and habitually is easier than giving thought to what to do next (Diamond, 2013). Consequently, there is a large body of research exploring self-regulation failures whereby an individual intends to attain but fails to achieve a goal. The strength model of self-control states that self-regulation depends on a limited resource and when this resource is depleted there is an increased possibility for failures of self-regulation (Baumeister & Heatherton, 1996). For example, an individual who is dieting and has already resisted the temptation of crisps, or who has not slept well overnight, may be more likely to break their diet and eat a cream bun.

Successful self-regulation is said to be formed of three components or stages 1) standards of thought, feeling and behaviour that an individual seeks to attain, 2) sufficient motivation to try to reduce differences between the desired standard and the current state, and 3) sufficient capacity to reduce the difference despite any obstacles or distractions (Baumeister & Heatherton, 1996; Heatherton & Wagner, 2011). Executive functions are thought to be a core-component of self-regulation, particularly in ensuring that there is sufficient capacity to reach a desired goal (e.g., see Barkley, 1997; Hofmann et al., 2012). Furthermore, emotion regulation is necessary to ensure that there is an optimal level of emotional arousal to be motivated to obtain a goal without high levels of arousal leading to self-regulation failures (Vohs & Baumeister, 2004).

1.3.2 How is self-regulation associated with health and wellbeing?

Self-regulation is positively associated with several adaptive functions and outcomes in children, adolescents and adults. For example, child and adolescent self-regulation is linked to school success and social competence (Blair & Razza, 2007; Spinrad et al., 2006). Furthermore, greater self-regulation in childhood is a strong predictor of health and wellbeing in adulthood (Moffitt et al., 2011). Deficits or difficulties with self-regulation can result in problems with social and emotional functioning, for example under control can lead to substance misuse or obesity and over control can result in hyper-perfectionism or a lack of emotional expression (Baumeister, Heatherton, & Tice, 1994). Deficits in self-regulation are also a feature of a few externalising problems that are prevalent from childhood, such as attention deficit hyperactivity disorder (ADHD), autistic spectrum disorder, and conduct disorders (Barkley, 1997; Hughes & Ensor,

2011; Ozonoff, Pennington, & Rogers, 1991). Furthermore, in adulthood lower self-regulation is associated with depression and anxiety, as well as more risk taking and poorer health behaviours (Airaksinen, Larsson, & Forsell, 2005; Carver, Johnson, & Joorman, 2008).

1.3.3 When and how does self-regulation develop in children?

The development of self-regulation is associated with the maturation of the pre-frontal cortex, a process that accelerates from late childhood to early adulthood (Casey, Getz, & Galvan, 2008; Fair et al., 2007). The development of self-regulation relies on changes in the function and capacity of executive function and attention networks. In early infancy there is a reliance on the orientation of attention for self-regulation, in particular orientation toward goal relevant and away from goal irrelevant stimuli (Rueda et al., 2004). Attention orientation is reactive and inflexible and ultimately not suitable as the primary mechanism of self-regulation (Petersen & Posner, 2012). During adolescence brain maturation allows for a move to implementation of long-term strategic self-regulation, such as reducing mind wandering and increased use of cognitive appraisal (DeCicco, Solomon, & Dennis, 2012; Deng et al., 2012; Kaunhoven & Dorjee, 2017; McRae, Ciesielski, & Gross, 2012). Childhood experiences can affect the development of self-regulation, particularly where there is heightened stress reactivity that results in increased sensitivity to and decreased regulation of stress or emotional arousal (Fonagy & Target, 2002). This can impact on self-regulation by reducing the efficiency of the executive attention network and heightening activation of brain regions associated with emotional processing (McDermott, Westerlund, Zeanah, Nelson, & Fox, 2012; Noble, Houston, Kan, & Sowell, 2012).

1.3.4 Is there an association between mindfulness and self-regulation?

There is strong evidence of an association between trait mindfulness and self-regulation in adults and emerging evidence supporting an association in children and adolescents. This observational evidence does not elucidate on the directions of these associations, whereby mindfulness may predict self-regulation or self-regulation is an outcome of mindfulness (or vice versa).

In a systematic review of 93 cross-sectional studies with adults, there were significant associations between higher trait mindfulness and executive function and emotion regulation, and negative associations between higher trait mindfulness and impulsivity, stress reactivity, rumination and avoidant coping styles (Tomlinson, Yousaf, Vitterso, & Jones, 2018). Furthermore, in a systematic review of research pertaining to mindfulness and attention, a significant positive

association was found between trait mindfulness and several attention subtypes (sustained attention, alerting and orienting), and one element of executive function (inhibition; $k = 28$; Verhaeghen, 2020). The same author reported no association between trait mindfulness and other measures of executive functions (set shifting, working memory).

In a validation study of a trait mindfulness measure there was a reported significant positive association between trait mindfulness and self-regulation in children aged 10-16 years (de Bruin, Zijlstra, & Bögels, 2014). Similarly, the same study reported negative small to moderate significant associations between trait mindfulness and three aspects of emotion regulation: self-blame, rumination, and catastrophizing, but a non-significant association between trait mindfulness and acceptance. In a further validation study small to moderate significant positive associations were reported for 10–18-year-olds between each of the five facets of trait mindfulness (observing, describing, non-judging, non-reactivity, acting with awareness) and self-regulation (Cortazar, Calvete, Fernández-González, Orue, 2019). Lastly, a number of cross-sectional studies report on the association between trait mindfulness and executive function in children and adolescents aged 7-13 years demonstrating moderate to strong associations with working memory, inhibitory control, and set shifting (Geronimi, Arrellano, & Woodruff-Borden, 2020; Oberle, Schonert-Reichl, Lawlor, & Thomson, 2012; Riggs, Black, & Ritt-Olsen, 2015; Shin, Black, Shonkoff, Riggs, & Pentz, 2016).

1.3.5 What is the theoretical evidence for an association between mindfulness and self-regulation?

Self-regulation appears as one of the most consistent constructs across the proposed models of mindfulness for children, adolescents and adults. For example, self-regulation is one component of the Buddhist informed Self-awareness, Self-regulation, and Self-transcendence (S-ART) framework (Vago & Silbersweig, 2012). The model proposes that self-regulation includes enhanced attention regulation, cognitive regulation and emotion regulation, supported by greater decentering and acceptance, and less experiential avoidance (Vago & Silbersweig, 2012). Similarly, Brown and colleagues (2007) suggest that mindfulness can reduce the presence of filters through which we view the world (e.g., appraisals, memories, schemas) that act to alter our perspective on present moment experiences. Through greater trait mindfulness the theory proposes there is a change toward non-elaborative and non-judgemental processing of experience, which can reduce self-regulation failures caused by for example, high emotional arousal. Furthermore, mindfulness may improve self-regulation through gains in sustained attention (Shapiro et al.,

2006), which may occur by way of reduced cognitive distractions (e.g., mind wandering, elaboration or rumination; Bishop et al, 2004). Greater trait mindfulness may therefore allow a less biased view of the world, reducing emotional and cognitive reactivity to experience, which in turn enhances self-regulation by regulating attention toward a task or goal.

In a review of empirical evidence, the benefits of mindfulness training on self-regulation for children and adolescents were summarised into three areas: coping processes (reduced rumination and maladaptive coping, greater adaptive coping), psychological function (greater self-awareness; and reduced anxiety, anger reactivity, and difficulties with emotions), and cognitive function (enhanced impulse control, attention, and cognitive flexibility; Perry-Parrish, Copeland-Linder, Webb, & Sibinga, 2016). In addition, self-regulation is a principle component of two theoretically proposed models of mindfulness for children and adolescents (see subsection 1.2.5 for more details; Kaunhoven & Dorjee, 2017; Zelazo & Lyons, 2012).

1.3.6 What are the broader implications of researching self-regulation as an outcome of mindfulness?

There may be some tensions between the broader foundations and ethical principles of mindfulness and the construct of self-regulation. This tension may arise for two reasons. Firstly, self-regulation to obtain a goal that is not ethical or a goal that is not aligned with an individual's values, would conflict with the historical principles from which Western mindfulness approaches are developed. An often-used example is that mindfulness training may be used to assist employees to tolerate work related stress or to improve concentration to more effectively carry out negative actions, such as in military settings (for discussion see Monteiro, Musten, & Compson, 2014). Secondly, part of the broader education of mindfulness training is learning to function less in a *doing mode* and more in a *being mode* (Burch & Penman, 2013). In the *doing mode* one would be seeking or striving to obtain a goal or change how things are in the present moment, whereas in the *being mode* one is accepting and aware of their present moment experience (Kabat-Zinn, 2013; Burch & Penman, 2013). Self-regulation may be a process that better aligns with the doing mode, however self-regulation may also support the being mode by regulating attention toward the present moment and regulating emotions in order to hold an accepting attitude to experience. Furthermore, it is recognised in mindfulness training programmes that goal pursuit is a necessary and helpful way to function (Burch & Penman, 2013; Hayes et al., 2009). Similarly, self-regulation to obtain goals that are ethical or in accordance with personal values aligns well with the historical principles of mindfulness. It is also important to consider that self-regulation has broad benefits (as

discussed in section 1.3.3), and it is therefore important to understand how self-regulation may be enhanced.

1.3.7 Can mindfulness training enhance self-regulation?

There is some support for an effect of mindfulness training on self-regulation for adults. The effects of mindfulness training on emotion regulation have been synthesised in a systematic review and meta-analysis of 72 trials, with moderate-strong beneficial effects $d = 0.58$ reported following mindfulness training ($k = 72$; Hoge et al., 2020). A recent systematic review and meta-analysis of 40 trials of mindfulness training for attention and executive function reported moderate significant effects for executive attention, inhibition, updating, working memory, set shifting, and sustained attention but not alerting or orienting (Verhaeghan, 2020). Whereas a systematic review of 57 published papers found mixed evidence from randomised trials of mindfulness training on subsystems of attention (alerting, orienting, executive), but more conclusive evidence of an effect of mindfulness training from research using other designs (e.g., pre-post designs, non-randomised intervention trials; Prakash, Fountain-Zaragoza, Kramer, Samimy, & Wegman, 2020). Two earlier systematic reviews reported little evidence to support an effect of mindfulness-based programmes or mindfulness training on attention and executive function for adults (Chiesa, Calati, & Serretti, 2011; Lau, Kissane & Meadows, 2016).

As well as an outcome of mindfulness training self-regulation has also been proposed as the main mechanism of change following mindfulness training (Tang et al., 2015). Moreover, other theoretical evidence proposes self-regulation as one of several potential mechanisms of mindfulness (see subsection 1.3.6 for more discussion; also see Keng, Smoski, & Robins, 2011). Similarly, a systematic review of intervention studies for mindfulness training identified constructs related to self-regulation, specifically cognitive and emotional regulation, as significant mediators of change following mindfulness training in adults (Gu et al., 2015).

There is preliminary evidence that for children and adolescents, mindfulness training may effect change in self-regulation. The components of self-regulation (executive function, emotion regulation and attention) have been included as outcomes in six systematic reviews. The most recent systematic review and meta-analysis of randomised controlled trials (RCT; $K = 33$) compared the relative effect of MBPs with active and non-active control groups (Dunning et al., 2019). The authors reported a synthesised effect of mindfulness on executive function $d = .30$ ($k = 15$) and attention $d = .19$ ($k = 15$). Notwithstanding, there was moderate statistical heterogeneity

for those studies measuring executive function, and across both outcomes of executive function and attention a risk of publication bias and low methodological quality. Furthermore, when the mindfulness intervention was compared to only active control groups, the effects on executive function d = .10 (k = 7) and attention d = .13 (k = 5) were no longer significant.

In a systematic review by Klingbeil and colleagues (2017), 76 studies (including pre-post designs) were identified from both community and clinical samples of children and adolescents aged 3-18 years. There was a significant synthesised effect for the mindfulness-based interventions on meta-cognition and cognitive flexibility g = .40 (k = 9), attention g = .29 (k = 10,) and emotional and behavioural regulation g = .32 (k = 16). Notwithstanding, the authors reported moderate to high heterogeneity for each of the subgroup meta-analyses.

In a systematic review of attention and executive function outcomes (K = 13), Mak and colleagues (2018) included studies from community and clinical populations of children and adolescents aged 5-18 years, using a broad definition for the intervention where mindfulness, yoga and meditation interventions were included. Results were synthesised narratively except for a meta-analysis (k = 2) that found no significant effect d = -.11 of the mindfulness training on the Stroop Test (Stroop, 1935). Overall, the authors concluded that mindfulness had the potential to impact on executive function and attention in children and adolescents, although they stated the evidence did not yet offer any firm evidence.

In an inclusive review of mindfulness-based interventions for children and young people aged 4-20 years, Maynard and colleagues (2017) included all designs (including case studies), studies with and without control groups, and measures related to cognitive, behavioural and socio-emotional outcomes, as well as reports of academic achievement. The reported meta-analysis demonstrated there was an effect on cognitive outcomes g = .25 (k = 10), and socio-emotional outcomes, including emotion regulation g = .22 (k = 28). Across the included studies there was low to moderate methodological quality, a risk of publication bias for those studies reporting cognitive outcomes, and potential for researcher allegiance bias (51% of studies included authors who had a role in intervention development or delivery). Two slightly older systematic reviews report similar effects for cognitive outcomes and attention and present the same caveats about the quality of the included evidence (Zenner, Herrnleben-Kurz, & Walach, 2014; Zoogman, Goldberg, Hoyt, & Miller, 2015).

Across systematic reviews there is some support for an effect of mindfulness training on components of self-regulation, although this is a tentative conclusion given the acknowledged risks of bias and high heterogeneity. A limitation to this evidence is that mindfulness training is formed of multiple components (Crane et al., 2017) and typical intervention trials are unable to pull-out the contributions of each intervention component on overall effects. One component of mindfulness training is mindfulness meditation practice and the experimental evidence for the effect of this component of training on self-regulation will now be presented.

1.3.8 What are the effects of mindfulness meditation practice on self-regulation?

Current experimental evidence offers some support for a potential for mindfulness meditation practice to elicit a short-term effect on the emotion regulation component of self-regulation in adults. Notwithstanding there are issues pertaining to methodological quality and risk of bias that challenge confidence in the existing evidence, as documented in the two available published systematic reviews. In a systematic review and meta-analysis of 34 studies there was no significant effect of a mindfulness meditation practice on executive function (k = 9) or attention (k = 10; Gill et al., 2020). The authors reported that the majority of included studies had a weak methodology and high risk of bias, although there was no examination of the effect of methodology (e.g., research design) on outcome effects. In a second systematic review and meta-analysis there was a significant effect of a single mindfulness meditation practice compared to control activities on negative affectivity g = .22 (k = 54), with the authors highlighting the presence of publication bias as a caveat to this evidence (Schumer et al., 2019). In the same review a separate subgroup analysis revealed a larger effect of a brief mindfulness training (from a single mindfulness meditation practice to two weeks of mindfulness training) on negative affectivity g = .27 when including a distress paradigm (relative to when no distress paradigm was used, g = .10). The use of distress paradigms in experimental trials for a single mindfulness meditation aids in assessing the effect of mindfulness meditation on emotion regulation.

Application of the experimental method applied to mindfulness meditation practices for self-regulation can include or not include a distress paradigm. An example of an experiment using a distress paradigm is given by Arch and Craske (2006) where a 15-minute mindfulness meditation practice (mindfulness of breathing) was compared to two control groups (mind wandering or induced worry). Participants (N = 60) were presented with emotional visual imagery (negative or positive) and then assessed for their emotional state. The authors reported some significant differences in emotion regulation favouring the mindfulness meditation compared to those in the

induced worry group for lower negative affect; however, many of the between group differences were not significant. An example of an experimental trial that did not use the distress paradigm was a comparison of a 25-minute mindfulness meditation, with a sham meditation (practice explicitly labelled as a mindfulness meditation but no mindfulness instructions) or a book reading control on measures of state mindfulness, executive function and attention (N = 92; Johnson, Gur, David, & Currier, 2013). There were significant effects of both the mindfulness meditation practice and the sham meditation practice to increase state mindfulness relative to the control condition, but no significant effects on executive function or attention.

There has been considerably less research interest testing the effect of a mindfulness meditation on self-regulation in children and adolescents relative to adults. There are currently four published papers with the evidence being inconclusive as to whether there is an effect of mindfulness meditation practice on self-regulation in children and adolescents. For example, Hilt and Pollak (2012) randomly assigned 96 young people aged 10-14 years to either an 8-minute mindfulness meditation practice, problem solving activity or a distraction exercise and compared the effect of the practice on emotion regulation (rumination) following a social stressor activity. There was a positive significant effect of the mindfulness meditation compared to the problem-solving activity for rumination, but no difference between mindfulness meditation and distraction.

Lim and Qu (2017) found no significant differences in the effect of a 15-minute mindfulness meditation practice or comparison activity (time spent dancing, singing, and counting) for 92 children age 4-6 years on the subsystems of attention (alerting, orienting, executive) as measured by the Attention Network Task (Rueda et al., 2004). Nadler and colleagues (2017) used the self-assessment manikin (Bradley & Lang, 1994) as a measure of self-regulation with 46 children (in two samples) aged 7-9 years, and found a positive significant difference following the mindfulness meditation practice compared to the non-active control condition in calmness (also known as arousal), but no difference in pleasure or dominance. Deng and colleagues (2019) assessed emotion regulation in 35 children aged 9-11 years using event related potentials following presentations of negative, positive and neutral visual stimuli. A 10-minute mindfulness meditation was compared to a non-active control with significant differences detected favouring the mindfulness meditation practice. Specifically, mindfulness meditation had a significant effect on attention control, selective attention to negative stimuli and emotion regulation. Despite the authors highlighting the significant effects of the mindfulness meditation practice, around two thirds of the statistical between group comparisons were not significantly different.

There are considerations related to the limitations of the existing evidence testing the effect of a mindfulness meditation practice on self-regulation with children and adolescents. Specifically, the sample sizes were small across the included studies (N_{range} = 35-96), which would undoubtedly have limited the power of the included studies to detect an effect. There were other methodological considerations, such as the conceptualisation of the calmness component of the self-assessment manikin as a measure of self-regulation (Nadler et al., 2017). Specifically, the measure of calmness is a visual self-reported measure of state affect, which in the absence of any requirement for emotion regulation is not a measure of self-regulation. Another shortcoming of the existing evidence is that there are no experimental studies with children or adolescents measuring the effect of a mindfulness meditation practice on executive function. This is a pertinent issue as executive function is considered a principle and highly necessary component of self-regulation (Hofmann et al., 2012). Similarly, there is only one published experimental study measuring the effect of a mindfulness meditation practice on attention (Lim & Qu, 2017). This study used the child version of the ANT as the attention measure (Rueda et al., 2004), which measures the efficiency of three distinct networks of attention: executive control, orienting and alerting. A review of the evidence suggests that the ANT may not be an appropriate measure of pre-post change in attention given its low test-retest reliability (MacLeod et al., 2010).

1.3.9 Current gaps in the evidence base

The most pressing gap in the evidence for an effect of mindfulness meditation practice on outcomes relating to self-regulation was that as of 2017 there had been many published experimental trials but no systematic search and synthesis of this evidence. The lack of a systematic synthesis of this evidence meant that there was a risk of selection bias in the reporting of the effects of mindfulness meditation practices on self-regulation. As such one aim of the present thesis was to address this gap in the evidence base by conducting and publishing the first systematic search and synthesis of experimental research testing the effect of a single mindfulness meditation practice (Leyland, Rowse, & Emerson, 2019). The focus of this review was on evidence pertaining to self-regulation and it is this research that forms the basis of chapter two in this thesis.

The current evidence base applying an experimental method to test the short-term effects of a mindfulness meditation practice for self-regulation in children and adolescents is relatively small. As such there is a lot of potential for further empirical exploration. The present thesis aims

to address two areas where further research may make a significant contribution. Firstly, testing the effects of a mindfulness meditation practice on executive function and secondly testing the effect on a measure of attention more appropriate for experimental designs. Furthermore, the empirical evidence of the present thesis seeks to improve on the methodological limitations seen in the sample sizes and operationalisation of outcomes within the existing evidence.

1.4 An overview of the present thesis

Mindfulness meditation practices have the potential to effect short term change in self-regulation. These short-term state changes may lead to long term changes in self-regulation that have broad benefits for health and wellbeing of children, adolescents and adults. Furthermore, mindfulness meditation practices are a core component of mindfulness training, and they are potentially an active contributor to the effects gained following mindfulness training. There are gaps in understanding of the mechanisms of mindfulness and mindfulness meditation practice in effecting change in self-regulation. A significant gap is the lack of a rigorous synthesis of existing experimental trials of the effect of mindfulness meditation practice on self-regulation. In addition, the empirical trials that have been conducted with children and adolescents have had methodological weaknesses including small sample sizes, poor operationalisation of self-regulation as the core construct and low reliability of outcome measures. Furthermore, in children and adolescents there has been no investigation of the potential of a mindfulness meditation practice to effect change in executive function, a core component of self-regulation.

The research presented in this thesis aims to contribute evidence to answer the following research questions:

i. What is the effect of a single mindfulness meditation practice on self-regulation?
ii. Can mindfulness meditation practice effect a short-term change for self-regulation in children aged 4-11 years?

To answer these research questions the present thesis presents a systematic review and meta-analysis of experimental investigations using an experimental design to test a single mindfulness meditation on self-regulation and two empirical studies applying the same design with children. The findings of the chapters of this thesis will now be briefly summarised.

Chapter two systematically reviewed 27 randomised experimental studies as to the immediate effect of a mindfulness meditation practice on self-regulation for all ages. A meta-analysis revealed a significant effect of mindfulness meditation compared to control activities on the regulation of experimentally induced negative affect d = -.28. Narrative synthesis revealed that there was little evidence for a direct effect of a mindfulness meditation practice on emotion regulation strategies or executive function and only emerging evidence of an effect on attention.

Chapter three showed that a 5-minute mindfulness meditation practice was not sufficient to enhance executive functions of children aged 4-7 years (N = 156). Participants were randomly assigned to either a mindfulness or active control condition before completing four measures of executive function.

Chapter four showed that a 10-minute mindfulness meditation practice was sufficient to effect significant change in minor sustained attention errors d = -38, when compared to an active control activity in children aged 7-11 years (N = 191). The effects of the mindfulness meditation practice on sustained attention were moderated by greater positive state affect. The findings provide preliminary support that mindfulness meditation practice may be an active component of mindfulness training for children from age 7 years.

Overall, the thesis demonstrates that there is evidence for all ages of a direct short-term effect of a single mindfulness meditation practice on self-regulation by impacting on attention and state affect. Chapter five presents an original theoretical model for the short-term effects of mindfulness meditation practice on self-regulation based on these thesis findings. As such the findings of this thesis offer a novel contribution to an emerging area of research within the domain of mindfulness.

2

EXPERIMENTAL EFFECTS OF MINDFULNESS INDUCTIONS ON SELF-REGULATION: SYSTEMATIC REVIEW AND META-ANALYSIS

The research presented in chapter two (from section 2.1) is a published manuscript in a peer-reviewed journal: Leyland, A., Rowse, G., & Emerson, L. M. (2019). Experimental effects of mindfulness inductions on self-regulation: Systematic review and meta-analysis. *Emotion, 19*(1), 108.

The research presented in this chapter builds on the review of evidence from chapter one. Specifically, chapter one presented evidence in support of mindfulness meditation practices as an active component of mindfulness training, contributing to the many reported benefits of mindfulness training and enhanced trait mindfulness. The chapter also reviewed evidence for the direct effects of a single mindfulness meditation practice as assessed by experimental trials, concluding that a systematic synthesis of findings from experimental trials of mindfulness meditation practice was required in order to draw clear evidence from this pool of literature. Furthermore, self-regulation was identified as an outcome of mindfulness training and a moderator of the effects of mindfulness training on other outcomes. Chapter one also identified that self-regulation was a theoretically proposed mechanism of mindfulness for children, adolescents and adults supported by empirical and observational evidence.

This chapter draws on the findings and conclusions of the previous chapter by conducting a systematic review, meta-analysis and narrative synthesis of experimental designs testing the short-term effect of a single mindfulness meditation practice on self-regulation. This chapter addresses

the first thesis research question that seeks to understand what effect a single mindfulness meditation practice has on self-regulation.

2.1 Introduction

Self-regulation is the regulation of affect, cognitions or behaviours in accord with goal directed behaviour (Karoly, 1993). Self-regulation has been considered to encompass three main components. The first is the endorsement of standards of thought, feeling or behaviours that are mentally represented and monitored. The second component is the motivation to reduce discrepancies between standards and real states. The third component is sufficient capacity to reduce the discrepancy, despite encountering barriers and temptations (Baumeister & Heatherton, 1996; Carver & Scheier, 2012). Failures in self-regulation can occur in any of these three areas and all are considered to be necessary to enable successful self-regulation. Difficulties with self-regulation are symptomatic of many clinical conditions, such as impulsivity in attention deficit hyperactivity disorder (Barkley, 2010) or rumination in depression (Aldao, Nolen-Hoeksema, & Schweizer, 2010). However, problems with self-regulation are also common in non-clinical populations and are negatively associated with physical health, management of personal finances and criminal offending (Moffitt et al., 2011). Self-regulation is a complex function relying on multiple cognitive and affective systems, and effective symbiosis between these systems. The most pertinent systems are executive functions (EFs) and emotion regulation. The discussion of self-regulation will therefore be presented here with consideration of self-regulation via these two related mechanisms.

2.1.1 Executive function and emotion regulation: core components of self-regulation

Some of the proposed mechanisms underpinning self-regulation are EFs, which have been widely accepted by researchers as consisting of working memory, inhibitory control of prepotent impulses and mental set-shifting (Miyake et al., 2000). A bi-directional model of EFs and self-regulation has been proposed that presents the constructs as operating in an interactive feedback loop (Blair & Urasche, 2011). Within this model, EFs are primary mechanisms for self-regulation, particularly impacting on and interacting with attention and emotion systems. Through this, EFs facilitate self-regulation by directing attention and emotion systems, while also depending on bottom-up nonexecutive regulation of attention and emotion to effectively operate (Blair & Urasche, 2011). Factors such as stress, intoxication and negative affect can impair EFs and

consequently cause self-regulation failures (See Hofmann, Schmeichel, & Baddeley, 2012; Wagner & Heatherton, 2014)). As an exemplar, negative affect can disrupt self-regulatory processes by interfering with each stage of self-regulation: amplifying desires, decreasing monitoring, depleting limited capacity and encouraging incorrect use of regulation strategies (Wagner & Heatherton, 2014). If not effectively regulated, negative affect may even lead to self-regulation failure, where behaviours are enacted that are not in line with long term goals and a state of negative affect persists.

The self-regulation of emotion or 'emotion regulation' is broadly defined as any effort that is made to modulate emotional experiences (Gross, 2002). Situations can give rise to affective responses both with primary immediate raw emotional responses and a secondary regulated response (Larazus, 1991). The temporality between these two phases of response can vary, as can the regulatory strategy. The process model of emotion regulation identifies four stages of emotion generation (Gross, 1998; 2001). The stages are the emotive situation, the deployment of attention, cognitive appraisals and emotion expression. Each stage has potential to give rise to emotions and be the target for different emotion regulation strategies. The strategies for emotion regulation include modification or selection of the situation, attention deployment away from emotive stimuli, changing the cognitions relating to the situation, and response modulation. It is proposed that engaging in emotion regulation strategies at an earlier stage of the process is more cognitively efficient and effective (Gross, 2001). For example, exiting the emotive situation (situation selection) uses less cognitive resources and is more effective than altering the cognitive appraisals of the emotive situation (cognitive change).

To support goal pursuit the feedback model of emotion and behaviour denotes that the primary mechanism of most emotions is to inform cognition, which can in turn elicit behaviours or behaviour changes (Baumeister, Vohs, DeWall, & Zhang, 2008). In some cases, behaviour may be directly guided by reflexes (e.g., flight or fight) or highly charged emotions. These reflexes, such as an urge to flee a situation, can impair EFs and result in impulsive behaviours. These impulsive actions may not be in line with long-term goals. Emotions are considered far more challenging to regulate than cognitions or behaviours and often they require the most complex interventions and strategies to elicit change (Baumeister, Vohs, DeWall, & Zhang, 2007; Baumeister, Heatherton, & Tice, 1994).

2.1.2 Mindfulness and self-regulation: theoretical models

Mindfulness meditation is often described as non-judgemental attention and acceptance of present moment experience (Brown & Ryan, 2004). Several theoretical models include self-regulation as a proposed mechanism of change of mindfulness training. Tang, Hölzel and Posner (2015) suggest that mindfulness meditation exerts effects through emotion regulation, attention control and self-awareness. These three components work together to generate enhanced self-regulation. Mindfulness may serve as a tool for emotion regulation by increasing reperceiving of experience, also referred to as mindful reappraisal or decentering. As a meta-cognitive function, reperceiving requires a process of stepping back from an experience in order to more clearly assess it (Garland, Gaylord, & Park, 2009). Within the process model of emotion regulation, these are examples of cognitive change strategies of emotion regulation that occur as appraisals of emotions are altered (Gross, 2001). Attention control or attention regulation pertains to the ability to sustain attention on a chosen object and to redirect attention back to the object when there are distractions (Hölzel et al., 2011). Mindfulness practices often include a focus of attention, such as the breath, and instructions to return attention to the breath when it inevitably moves to other internal or external foci. The cultivation of attention control in this manner is considered a foundation for later meditative practices (Hölzel et al., 2011). The process model of emotion regulation asserts that attention redeployment is an emotion regulation strategy and is more cognitively efficient than processes of cognitive change (Gross, 2001). The redeployment of attention can be both volitional and automatic (Posner & Petersen, 1990).

Mindfulness training supports volitional control of attention toward a selected object, such as the breath. Ultimately a goal of mindfulness training may be to increase awareness and ability to attend to emotions, cognitions and physical sensations, even when these experiences are highly emotionally charged. Counterintuitively the volitional control of attention towards a chosen object but away from the emotionally charged experience, e.g., towards the breath and away from feelings of sadness, may support increased awareness of and attention to the difficult experience. This temporary redeployment of attention away from the emotive experience may reduce the intensity of the emotionally charged experience and lessen the likelihood that a habitual behavioural reaction will be enacted. As a result, effective reappraisal strategies, such as decentering, can be more readily employed (Shapiro, Carlson, Astin, & Freedman, 2006). Mindfulness may enhance self-awareness, as mindfulness training promotes greater observation of internal experiences such as of the senses, breath and emotions (Hölzel et al., 2011).

The self-awareness, self-regulation and self-transcendence framework (S-ART) also provides a framework for understanding the mechanisms of mindfulness (Vago & Silbersweig, 2012). The S-ART framework views mindfulness as a training method to reduce self-specific biases through development in three areas. The first two areas are the enhancement of meta-awareness (self-awareness) and the effective management or alteration of impulses and behavioural responses (self-regulation). The final area is the development of a more positive relationship between the self and the environment that extends beyond mere selfish needs (self-transcendence). Furthermore, the S-ART framework proposes that mindfulness exerts change on these three domains via specific mechanisms of action: intention and motivation; attention regulation; emotion regulation; memory; prosociality; and non-attachment or decentering.

An alternative model proposes three axioms of mindfulness: intention (reason underpinning choice to practice mindfulness), attention (observation of moment-to-moment experience) and attitude (of acceptance, kindness and openness). These three axioms underpin a meta-mechanism of 'reperceiving', which then gives rise to several mechanisms of change, including self-regulation (Shapiro et al., 2006). In a similar manner the three mechanisms of mindfulness (emotion regulation, attention control and self-awareness) proposed by Tang and colleagues (2015) are all underpinned by the attitude and intention brought to the mindfulness practice by the individual. It is these axioms that determine the spirit with which one is paying attention and motivates one to practice mindfulness (Shapiro et al., 2006).

2.1.3 Mindfulness interventions and mindfulness inductions

Mindfulness-based interventions (MBIs) are typically formed of eight weeks of mindfulness training that encompasses experiential exercises (e.g., mindfulness of breathing, body scan), group discussions, home practices and psychoeducation relating to mindfulness theory and research. This typical group-based training format originates from two of the most influential mindfulness training models: mindfulness-based stress reduction (MBSR; Kabat-Zinn, 1990) and mindfulness-based cognitive therapy (MBCT; Williams, Teasdale, Segal, & Kabat-Zinn, 2007). Systematic reviews of the evidence identify significant positive effects of MBIs on emotion regulation (Eberth & Sedlmeier, 2012; Gu, Strauss, Bond, & Cavanagh, 2015) and mixed evidence for significant positive effects on EFs (Chiesa, Calati, & Serretti, 2011; Lao, Kissane, & Meadows, 2016). Although a review by Gu and colleagues (2015) reported on the theoretical support for self-regulation as a mediating mechanism of mindfulness interventions, they found no randomised

controlled trials or quasi-experimental studies that had tested this assertion. There is therefore more support for direct effects of mindfulness interventions on cognitive and affective aspects of self-regulation than viewing self-regulation as a mediating mechanism of mindfulness.

There is growing experimental interest in the potential utility of mindfulness as a one-off novel practice, referred to here as a mindfulness induction. A mindfulness induction is an experiential mindfulness practice that may form part of an MBI programme, for example mindfulness of breathing, loving kindness and acceptance practices. As an exemplar of a mindfulness induction, Arch and Craske (2006) utilised a 15-minute guided practice focussing attention on present moment sensations, including the breath, before assessing emotion regulation. A mindfulness induction utilised in an experimental design allows for more control over the nature and dosage of the exposure, and its comparator. Consequently, more robust casual inferences can be drawn (Keng, Smoski, & Robins, 2011; Tang, Hölzel, & Posner, 2015).

Mindfulness inductions differ in many ways from MBIs as they are standalone experiential practices delivered without broader instruction on mindfulness theory or education. In comparison, MBIs have multiple sessions and include broader training, group discussion and homework practices. Additionally, the formation of MBIs is supported by guidelines regarding their necessary constituents (Crane et al., 2017). Whereas mindfulness inductions have no agreed form for their content, delivery mode or duration. As a result, the format and delivery of each mindfulness induction is variable across published papers. In a narrative review of the literature, Keng et al. (2011) concluded that a mindfulness induction could lead to immediate benefits, particularly for recovery from dysphoria and reducing emotional reactivity to aversive stimuli. A mindfulness induction was also shown to increase decentering (Mahmood, Hopthrow, & Randsley de Moura, 2016; Lebois et al., 2015), reduce thought suppression (Brunyé et al., 2013), and aid recovery from negative mood (e.g., stress, Steffen & Larson, 2015; low mood, Huffziger & Kuehner, 2009). Similarly, a mindfulness induction has improved executive attention (Kuo & Yeh, 2015; Gorman & Green, 2016). In a review of neurobiological evidence, three mindfulness induction studies (comparing to no-control, cognitive reappraisal and no instruction) measuring functional magnetic resonance imagery provide evidence of both top-down and bottom-up emotion regulation effects (Guendelman, Medeiros, & Rampes, 2017). This evidence contradicts some previous conclusions that novice meditators employ only top-down regulatory strategies (Chiesa, Serretti, & Jakobsen, 2013). The extent to which pre-existing theoretical models of mindfulness explain the empirical

effects of a mindfulness induction has not been explored in the literature, nor have alternative theories been proposed.

2.1.4 Aims and scope of the systematic review

Currently there is promise for a direct effect of a mindfulness induction on self-regulation. However, a comprehensive review of empirical investigations of the effects of a mindfulness induction on self-regulation across multiple disciplines is necessary to estimate the presence or strength of an effect. In a non-clinical population, self-regulation can be more precisely considered. One reason for this is because the presentation of self-regulation difficulties in non-clinical populations is more homogenous and is not interacting with other aspects of a complex clinical presentation. Therefore, as the initial attempt to consolidate evidence in this field, this review is focused on self-regulation in a non-clinical population. This focus can broaden our understanding of the theories and mechanisms of mindfulness, which can then be applied to more complex and specific presentations of self-regulation as they appear in each clinical group.

Self-regulation is a broad term that encompasses cognitive, affective, behavioural, physiological and neurological areas of functioning. This multiplicity is reflected in the use of diverse empirical measures and nomenclature denoting the term. This review focuses on the affective and cognitive domains of self-regulation measured using behavioural and self-report means. This spotlight on the evidence corresponds with the dominant theories of self-regulation the critical and intertwined role of emotions and cognitions in facilitating or precluding self-regulation and goal pursuit. Additionally, there is empirical support for the affective and cognitive aspects of self-regulation as a target for mindfulness training and theoretical evidence of self-regulation as a possible mechanism of mindfulness.

Specifically, the review reports on outcomes for emotion regulation and EFs, as these emerged as appropriate subgroups for the outcomes of the articles that met the inclusion criteria. Emotion regulation is measured in two ways, the regulation of experimentally induced negative affect and changes to regulatory strategies (e.g., rumination, decentering). EFs include three constructs: updating, set-shifting and inhibitory control (Miyake et al., 2000). Measures pertaining to the EF outcome have been grouped accordingly. Thus, the results are presented pertaining to three areas: the regulation of experimentally induced negative affect (meta-analysis), emotion regulation strategies and EFs (narrative synthesis). Based on the theoretical and empirical links

between mindfulness and self-regulation, we aim to explore whether a mindfulness induction can enhance self-regulation compared to alternative inductions.

2.2 Method

2.2.1 Search strategy

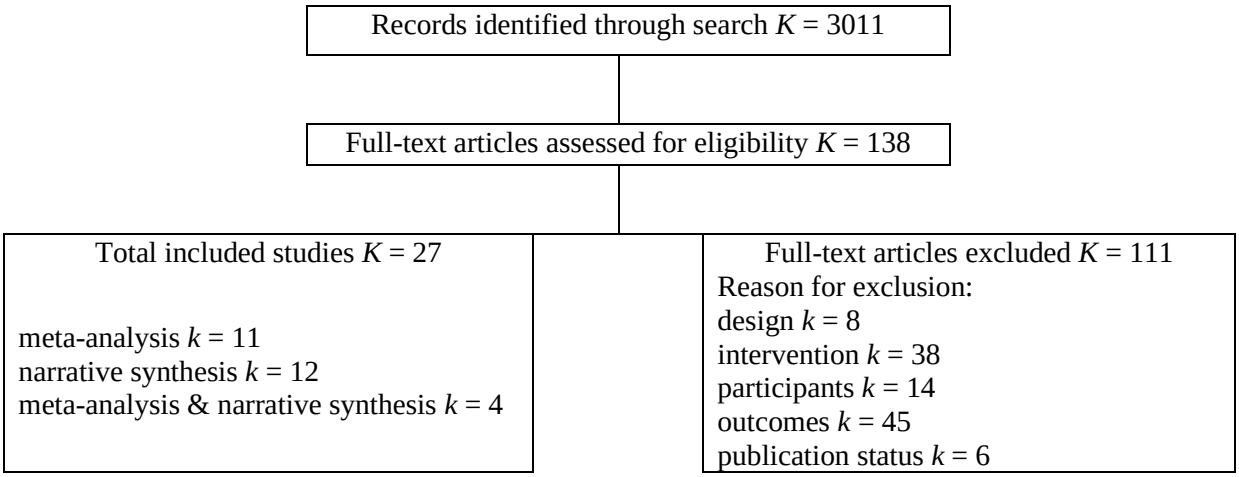
Major psychological and related databases (PsycINFO; PsychARTICLES; MEDLINE, Web of Science and ProQuest Dissertation & Theses) were searched using descriptors for the three key search areas: mindfulness meditation ("mindfulness*"; "loving kindness"; "mindful"; "body scan"; or "focused attention"); *experimental laboratory design* ("experimental" or "laboratory") and brief mindfulness induction ("brief"; "induction"; "instruction"; "short"; "single"; or "one"). Database tools were utilised to identify truncations or alternative spellings of terms (e.g., "mindful*"). Forward and backward citation searches were conducted for key reviews (Keng et al., 2011; Williams, 2010; Webb, Miles, & Sheeran, 2012; Levin, Hildebrandt, Lillis, & Hayes, 2012) and all articles meeting inclusion criteria. Finally, the journal 'Mindfulness' was hand-searched. Where relevant dissertations or theses were identified, a targeted search was conducted for published content. Searches concluded in May 2017.

2.2.2 Selection Criteria

A flowchart of the study selection process is shown in Figure 2.1. Qualifying studies fulfilled five selection criteria: (1) experimental design where participants were allocated to a mindfulness induction or comparison group and all data was collected in one session. Designs incorporating additional experimental inductions (e.g., negative affect, rumination) were included except where both inductions were delivered concurrently, as this mode of delivery constitutes a different form of mindfulness practice; (2) A mindfulness induction was defined as a practice derived from one of the core experiential components of MBIs (e.g. mindfulness of breathing, body scan) with a single practice completed in one experimental session. (3) Participants were drawn from a general non-clinical population, extending exclusions to those who selected a subsection of non-clinical participants e.g., heavy drinkers, elevated depression. Data collection occurred independently (e.g. not through group interactions) and the majority of the participant sample had no previous meditation experience; (4) Outcomes were behavioural or self-report measures of self-regulation including: regulation of negative affect (e.g. affect measure before-after induction), emotion regulation strategies (e.g. self-report use of a regulation strategy) and EFs; (5) Status of publication included peer reviewed publications written in English.

The papers included in the three outcome groups: regulation of negative affect, emotion regulation strategies and EFs, were considered with regards to their methodological similarity, for example the outcome measures, order of induction, inclusion of additional experimental induction. Only one outcome group, the regulation of negative affect, was considered sufficiently methodologically homogenous for meta-analysis. Additional criteria only applied to papers included in the meta-analysis were (6) randomisation to experimental group, (7) induction of negative affect (e.g., sadness, anger) and (8) the subsequent measurement of negative affect as an indicator of emotion regulation. Outcome data from one study could be included in more than one outcome subgroup and when the subgroup was analysed narratively, more than one outcome measure could be included in the analysis. A list of excluded studies, and the rationale for exclusion, can be obtained from the first author upon request.

Figure 2.1 Flow chart of study inclusion and exclusion process



2.2.3 Quality appraisal

The quality of included papers was assessed using the Effective Public Health Practice Project tool for quantitative studies (EPHPP; 2009), which is appropriate for use on cross-sectional case-control design studies. The EPHPP tool consists of 15 questions across six components (selection bias, study design, confounders, blinding, data collection methods, withdrawals and dropouts). A rating for each component and overall quality is made according to the following: strong (overall no weak components), moderate (overall 1 weak component) or weak (overall 2 or more weak components). The withdrawals and drop-outs item of the EPHPP was adapted to include participant data that was excluded for any reason (e.g., technical error), in order to accurately capture the number of participants whose data was collected in part or in full but subsequently not analysed. The quality of the included studies was assessed by a second researcher

with an agreement of *Kappa* = .82; discrepancies, mostly regarding the application of the validity and reliability items, were resolved through discussion.

2.2.4 Data extraction

The following data were extracted for each study: publication details; study design; details of mindfulness induction; participant details; induction manipulation measure (e.g. state mindfulness, negative affect) and details about the primary outcome measures used. Descriptions of comparison group activities were coded (by the first author and a post-graduate researcher) into five categories: distraction (activity not related to self-directed thoughts e.g. reading), mind wandering (instruction to think freely), maladaptive regulation (instruction to have self-directed thoughts, worries or suppress thoughts); alternative adaptive regulation (instructions informed by other therapeutic techniques known to alter affect, such as reappraisal) and no instruction (no activity, waiting). Agreement between coders was *Kappa* = .85; with discrepancies resolved through discussion.

Only one outcome was included from each paper in the meta-analysis (regulation of negative affect). Where there was more than one comparison group the comparator was the least active in the following order: no instruction, distraction, mind wandering, alternative adaptive regulation and maladaptive regulation. For the remaining outcomes (emotion regulation strategies, EFs) all relevant data were extracted. Data from Stroop tests (Stroop, 1935) and the Flanker Task (Eriksen & Eriksen, 1974) were entered as interference scores calculated by dividing the differences in latencies in reaction times or error rates of incongruent and congruent trials by the total latencies or error rates for both trial types.

2.2.5 Calculation of effect sizes

Standardised mean differences were calculated based on means and standard deviations as the measure of effect sizes for all relevant data for the three outcomes. Where available, the pre-test standard deviation was utilised, as it is a more consistent estimate of variance between groups because there is no effect of the experimental manipulation (Becker, 1988). Where insufficient data was reported (k = 10), corresponding authors were contacted to obtain access to data; where this was not provided (k = 3), test statistics were used to calculate effect sizes (k = 1), or the findings were presented as a narrative summary only (k = 2). Standardised mean differences were calculated comparing the mindfulness induction group with each comparison group separately. A meta-analysis pooled the effects of a mindfulness induction on the regulation of negative affect

using a random effects model. The random effects model assumes each effect size distribution interacts with the between study variance component (τ^2, Hedges & Vevea, 1998). This approach allows for broader generalisation of the findings (Field, 2005) and reduces the Type I error rate inflated by the fixed effects model (Hunter & Schmidt, 2000). The meta-analysis was conducted in Review Manager 5 with the analytical process informed by Deeks and Higgins (2010).

2.2.6 Heterogeneity and publication bias

For meta-analytic data, heterogeneity of effect sizes was determined using the Q-statistic and I^2 values. The Q-statistic tests the hypothesis that variance of the effect sizes is no different than would be expected as a result of sampling error alone. I^2 was calculated as an indicator of the proportion of heterogeneity among the studies that is beyond that which may be expected by chance (Higgins & Thompson, 2002; Higgins, Thompson, Deeks, & Altman, 2003). I^2 values of 25, 50, and 75 were considered low, moderate and high respectively (Higgins & Thompson, 2002).

Publication bias can result in overrepresentation of significant findings in published papers (Rothstein et al, 2005) and for this review the effect of publication bias was assessed visually on a funnel plot (Egger, Smith, Schneider, & Minder, 1997) and through calculation of the Fail-Safe *N* (Rosenthal, 1979). The funnel plot represents the distribution of study effect sizes against the standard error of effects. In the current sample a bias would be identifiable by a missing right-hand tail of an inverted funnel shape. In the event of visual identification of bias, a trim and fill method are required to identify the number of studies that favour the comparison induction that would need to be published in order to eliminate the effect of publication bias on the meta-analysis outcome (Duval & Tweedie, 2000). The fail-safe *N* indicates the number of missing studies that have a mean effect of zero that would need to be added to the existing studies before the combined effect is no longer statistically significant.

2.3 Results

Twenty-seven studies met inclusion criteria (Figure 2.1) but only a subset of included articles was deemed suitably methodologically homogenous to be entered into a meta-analysis. Fifteen papers reporting effects on the regulation of negative affect following an emotion induction were sufficiently similar in design to be pooled in a meta-analysis. The remaining two groups were synthesised narratively for outcomes pertaining to emotion regulation strategies (k = 7) and EFs (k = 9; Figure 2.1). These papers were methodologically heterogeneous with regards to the variation of the outcome measured, including differences in the target construct (e.g., inhibition, updating,

set shifting as subcomponents of EF) and means of assessment (e.g., Stroop test, digit span). Additionally, a subset of these papers included other experimental manipulations (e.g., affect induction; *k* = 19; Table 2.1).

2.3.1 Quality

Overall, the quality of the included papers was rated as weak in both the meta-analysis (*k* = 11) and narrative synthesis (*k* = 14; Table 2.1) based on the criteria of the EPHPP appraisal tool. The areas of weakness particularly related to the generalisability of the samples, as most were from undergraduate populations (*k* = 26), failure to report on or use valid and reliable outcome measures (*k* = 20) and non-reporting or unclear reporting of exclusions of data (*k* = 10). Also, despite the experimental methodology lending itself well to a double-blind procedure, explicit reports of blinding of experimenters (*k* = 3) or participants (*k* = 4) were rare and consequently the papers scored lower on this component.

2.3.2 Mindfulness induction

A design overview and summary of mindfulness inductions of the 27 included papers is presented in table 2.1. Most mindfulness inductions referred to a focal object (*k* = 22) such as the breath, senses or food. Most mindfulness inductions gave instructions to be aware of the breath or body (*k* = 24), focus attention (*k* = 14) and acceptance of experience (*k* = 16). A small proportion of papers included full scripts of the inductions in text or as supplementary materials (*k* = 5). The average duration of mindfulness induction was 10-minutes (*SD* = 3 minutes; range = 5-25 minutes). There were 39 comparison inductions described across the papers, with 12 papers reporting two comparators. The most frequently used comparison group was distraction (*n* =17), followed by no instruction (*n* = 6), alternative adaptive regulation (e.g., reappraisal; *n* = 6), mind wandering (*n* = 5) and maladaptive regulation (e.g., thought suppression; *n* = 5).

Table 2.1 Overview of study characteristics across all included studies, including descriptions of mindfulness and comparison inductions

				Mindfulness induction components								
Author (year) Country	Study Design / Procedure/ Randomised	N (attrition)	Quality	Focus attention	Regulate attention	Aware present moment	Aware breath/ body	Aware thoughts/ emotions	Attitude	Mindfulness induction duration (mins)/ descriptor/ script / origin	Comparison induction(s)/ Manipulation Check	Experimental Induction (EXI) method/ inducing/ manipulation check/ measure
Arch & Craske (2006) USA	POST; EXI-MF-EXI-	60 (-)	WK	X		X	X			15; Ind; Exerts; KZ + SEG	MW MAL; Y	Images; NA; Y; PANAS
Bing-Canar, Pizzuto, & Compton (2016) USA	POST; NR	44 (7)	WK	X		X	X			15; Exe; No; KZ + LARS	DIS; No	-
Broderick (2005) USA	PRE-POST; EXI-MF; R	209 (32)	MOD				X		X	8; Cond; No; KZ	DIS; Y	Statements + music; Sad; Y; PANAS
Carlin & Ahrens (2014) USA	POST; MF-EXI; R	100 (-)	WK	X			X			15; Ind; No; ARCH + KZ	MW; No	Film; Fear; Y; maths test
Cooke Long & Christian (2015) USA	PRE-POST; MF-EXI; R	117 (8)	WK	X		X	X		X	12; Man; Exerts; KIKE	NOIN; No	Feedback; Inj; Y; PANAS
Erisman & Roemer (2010) USA	PRE-POST; EXI-MF; R	33 (3)	WK	X			X	X	X	10; Exp; Full; SEG	DIS; No	Film; Sad; Y; PANAS

				Mindfulness induction components								
Author (year) Country	Study Design / Procedure/ Randomised	N (attrition)	Quality	Focus attention	Regulate attention	Aware present moment	Aware breath/ body	Aware thoughts/ emotions	Attitude	Mindfulness induction duration (mins)/ descriptor/ script / origin	Comparison induction(s)/ Manipulation Check	Experimental Induction (EXI) method/ inducing/ manipulation check/ measure
Feldman, Greeson, & Senville (2010) USA	POST; R	190 (-)[a]	WK		X		X		X	15; None; No; SEG + ARCH	AAR AAR; Y	-
Heppner et al. (2008) USA	POST; MF-EXI; R	60 (3)	WK	X			X			6; Ind; Full; KZ	NOIN; No	Peer feedback; Ang; No; Noise Blast
Hilt & Pollak (2012) USA	PRE-POST; EXI-MF; R	102 (6)[b]	MOD			X	X	X	X	8; Int; Exert; BROD	AAR DIS; No	Feedback + Rum; NA + Rum; Y; PANAS
Hooper, Villatte, Neofotistou, & McHugh (2010) UK	PRE-POST; EXI-MF;	50 (26)	WK	X						10; Ind; No; ARCH	MAL; Y	Images; NA; No; IRAP + AAQ
Johnson, Gur, David, & Currier (2013) USA	PRE-POST; R	92 (-)	WK	X			X	X	X	25; SS; Full; ZEID	AAR DIS; Y	-
Keng, Robins, Smoski, Dagenbach & Leary (2013) USA	PRE-POST; MF-EXI; R	125 (29)	WK			X	X	X	X	10; Cond; SUP; SING	AAR NOIN; Y	Recall event + music; SAD; Y; VAS
Keng, Tan, Eisenlohr-Moul, & Smoski (2017) SIN	PRE-POST; MF-EXI; R	171 (46)	WK					X	X	10; Cond; No; SING	AAR MAL; Y	Recall event + music; Sad; Y; VAS

				Mindfulness induction components								
Author (year) Country	Study Design / Procedure/ Randomised	N (attrition)	Quality	Focus attention	Regulate attention	Aware present moment	Aware breath/ body	Aware thoughts/ emotions	Attitude	Mindfulness induction duration (mins)/ descriptor/ script / origin	Comparison induction(s)/ Manipulation Check	Experimental Induction (EXI) method/ inducing/ manipulation check/ measure
Kiken & Shook (2014) USA	POST; MF-EXI; R	102 (-)	WK	X	X	X	X	X	X	10; Ind; No; ARCH + KIKE	MW; No	Thought list + music; Sad; Y; VAS
Kuehner, Huffziger, & Liebsch (2009) GER	PRE-POST; EXI-MF; R	60 (-)	WK			X	X	X	X	8; Con; Exerts; SEG + HEID + SING	DIS MAL; No	Event recall + music; Sad; Y; PANAS
Larson, Steffen, & Primosch, (2013) USA	POST; R	62 (7)	WK	X		X	X			14; Int; No; KZ2	DIS; No	-
McHugh, Procter, Herzog, Schock, & Reed (2012) UK	POST; R	19 (-) 30 (-)	WK	X	X		X			15; Ind; Full; None	MW; No	-
Molet, Macquet, Lefebvre, & Williams (2013) FRA	POST; MF-EXI; R	48 (-)	WK	X		X	X			12; Ind; No; MCH	MW; Y	Computer game; Ost; Y; Affect Scale
Mrazek, Smallwood, & Schooler (2012) USA	POST[c]; R	60 (-)	WK	X			X	X	X	8; Task; No; None	DIS NOIN; No	-
Ortner & Zelazo (2012) CAN	PRE-POST; EXI-MF; R	52 (-)	WK	X	X	X	X	X	X	10; Man; No; SEG	DIS NOIN; Y	Event recall; Ang; Y; PANAS

				Mindfulness induction components								
Author (year) Country	Study Design / Procedure/ Randomised	N (attrition)	Quality	Focus attention	Regulate attention	Aware present moment	Aware breath/ body	Aware thoughts/ emotions	Attitude	Mindfulness induction duration (mins)/ descriptor/ script / origin	Comparison induction(s)/ Manipulation Check	Experimental Induction (EXI) method/ inducing/ manipulation check/ measure
Remmers, Topolinski & Koole (2016) GER	PRE-POST; EXI-MF; R	78 (6)	MOD			X			X	5; Ind; No; HUF	DIS RUM; No	Event recall + music + statements; Sad; Y; IPANAT
Reynolds, Lin, Zhou, & Consedine (2015) NZ	PRE-POST; MF-EXI; R	104 (3)	MOD				X	X		10; Ind; No; ERIS	DIS; Y	Smell; Dis; Y; DES
Villa & Hilt (2014) USA	PRE-POST; EXI-MF; R	114 (3)	WK	X		X	X	X	X	8; Int; No; BROD	DIS NOIN; No	Event recall + music + rum; NA + rum; Y; PANAS
Watford & Stafford (2015) USA	POST; MF-EXI; R	70 (-)[d]	MOD				X	X		15; Int; No; ERIS + KZ	DIS; Y	Images + sounds; NA; Y; PANAS
Watier & Dubois (2016) CAN	POST; R	78 (6)	WK			X	X	X		10; SS; No; ERIS	DIS DIS; Y	-
Weger, Hooper, Meier, & Hopthrow (2012) UK	PRE-POST; MF-EXI; R	71 (-)	WK	X			X	X		15; Int; No; HEPP	DIS; No	Task instruction; Ste Thr; Y; Math test

				Mindfulness induction components								
Author (year) Country	Study Design / Procedure/ Randomised	N (attrition)	Quality	Focus attention	Regulate attention	Aware present moment	Aware breath/ body	Aware thoughts/ emotions	Attitude	Mindfulness induction duration (mins)/ descriptor/ script / origin	Comparison induction(s)/ Manipulation Check	Experimental Induction (EXI) method/ inducing/ manipulation check/ measure
Yusainy & Lawrence (2015) UK	PRE-POST; R	110 (8)[e]	WK	X	X		X		X	15; Ind; No; WILL + KRA	DIS; No	-

Note. *SIN* = Singapore; *GER* = Germany; *FRA* = France; *CAN* = Canada; *NZ* = New Zealand; *N* = whole sample; *MF* = Mindfulness induction; *EXI* = Experimental induction; *R* = randomised; *NR* = not randomised; *WK* = weak; *MOD* = moderate; *Ind* = Induction; *Exe* = exercise; *Cond* = condition; *Man* = manipulation; *Exp* = experimental; *Int* = intervention; *SS* = single session; *KZ* = Kabat-Zinn (1990); *SEG* = Segal (2002); *LARS* = Larson, Steffen, and Primosch (2013); *ARCH* = Arch and Craske (2006); *KIKE* = Kiken and Shook (2011); *BROD* = Broderick (2005); *ZEID* = Zeidan, Johnson, Diamond, David, and Goolkasian (2010); *SING* = Singer and Dobson (2007); *HEID* = Heidenreich and Michalak (2003); *KZ2* = Kabat-Zinn (2006); *MCH* = McHugh et al. (2012); *HUF* = Huffziger and Kuehner (2009) *ERIS* = Erisman and Roemer (2010); *HEPP* = Heppner et al. (2008); *WILL* = Williams and Penman (2011); *KRA* = Kramer, Weger, and Sharma (2013); *SUP* = supplementary online material; *MW* = mind wandering; *MAL* = maladaptive alternative regulation; *Y* = yes; *DIS* = distraction; *NOIN* = no instruction; *AAR* = alternative adaptive regulation; *NA* = negative affect; *PANAS* = Positive and negative affect schedule; Sad = sadness; Inj = injustice; Ang = anger; Rum = rumination; VAS = visual analogue scale; *Ost* = ostracism; *IPANAT* = Implicit Positive Affect and Negative Affect Test; *DES* = Differential Emotion Scale; *Ste Thr* = stereotype threat.

Participant attrition rates were averaged where exclusion rates differed between statistical tests within a single sample.

[a] All participants were female

[b] Participant's age 9-14 years' old

[c] SART practice trials took place pre-induction

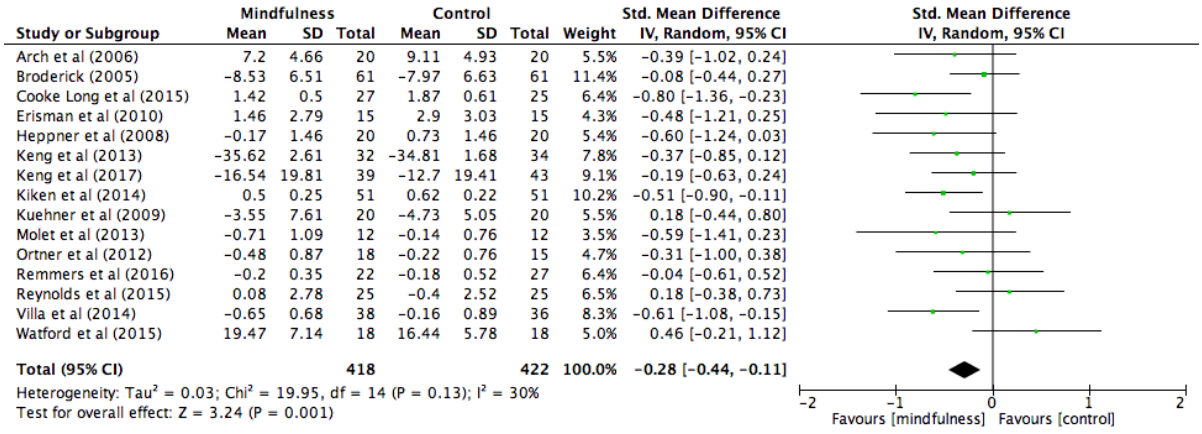
[d] Both negative and positive affect were manipulated experimentally, only data from negative affect induction are presented here

[e] A self-control depletion activity was administered to some participants, data for those participating in the depletion activity is excluded from this review

2.3.3 Mindfulness induction and the regulation of negative affect

The meta-analysis included data from 15 peer-reviewed studies (Table 2.1) generating 15 effect sizes between d = -0.80 and 0.46 (Figure 2.2). Twelve effect sizes were not significant with the remaining three favouring a mindfulness induction (Cooke-Long & Christian, 2015; Kiken & Shook, 2014; Villa & Hilt, 2014). The weighted mean effect of a mindfulness induction on regulation of negative affect was $SMD_{weighted}$ = -0.28, 95% CI = [-0.44, -0.11], Z = 3.24, p = .001 confirming that a mindfulness induction regulated negative affect more effectively than the comparison inductions (e.g., mind wandering, distraction). There was low-moderate heterogeneity (30%) for included studies based on the I^2 statistic (Higgins & Thompson, 2002) and a non-significant Q statistic indicating low statistical differences between included studies. The funnel plot tails appeared balanced and the fail-safe N (number of unpublished papers required to change the Z value to non-significant) was k = 879, which was greater than the estimated 85 unpublished studies.

Figure 2.2 Forest plot of weighted standardised mean differences and a pooled measure of effect of induction on regulation of negative affect



Note. Where a study design had two comparison groups the least active was entered in the analysis

Seven subgroup analyses were conducted to assess the effect of methodological differences between study designs on the pooled estimates of effect (Table 2.2). There was no significant difference between mindfulness and distraction on the regulation of negative affect, whereas mindfulness was superior to all other comparison inductions in reducing negative affect. There was only a significant effect of mindfulness on negative affect where the emotion induction targeted a specific emotion (e.g., sadness) rather than general negative affect, where the mindfulness

induction preceded the emotion induction and where the method of emotion induction was more personally relevant (e.g., recall of personal event). Effect sizes were only significant where pre-post-test designs were used and where affect was measured using means other than the PANAS (e.g., visual analogue scales of state affect). The effect of order of delivery of the mindfulness and emotion induction may mean that the mindfulness induction acted to prime participants to process the emotion induction differently from those who practiced mindfulness after the emotion induction. A meta-regression of duration of mindfulness induction (range = 5-15 minutes) did not reveal any effect of induction length and there was no association between duration of mindfulness induction and effect size strength $r = .03$, $p = .919$.

Table 2.2 Effect sizes for overall and sub-group meta-analysis of effect of induction on regulation of negative affect.

Overall effect or methodological subgroup		k	MF n	CT n	SMD	LCI	UCI
Overall Effect		15	418	422	**-0.28**	**-0.44**	**-0.11**
Comparison group [a]	Distraction	8	142	227	-0.01	-0.22	0.21
	Mind wandering	4	100	108	**-0.58**	**-0.86**	**-0.30**
	Maladaptive regulation	5	81	138	**-0.38**	**-0.65**	**-0.11**
	No instruction	4	64	105	**-0.50**	**-0.82**	**-0.18**
Emotion induction specificity	Specific emotion	11	291	297	**-0.24**	**-0.42**	**-0.06**
	General affect	4	127	125	-0.32	-0.73	0.10
Emotion induction personal relevance	High	8	215	220	**-0.35**	**-0.57**	**-0.14**
	Low	7	202	202	-0.19	-0.46	0.08
Induction order [b]	Emotion: mindfulness	6	174	174	-0.22	-0.45	0.02
	Mindfulness: emotion	8	209	209	**-0.30**	**-0.58**	**-0.02**
Induction duration [c]	5-15 minutes	15	418	422	-0.03	-0.09	0.03
Design	Post test	5	121	121	-0.34	-0.70	0.02
	Pre test-post test	10	297	301	**-0.26**	**-0.44**	**-0.05**
Outcome measure	PANAS	8	217	210	-0.26	-0.54	0.02
	Other	7	200	212	**-0.29**	**-0.50**	**-0.09**

Note. *k* = number of studies in subgroup; *MF* = mindfulness; *CT* = comparison group; *n* = number of participants in induction group; *SMD* = standardised mean difference; *LCI* = lower confidence interval; *UCI* = upper confidence interval

[a] Where mindfulness group was used as comparator against more than one comparison group the mindfulness group N was divided by the number of times the data was entered in the analysis; Alternative adaptive regulation not entered as subgroup analysis as subgroup contained data from only two studies.

[b] Arch et al (2006) was not entered as emotion inductions were repeated more than once.

[c] Meta-regression of induction length calculated on Comprehensive Meta-Analysis software version 3; the value denoted under heading *SMD* represents the regression coefficient.

2.3.4 Mindfulness induction and emotion regulation strategies

Seven articles reported the effect of a mindfulness induction on emotion regulation strategies generating 11 effect sizes (Table 2.3). The experimental aim was for a mindfulness induction to increase adaptive emotion regulation strategies (e.g., decentering) or reduce maladaptive regulation strategies (e.g., rumination, experiential avoidance) more than comparison inductions. Four effects (40%) from three studies (Cooke-Long & Christian, 2015; Feldman et al., 2010; Villa & Hilt, 2014) were significant with effect sizes ranging from .40 to -2.09. Three of the significant effects were for measures of rumination (of $k = 5$ measuring rumination) demonstrating a significant effect of a mindfulness induction to reduce rumination when compared to mind wandering and no instruction comparison groups. Contrastingly, the effect was not conclusive when compared to other adaptive regulation instructions (e.g., problem solving) and was equal to the effects of distraction.

Table 2.3. Effect sizes and 95% confidence intervals for mindfulness induction compared to comparison groups on measures of emotion regulation strategies

Strategy	CT	First Author	Measure	EXI induction	MF n	CT n	SMD	LCI	UCI
Experiential Avoidance	MW	Carlin	TP	Fear	25	25	0.31	-0.24	0.87
	MAL	Hooper	IRAP	Negative affect	15	9	0.13	-0.70	0.96
		Hooper	AAQ	Negative affect	15	9	0.28	-0.54	1.12
Decentering	AAR	Feldman[1]	TMS	None	68	63	0.33	-0.02	0.67
		Feldman[2]	TMS	None	68	59	**0.40**	**0.05**	**0.75**
Rumination	AAR	Hilt[3]	VAS	Negative affect	31	33	-0.37	-0.87	0.12
		Villa[1]	VAS	Negative affect	38	37	**-0.48**	**-0.94**	**-0.02**
	DIS	Hilt	VAS	Negative affect	31	32	0.09	-0.40	0.58
	MW	Cooke-Long	ARS	Injustice	27	25	**-1.30**	**-1.89**	**-0.70**
	NOIN	Villa	VAS	Negative affect	38	36	**-2.09**	**-2.65**	**-1.52**
Response Modulation	DIS	Yusainy	TCRT	None	30	29	-0.01	-0.51	0.52

Note. Significant effect sizes are in boldface. *CT* = comparison group; *MW* = mind wandering; *MAL* = maladaptive alternative regulation; *AAR* = alternative adaptive regulation; *DIS* = distraction; *NOIN* = no instruction; *n* = number of participants in induction group; *MF* = mindfulness; *SMD* = standardised mean difference; *LCI* = lower confidence intervals; *UCI* = upper confidence intervals; *TP* = task persistence; *IRAP* = Implicit Relational Assessment procedure; *AAQ* = Acceptance and Action questionnaire; *TMS* = Toronto Mindfulness scale; *VAS* = Visual Analogue scale; *ARS* = Anger Rumination scale; *TCRT* = Taylor Competitive Reaction Time task; *EXI* = experimental induction.
[1] Muscle relaxation [2] Loving Kindness Meditation [3]Problem solving

2.3.5 Mindfulness induction and executive functions

Nine studies reported the effect of a mindfulness induction on EFs (Table 2.4), with seven studies having sufficient detail to generate 25 effect sizes. Outcome measures reflected Miyake's classification of EFs (2000): updating (including working memory), set-shifting and inhibitory control. Three studies utilised an additional experimental induction of sadness (Keng et al., 2013; Keng et al., 2017) or stereotype threat (Weger et al., 2012), either before or after a mindfulness induction. Overall, eight effect sizes (32%) originating from four studies were significant, with seven of these measuring inhibition (58% of total measuring inhibition). The majority of the significant effects were reported by Mrazek and colleagues (2012) who measured executive attention using the Sustained Attention to Response Task (SART; Smallwood et al., 2004), comparing mindfulness to distraction and no instruction comparison groups.

Two significant effects found mindfulness significantly improved performance on the Stroop task when compared to a reappraisal induction and no instruction comparison group (Keng et al., 2013). One study reported improved working memory performance following mindfulness when compared to a distraction induction (Weger et al., 2012) and the final study found that an attention exercise reduced interference on an emotional Stroop more than a mindfulness induction, although this measure was taken at post-induction only (Watier & Dubois, 2016). Two studies lacked sufficient data to calculate effect sizes (McHugh et al., 2012; Bing-Canar et al., 2016). McHugh and colleagues (2012) reported significant positive effects of the mindfulness induction on measures of set-shifting, measured using a fixed interval schedule, compared to mind wandering. Comparatively, Bing-Canar and colleagues (2016) reported no effect of mindfulness or distraction induction on errors or reaction time on the Stroop task. The remaining 68% of effect sizes were not significant and the overall interpretation of the evidence for an effect of a mindfulness induction on executive functions tends towards a non-significant or no effect, with some evidence supporting effects for inhibition.

2.4 Discussion

This systematic review presents a meta-analysis and synthesis of published papers reporting the effects of a laboratory-based mindfulness induction on measures of three aspects of self-regulation: the regulation of experimentally induced negative affect (meta-analysis), emotion regulation strategies, and EFs (narrative synthesis). The results demonstrated that a mindfulness induction enhanced immediate emotion regulation beyond that of other activities (e.g., mind

Table 2.4 Effect sizes and 95% confidence intervals for mindfulness induction compared to comparison groups on measures of executive functions.

EF	CT	First author	Measure	MF n	CT n	ES	LCI	UCI
Inhibition	AAR	Keng (2013)[1]*	Stroop	43	43	**-0.67**	**-1.10**	**-0.23**
		Keng (2017)[1]*	Stroop	38	43	0.20	-0.24	0.64
	DIS	Larson	Flanker Err	28	27	-0.20	-0.73	0.33
		Larson	Flanker RT	28	27	-0.03	-0.87	0.19
		Mrazek	SART Err	19	20	**-0.77**	**-1.42**	**-0.12**
		Mrazek	SART RT CV[a]	19	20	**-0.72**	**-1.37**	**-0.08**
		Watier[2]	Stroop Emo	25	23	**0.79**	**0.20**	**1.38**
		Watier[3]	Stroop Emo	25	24	0.50	-0.07	1.07
	MAL	Keng (2017)[4]*	Stroop	38	42	0.40	-0.04	0.85
		Mrazek	SART Err	19	21	**-0.93**	**-1.59**	**-0.27**
		Mrazek	SART RT CV	19	21	**-0.73**	**-1.38**	**-0.09**
	NOIN	Keng (2013)*	Stroop	43	43	**-0.55**	**-0.98**	**-0.12**
Shifting	AAR	Johnson[1]	TMA	41	25[1]	-0.30	-0.80	0.21
		Johnson	TMB	41	25	-0.09	-0.59	0.41
	DIS	Johnson	TMB	41	26	0.28	-0.22	0.77
		Johnson	TMA	41	26	0.32	-0.18	0.81
Updating	AAR	Johnson[5]	DSB	41	25	-0.15	-0.65	0.35
		Johnson	TB	41	25	-0.12	-0.62	0.38
		Johnson	DSF	41	25	-0.09	-0.59	0.41
		Johnson	SDMT	41	25	0.07	-0.43	0.57
	DIS	Weger*	Maths	18	18	**0.94**	**0.24**	**1.63**
		Johnson	DSB	41	26	-0.24	-0.73	0.26
		Johnson	DSF	41	26	-0.23	-0.73	0.26
		Johnson	SDMT	41	26	-0.19	-0.68	0.30
		Johnson	TB	41	26	0.06	-0.43	0.56

Note. *EF* = executive function*; CT* = control group*; AAR* = alternative adaptive regulation; *DIS* = distraction; *MAL* = maladaptive alternative regulation; *NOIN* = no instruction; *n* = number of participants in induction group; *SMD* = standardised mean difference, *LCI* = lower confidence intervals; *UCI* = upper confidence intervals; *RT CV* = reaction time coefficient of variability; *TMA* = Trail Making Test A; *DSB* = Digit Span Backward; *TB* = Two-Back task; *DSF* = Digit Span Forward; *TMB* = Trail Making Test B; *SDMT* = Symbol Digit Modalities test; *SART* = Sustained Attention to Response task; *Err* = error; *RT* = reaction time; *Emo* = emotional; *Inc* = incongruent, *FIX* = fixed interval schedule

[1] Reappraisal [2]Active attention [3]Mathematics [4]Thought suppression [5]Sham meditation

[a] RT CV or reaction time of coefficient variability calculated by the authors as standard deviation of reaction time divided by mean reaction time

*Experimental design included an additional experimental induction (see table 2.1 for details).

wandering) but equal to the effect of distraction. A mindfulness induction also significantly enhanced EFs, particularly inhibition, only where the study design included an affect induction or where the aspect of executive function measured was sustained attention; there was little other evidence for an effect on EFs. Similarly, there was mixed evidence for a significant effect of a mindfulness induction on emotion regulation strategies; significant effects were limited to measures of rumination, such that a mindfulness induction reduced the use of this strategy.

The comparable results observed between mindfulness inductions and distraction can be understood in the context of theoretical models of emotion regulation strategies. Distraction is an effective emotion regulation strategy as it acts to redirect attention (attention redeployment) away from the emotive stimuli (Gross & Thompson, 2007). The process model of emotion regulation has four stages that can be targeted for different emotion regulation strategies: the emotive situation, attention deployment, cognitive appraisals and emotion expression (Gross, 1998; 2001). Compared to distraction, mindfulness is proposed to act at a later stage of the process model of emotion regulation (Gross, 1998) as a cognitive change process where emotions or emotive stimuli are reappraised, specifically through fewer negative appraisals and increasing non-judgement towards experience (Webb et al., 2012). Many of the mindfulness inductions included instructions to be accepting or non-judgemental toward experiences, in line with the mindfulness axiom of attitude (Shapiro et al., 2006) and through this may have targeted the regulation of emotions through an attitudinal change. However, more typically the mindfulness induction content focused on attention rather than acceptance and so this could have supported the primary mechanism of the mindfulness induction as acting on attention deployment and in turn explain the present findings. In support of this explanation, the equal effect of the mindfulness and distraction inductions suggests that both may have been acting on the attention axiom of mindfulness to redeploy attention away from the emotional experience without necessarily altering attitude.

Even if the mindfulness inductions were acting only on the attention axiom, this would likely result in a degree of cognitive change, as it has been proposed that attention regulation can reduce or inhibit elaborative processing of emotive stimuli (Bishop et al., 2004). The notion that a mindfulness induction was acting to alter attention but not attitude is supported by the inconclusive evidence in the present review that found that there was no effect of a mindfulness induction on decentering or reperceiving. Similarly, there was only tentative support for the effect of a mindfulness induction to reduce rumination. Rumination is an example of a maladaptive regulation strategy when applied to negative affect as it often acts to intensify the emotional state (Nolen-

Hoeksema et al., 2008), which is contrary to the intended regulatory effect. Contrastingly, the present review reported that mindfulness significantly enhanced sustained attention even when compared to distraction (Mrazek et al., 2012). This finding supports the notion that a mindfulness induction was acting to alter attention and suggests this mechanism may have extended beyond attention redeployment to support attention control (maintaining focused attention on a new stimulus). The cultivation of attention control is proposed as a core competency gained during early stages of meditation practice (Hölzel et al., 2011) and the present findings give tentative support to immediate gains on attention control following a single mindfulness induction. Alternatively, these findings may be explained in part, by the other comparison induction activities (mind wandering, maladaptive emotion regulation strategies, no instructions) inflating the effect of mindfulness and distraction by negatively enhancing or maintaining the state of negative affect in the comparison groups. There is some evidence demonstrating that mind-wandering can result in increased negative affect (Smallwood & Schooler, 2006) and this may be because it lies on a continuum with perseverative cognitions, such as rumination and worry (Ottaviani, Shapiro, & Couyoumdijian, 2013).

The present review reports that a mindfulness induction significantly enhanced the inhibition and updating components of EFs only where an additional experimental induction was included in the design (affect induction or stereotype threat). It has been proposed that all self-regulation failures are due to impaired functioning of the EFs (Hofmann et al., 2012). High levels of emotional arousal require bottom-up attention and emotion regulation to regain EF capacity (Blair & Urasche, 2011). The strength model of self-regulation (Baumeister & Heatherton, 1996) proposes that there is a shared cognitive resource that has a limited capacity, which can be drained by demands placed on the self-regulatory system. Negative affect can drain self-control resources and consequently reduce the capacity to inhibit prepotent responses or sustain attention (see Wagner & Heatherton, 2014). Therefore, a mindfulness induction may have enhanced the EFs indirectly by more effectively regulating emotions, thereby reducing cognitive load and increasing the resources available for subsequent demands on the EFs.

The findings of the review can be understood within existing frameworks that explain the association between mindfulness and self-regulation. Hölzel et al. (2011) and Tang et al. (2015), both propose that attention control and emotion regulation are two of the mechanisms through which mindfulness exerts change on self-regulation. These models review neurocognitive evidence that in novice meditators greater attention control can be achieved through greater top-down

control that sees increased activity in prefrontal brain regions. Similarly, attention control is implicated as a means for emotion regulation by individuals selectively attending to non-emotive stimuli or by engaging in secondary tasks that are distracting (Hölzel et al, 2011). The findings from the current review, that a mindfulness induction can regulate negative affect as effectively as activities designed to distract attention and that a mindfulness induction recovered EFs following an emotional induction, fit within these proposed models of effects of mindfulness on self-regulation (Hölzel et al., 2011; Tang et al., 2015).

The present review provides some evidence for reduced rumination, but little or no support for changes to other emotion regulation strategies such as decentering, experiential avoidance or response modulation. These findings are not explained by the proposed associations between mindfulness meditation and cognitive changes (including through either reappraisal or nonappraisal of experiences, or through greater experiential exposure) within existing models of mindfulness and self-regulation (Hölzel et al, 2011; Tang et al., 2015). However, the present findings may not be well represented by existing models as these models were based on findings from all forms of mindfulness research including dispositional mindfulness and with long-term meditators. Conversely, the present review reports on only the immediate effects of a one-off meditation practice. There is disparity between the existing models and the significant findings of the present review, that EFs were only enhanced under particular circumstances and decentering did not increase following a mindfulness induction. Speculatively, this may be because cognitive change processes such as reappraisal or experiential exposure require greater duration and breadth of mindfulness training than is offered by a single mindfulness practice. However, even reviews of evidence from randomised controlled and quasi-experimental trials of MBIs report mixed effects on components of self-regulation and these findings are equally not explained by existing theoretical models (e.g., Chiesa, Calati, & Serretti, 2010; Lao, Kissane, & Meadows, 2016). The interpretations of the present review are useful to provide greater understanding of the specific effects of a mindfulness induction in an experimental setting and perhaps inform the differential effects reported across all forms of mindfulness research.

Foremostly, the intention of the present review was to help determine whether a mindfulness induction could elicit an immediate effect on self-regulation and to interpret these

findings in accord with existing theoretical and empirical evidence. Moreover, the findings of the review and in particular the unique features of the mindfulness induction design, may be extrapolated to evidence from other more typical investigations of extensive mindfulness training or dispositions. One way in which mindfulness inductions are unique is that participants have the intention to engage in a research experiment rather than engage specifically with mindfulness practice. Shapiro et al. (2006) promote the importance of intention alongside attitude and attention in their IAA model of mindfulness, as mechanisms that facilitate change following mindfulness training. The way in which the intention component of mindfulness may impact on a mindfulness induction effecting change on self-regulation is unclear. It could be hypothesised that this may in part explain why existing models of mindfulness and self-regulation extend beyond the findings of the present review. Tang et al. (2015) highlight that for novice meditators there is relative greater mental effort required to achieve a meditative state than for more experienced meditators and this in turn may support the notion that intention and motivation are most important for those new to meditation.

Existing evidence demonstrates the importance of study methodology in determining the strength and significance of detected effects in experimental cross sectional emotion regulation research (for review see Webb et al., 2012). The present review similarly found an effect of study methodology on effect sizes for several variables, for example between pre-post-test or post-test designs, or where different outcome measures were used. The influence of methodological design may extend beyond the meta-analysis to the other outcomes of this review. Methodological differences other than those already mentioned (nature of comparison induction; inclusion of an emotion induction) could therefore account for the differential findings for EFs and emotion regulation strategies. The methodological heterogeneity of two outcomes (emotion regulation strategies, and EFs) was deemed to be too great for statistical synthesis in a meta-analysis. Although emotion regulation strategies and EFs can be understood within a unitary construct (Miyake et al., 2000; Gross, 1998), they are assessed using numerous and varied outcome measures. Therefore, it is difficult to determine the role of possible methodological mediators on the presence or absence of significant effects for these outcomes.

2.4.1 Future directions and limitations of included evidence

The present research findings offer direction for further empirical exploration. Some of the conclusions of the review, in particular evidence for the effects of a mindfulness induction on rumination and sustained attention and absence of an effect on decentering, are derived from only

limited numbers of included studies. Additionally, many of the included studies were rated as being of weak quality. Therefore, further testing of these tentative findings utilising and reporting more rigorous methodological standards would be beneficial. In particular, studies could improve on the generalisability of the participant samples, validity of outcome measures and double-blind procedures.

The present review employed broad inclusion criteria for the mindfulness inductions as no established classification system has been proposed, unlike for MBI (Crane et al., 2017). The evidence base would benefit from more stringent criteria for what does and does not classify as a mindfulness induction and specifically from authors providing access to full scripts of the mindfulness induction used. Particularly, this would allow future reviews to further explore the impact of the content of practices on outcomes, specifically the inclusion and emphasis of instructions pertaining to attitude and attention components of mindfulness. Additionally, further research would benefit from being informed by existing evidence (such as Webb et al., 2012) and the evidence from the present review that highlights the significance of selected methodologies in determining the strength and detection of effects. Specifically, this includes the choice of comparison induction and, when included, the personal relevance and specificity of the emotion induction.

This review provides evidence for the immediate effects of a mindfulness induction on self-regulation, in particular through the regulation of negative affect and subsequent gains in EFs, and through gains in sustained attention. The review is limited in the extent to which it can expand our understanding of the temporality of effects of a mindfulness induction, as all included data were for measures of immediate effects. As an initial step in reviewing the evidence using mindfulness inductions experimentally, the scope of the review was focused to include only non-clinical participants and the affective and cognitive aspects of self-regulation. The present findings may give impetus for additional reviews to further explore this method as applied in clinical samples and self-regulation measured through physiological and neurological outcomes. Additionally, as with all review processes the present research may have been influenced by biases (e.g., study selection); however, attempts were made to mitigate against these wherever possible, for example two researchers coded the comparison group categories and quality appraised the included papers. A further inclusion criterion was that all included papers were peer-reviewed, although this potential limitation was mitigated against by the estimation of publication bias and the Fail-Safe N (Rosenthal, 1979), which demonstrated that, although some non-significant

findings may not have been published, the effect size of the meta-analysis was robust and representative of the overall findings.

3

TESTING FOR AN EFFECT OF A MINDFULNESS INDUCTION ON CHILD EXECUTIVE FUNCTION

The research presented in chapter three (from section 3.1) is a published manuscript in a peer-reviewed journal: Leyland, A., Emerson, L. M., & Rowse, G. (2018). Testing for an effect of a mindfulness induction on child executive functions. *Mindfulness, 9*(6), 1807-1815.

The research presented in this chapter builds on the evidence garnered from chapters one and two of this thesis. The evidence reviewed in chapter one demonstrated that there is some support for an effect of mindfulness training on self-regulation in children and adolescents. Chapter one also presented a discussion of theoretical and empirical evidence for the age and stage of development at which children and adolescents may be able to engage with and benefit from mindfulness training and mindfulness meditation practice. A pertinent gap in the evidence base highlighted in earlier chapters of this thesis was recognising that there had been very few experimental trials testing the short-term effect of mindfulness meditation practice with children and adolescents. Furthermore, there was no no experimental trial testing the effect of a mindfulness meditation practice on executive function, despite executive function being a principal component of self-regulation.

Chapter two synthesised evidence from experimental trials for the effect of a single mindfulness meditation on self-regulation in people of all ages. It also reported on the

methodological differences across the included studies and the impact of the methodological differences on effect sizes. For example, the choice of comparison activity and outcome measure impacts on whether there is detection of between group effects. This systematic review, meta-analysis and narrative synthesis of this evidence was extremely important to make sense of existing literature to inform the methodology of the present chapter. Without this systematic review of the evidence the risk of bias in summarising existing evidence is increased, particularly in the domain of mindfulness where positivity bias in the reporting of empirical findings is highly prevalent (see Coronado-Montoya et a., 2016). Furthermore, chapter two demonstrated the utility of experimental designs within the domain of mindfulness and gave greater impetus for its potential application with children and adolescents.

Chapter two reported that there was limited evidence for an effect of a single mindfulness meditation practice on executive functions in adults. Nevertheless, executive functions were selected as the outcome of the present study as there was evidence from experimental trials (for example see Lillard & Peterson, 2011) that informed a working hypothesis that children's executive functions could be impacted upon in the short-term in a laboratory setting. Furthermore, in the definition of self-regulation held in this thesis, executive function is a core component of self-regulation. As such to exclude it from empirical enquiry with children based on evidence from adults seemed unempirical.

Consequently, this chapter uses an experimental design to test the effect of a single mindfulness meditation practice on executive functions in children aged 4-6 years. This chapter addresses the second thesis research question that seeks to understand whether a mindfulness meditation practice can effect a short-term change for self-regulation in children aged 4-11 years.

3.1 Introduction

Executive functions (EF) are critical for child social and emotional competence as they allow modulation of emotions, thought and behaviour and are positively linked to academic attainment and social-emotional functioning in children (Kochanska, Coy, & Murray, 2001). EF enable goal pursuit through sustaining and redirecting attention to goal related tasks and inhibiting pre-potent (and often emotional) responses that may threaten goal attainment. Typically, EF are conceptualised as formed of three distinct but highly related cognitive processes: inhibitory control, cognitive flexibility and working memory (Miyake et al., 2000). Targeted interventions, including mindfulness training, can enhance EF in children (Diamond & Lee, 2011) but little is

known about the dose effect of mindfulness or which aspects of mindfulness training exert beneficial effects. Abbreviated mindfulness training and experimental mindfulness inductions can enhance EF in adults (e.g., Keng, Robins, Smoski, Dagenbach, & Leary, 2013) but there are no empirical reports testing the effect of mindfulness inductions on child EF.

3.1.1 Mindfulness and executive function

Mindfulness is commonly operationalized as having two components: the self-regulation of attention and the possession of a particular orientation to experience (of openness, non-judgement and curiosity; Bishop et al., 2004). Mindfulness encourages practitioners to attend to present moment experience (thoughts, emotions, body sensations) and to refocus attention on the present moment when the mind engages with cognitive (e.g., thinking about the past or future) or meta-cognitive (e.g., appraising thoughts) processes. Typically, mindfulness-based interventions (MBI) are delivered as weekly group sessions (e.g., 2.5 hours) over eight-weeks incorporating experiential practices (e.g., mindfulness of breathing, body scan), group discussion and home practice (Crane et al., 2017). There is some emerging but inconclusive empirical evidence for the effect of MBI on EF in children. Flook et al., (2010) demonstrated gains in parent and teacher reported EF for those children with low baseline EF following an 8-week MBI compared to a silent reading control. A longer 12-week MBI was compared to a social responsibility programme and found improved reaction times but not accuracy for two behavioural measures of EF (Schonert-Reichl et al., 2015). Another 12-week MBI was compared to a wait-list control group on three measures of EF and found no significant differences between groups (Flook, Goldberg, Pinger, & Davidson, 2015). An 8-week MBI (90-minutes weekly plus home practice) delivered to children and their parents reported greater gains on attention regulation for children in the mindfulness group compared to a wait-list control (Felver, Tipsord, Morris, Hiatt Racer, & Dishion, 2014). The evidence suggests mindfulness may exert an effect on EF in children particularly when reaction times are measured, when baseline EF is low and for attention regulation.

The executive control of attention (Shapiro, Carlson, Astin, & Freedman, 2006) and decentering (the ability to observe rather than judge present moment experience) are two proposed mechanisms through which mindfulness may enhance EF. The executive control of attention towards goal directed stimuli relate most strongly to the cognitive flexibility component of EF and so mindfulness may exert a benefit on EF via direct improvements to cognitive flexibility (Miyake et al., 2000). Comparatively, decentering is an emotion regulatory strategy (Gross, 2002) and so

mindfulness training may benefit EF by down-regulating emotions that at high levels can impair EF (Zelazo & Lyons, 2012). There is growing understanding of the effects of MBI on EF; however, less is known about the dose effect of mindfulness training, and whether experimental inductions of mindfulness can produce effects.

3.1.2 Mindfulness inductions and executive function

The use of one-off experimental mindfulness inductions enables researchers to conduct fine-grained comparisons between mindfulness and viable control inductions, thereby extrapolating the specific effects of mindfulness (Tang, Hölzel, & Posner, 2015). Researchers have explored the effect of mindfulness inductions on EF in adults, however the reported effects are mixed. Johnson et al., (2013) reported no significant differences on multiple measures of EF when a 25-minute mindfulness of breathing induction was compared with sham-meditation (explicit labelling of practice as meditation, guided breathing practice but no other mindfulness components) and a book listening task. A similar study compared a 10-minute mindfulness of breathing induction with an attention induction (e.g., participants imagine counting windows in their house) and an arithmetic exercise (Watier & Dubois, 2016). The researchers found no difference in performance on EF (emotional Stroop task) but for those with low trait mindfulness, the mindfulness induction increased executive attention compared to both comparison groups.

There is also evidence of gains to EF following mindfulness inductions. Keng et al., (2013) demonstrated that a 10-minute mindful acceptance induction reduced interference on the Stroop task compared to both a reappraisal induction and control group (no training). Similarly, a 5-minute mindful eating task (compared to participants instructed to eat two raisins in 5-minutes) resulted in greater recovery in working memory performance following a stereotype threat task (Weger, Hooper, Meier, & Hopthrow, 2011). The reason for the contradiction in the literature remains unclear. Some authors propose that to detect immediate changes following mindfulness inductions, measures of EF need to be sensitive to momentary lapses in attention (Johnson, Gur, David, & Currier, 2013), or that the mindfulness induction is acting indirectly by altering state affect or fatigue (Zeidan, Johnson, Diamond, & Goolkasian, 2010) or is mediated by the induction of a mindful state (Mahmood, Hopthrow, & Randsley de Moura, 2016).

3.1.3 Mindfulness induction and executive function in children

Three published papers report the effects of a mindfulness induction with child participants. In one study children aged 9-14 years participated in a surprise speech task and were

given false negative feedback from peers to induce negative mood before being guided to ruminate on their experience (Hilt & Pollak, 2012). They were then randomised to complete an 8-minute guided practice of mindfulness, problem solving or distraction. The authors reported an equal effect of the mindfulness induction to the distraction activity in reducing rumination, but both activities were significantly more effective than problem solving to reduce rumination. A second study reported the effects of a 10-minute mindfulness induction compared to quiet play on children aged 7-9 years on measures of arousal, mood and social dominance (Nadler, Cordy, Stengel, Segal, & Hayden, 2017). The authors reported no significant effects of experimental condition on mood or social dominance, but mindfulness resulted in reduced arousal (i.e., increased calmness) compared to those playing quietly, in two samples (*Cohen's d* = 0.60; 2.40).

A further study by Lim and Qu (2017) measured the effect of a 15-minute mindfulness induction compared to an active control induction (e.g., dancing, singing, counting) on several measures of attention of 122 children aged 4-6 years. No between group differences were found for orienting, alerting or executive control of attention but changes were reported in the reduction of attention scope bias (i.e. a preference for global or local processing at pre-induction) for those in the mindfulness induction group. This finding gives some impetus for further investigation of mindfulness inductions using experimental designs with children. There are however gaps in current understanding including whether the methodology is feasible in a younger child sample and if mindfulness inductions can exert an effect on EF in children.

The central goal of this study was to assess the immediate effects of a mindfulness induction on EF compared to a comparison activity. We hypothesise that children participating in the experimental mindfulness induction will subsequently achieve higher EF scores than those participating in the comparison (dot-to-dot activity) group.

3.2. Method

3.2.1 Participants

The study used a between groups design with two conditions: mindfulness induction and a comparison group. Scores on post-intervention tasks that measure EF formed the dependent variable. Children aged 4-7 years with English as a first language were recruited from three schools in a city in the North of the United Kingdom $N = 159$. Informed consent was obtained from all parents and assent from children participating in the study. The study had 93% power to

detect a medium effect size $d = 0.5$. Children were assigned to conditions using block randomisation aiming for equal condition allocation between schools. Two children did not assent to participate in the study and one child could not understand the task instructions $N = 156$. Both groups had a mean age of 6-years old SD = 11-months with the mindfulness group $n = 80$, having 45% female participants and the comparison group $n = 76$, 46% female. Both conditions had 11% of participants in receipt of free school meals (used as an indicator for social deprivation).

3.2.2. Procedure

Data collection occurred individually in each school in a quiet room. Children were told they were going to "play some games" and asked to give their assent to participate. Participants were randomly assigned to one of three activities and either watched a cartoon on a laptop computer or coloured in a line drawing. Both the experimenter and the participant then followed instructions for the mindfulness induction, played through laptop computer speakers, or completed a dot-to-dot drawing task. For the mindfulness induction, the participant and experimenter were positioned on the ground facing each other around one metre apart with a marble placed on the floor between them. Those children completing the dot-to-dot task were positioned at a table with the experimenter sitting adjacent to them. After completion of the induction the experimenter followed a standardised procedure and script to administer the four tasks measuring EF, in the following order: Tower of Hanoi, head toes knees and shoulders (HTKS), delay of gratification and backward digit span. Data collection lasted around 35 minutes (see appendix one for full details of procedure).

Depletion activity

Prior to engaging in the induction children were randomly assigned to participate in one of three depletion activities: one of two cartoons of fast or slow pace, or colouring. The activities aimed to place differing demands on cognitive resources and had previously been reported to deplete EF in children aged 4 years, specifically with those watching the fast-paced cartoon having poorer performance on EF relative to those colouring (Lillard & Peterson, 2011). The cartoons were presented on a laptop computer and each depletion activity lasted for 9-minutes.

Inductions

The mindfulness induction was a brief version (3-minutes 20-seconds) of the 'sound in space game' (Greenland, 2010, p. 95) pre-recorded by a clinical psychologist experienced in teaching mindfulness to children. The game uses several foci of attention: visual (marble), auditory (chime) and sensory (movement of breath; for full script see appendix three). The induction is age

appropriate and used within an established mindfulness programme for children (Flook et al., 2010). The comparison group completed a few dot-to-dot drawings for the same duration. The comparison group activity was designed to match the general aspects of the experimental mindfulness induction (e.g., experimenter-participant interactions) so that mindfulness-specific aspects of the induction e.g., monitoring of sensory experience, could be empirically tested.

Measures

The Strength and Difficulties questionnaire-parent(SDQ-parent) is a 25-item behavioural screening tool assessing the behaviours, emotions and relationships of children age 4-16 years (Goodman, 1997; appendix two). Items are scored on a three-point scale (not true, somewhat true and certainly true) with parents rating their child's behaviour over the last six months. The measure is formed of four subscales of behaviour difficulties (peer relationship problems, hyperactivity/inattention, conduct problems, emotional symptoms) and the pro-social behaviour subscale. The SDQ-parent has shown good reliability in a large community sample for all subscales including prosocial behaviour $\alpha = 0.65$ and behavioural difficulties $\alpha = 0.82$ (Goodman, 2001). The present study included the score for behaviour difficulties and prosocial behaviour as indicators of baseline functioning in key areas associated with EF: attention, social functioning and behavioural self-regulation.

The Tower of Hanoi(Simon, 1975) was used to assess planning and working memory (Welsh, Satterlee-Cartmel, & Stine, 1999). Three wooden pegs on a base were described as trees and the two discs were positioned on the left peg. The discs were described as 'Mummy monkey' (small red disc) and 'Daddy monkey' (large blue disc) who wanted to move to their sleeping tree (the right peg; Welsh et al., 1999). A visual aid depicting the final configuration of monkeys and trees was also presented on A4 paper. Children were told three rules to follow: one monkey could be moved at a time; the Daddy monkey could never go on top of the Mummy monkey and the monkeys always needed to be on a tree. A score of one was given if all rules were followed to achieve the final disc configuration and zero if rules were broken or the task not completed. The task is valid with young children and has good test-retest reliability ($\alpha = .72$; Gnys & Willis, 1991).

The HTKS primarily assesses inhibitory control and behaviour regulation but also measures working memory and attention (Ponitz, McClelland, Matthews, & Morrison, 2009). This task consists of three progressive rounds of auditory commands where the child is required to

inhibit a dominant motor response (e.g., "When I say touch your head, I want you to touch your toes, and when I say touch your toes, I want you to touch your head"). Following a brief practice, children progressed to the first round. Responses were scored: incorrect (0), initially incorrect but then corrected (1) or correct (2). If children scored 10 points on their first round, they progressed to round two, where two further instructions (shoulders-knees) were added; those who scored 14 or more in round two progressed to round three, where the rule was changed (head-shoulders, knees-toes). HTKS has good reported validity with parent and teacher reports of child EF (Ponitz et al., 2009).

The delay of gratification task is a sustained delay task where children are given the option of immediately eating a small portion of a chosen snack (sweet crackers, jellybeans, chocolate buttons) or waiting an unknown length of time to eat a larger portion (Mischel, Shoda, & Rodriguez, 1989). Ten pieces of the snack were placed on one plate and two pieces on the other, with a hand bell between the two plates arranged on a table in front of the seated child. Children were told that the experimenter was about to leave the room and that they could ring the bell at any time to signal the experimenter to return, at which time they could eat the smaller plate of snacks. Alternatively, they could choose to wait an unspecified length of time for the experimenter to return when they would be able to have the larger plate of snacks. The experimenter recorded the time between leaving the room and the bell ringing or when the child ate the snack, or they returned to the child after 330 seconds. Delay of gratification tasks, including the sustained delay paradigm used here, have good convergent validity r = .21, *95% CI* = .09, .32 (Duckworth & Kern, 2011).

The backward digit span task (Wechsler, 1949) measures the phonological loop and central executive components of working memory (Morra, 1994). The task requires children to repeat back in reverse order a verbally presented series of digits. Fifteen number strings of two-six digits were created for use in this experiment and were scored according to established guidance (Carlson, 2005) with the highest level of success recorded between 0 and 5. The task finished at a score of 5 or after three consecutive incorrect responses. The measure shows good convergent validity and good test-retest reliability α = .62 (Gathercole & Pickering, 2000; Gathercole, Pickering, Ambridge, & Wearing, 2004)

Data Analyses

To assess differences on pre-induction variables, independent *t* tests and chi-square analysis were used. Any baseline differences can be assumed to have occurred by chance as the participants were randomly assigned to induction groups. Notwithstanding, where the baseline measure and the main outcome: interact differently between groups, or there is theoretical or empirical reason to believe there may be an association between a baseline measure and the outcome, then the appropriate analysis is multiple regression (Miller & Chapmen, 2001). A composite score for EF was calculated by summing transformed *z* scores for each of the four measures of EF, *Cronbach's* α = .66. A hierarchical regression was conducted to determine the effect of the induction on the composite EF score and the relative effect of any predictors. Variables were entered as predictors because of their potential direct effect on the outcome or because they may have been interacting with the induction to affect the outcome.

Table 3.1 Demographic, SDQ and EF measures for the mindfulness induction and dot-to-dot comparison group

	Mindfulness *n* = 80 (SD)	Comparison group *n* = 76 (SD)
Age months	72.41 (10.7)	72.58 (10.5)
Female	45%	46%
Free school meals	11%	11%
SDQ Pro-social Behaviour	6.69 (3.75)	4.53 (3.68)
SDQ Behavioural Difficulties	8.77 (7.20)	12.18 (6.80)
Delay of Gratification time waited seconds	263.77 (121.00)	244.33 (132.72)
Backwards digit span	1.79 (0.87)	1.81 (1.09)
Head toes knees and shoulders	45.18 (15.58)	42.77 (18.37)
Tower of Hanoi completed successfully	55%	55%

3.3 Results

3.3.1 Baseline comparisons

Participant demographics and measures taken pre-induction are presented in table 3.1. Baseline differences between induction groups were assessed and groups were equal for: age $t(154) = .10$, $p = .467$, gender $x^2(1) = .04$, $p = .873$, and free school meals $x^2(1) < .01$, $p = 1.000$. The comparison group had a significantly higher score than the mindfulness group for behavioural difficulties $t(149) = 3.00$, $p = .003$ and lower score for pro-social behaviour $t(149) = -3.57$, $p < .001$. On further examination, behavioural difficulties were interacting differently with

performance on measures of EF, with a moderate significant negative correlation for the comparison group r = -.48, p < .001 and a positive but non-significant association for the mindfulness induction r = .04, p = .763. There was no significant effect of the depletion activity across the participant group for its effect on the composite score of EF $F(149,2) = 1.24$, p = .292. Consequently, the effect of the depletion activity was excluded from further analysis.

3.3.2 Effects of mindfulness induction on EF

Results of measures of EF for the mindfulness and comparison groups are reported in table 3.1. The mindfulness group score for EF was higher M = .12 SD = 2.71 than the comparison group M = -.05 SD = 2.97. The multiple regression analysis (step one predictor of behavioural difficulties; and step two predictor of induction group) significantly predicted EF and could explain 5.3% of variance in the outcome $F(2,144) = 4.05$, p = .019 (Table 3.2). Step one predictors significantly predicted EF $F(1,145) = 7.85$, p = . 006, but the addition of the induction group as a predictor was not significant and did not increase the predictive value of the model. An experimental mindfulness induction had no significant impact on performance on measures of EF when compared to a dot-to-dot comparison group activity.

Table 3.2 Hierarchical Multiple Regression analysis predicting EF from induction and behavioural difficulties

	Composite EF score			
	Step 1		Step 2	
Variable	β	95% CI	β	95% CI
Constant	0.96	0.15, 1.77	1.13	0.10, 2.16
Behavioural difficulties	-0.23*	-0.15, -0.03	-0.24*	-0.16, -0.03
Induction			-0.04	-1.19, 0.69
R^2	0.05		.05	
F	7.85*		4.05*	
ΔR^2			.00	
ΔF			.28	

Note. Δ = change.

3.4 Discussion

The current study tested whether a 3-minute mindfulness induction could exert an immediate effect on EF in children aged 4-7 years. Those in the mindfulness group performed better on a composite measure of EF than those in the comparison (dot-to-dot activity) group. Nevertheless, it is notable that this outcome was not due to participation in either the mindfulness induction or dot-to-dot comparison activity. Instead, this result was due to the groups having

significantly different scores for behaviour difficulties, which were interacting differently with the main outcome. This outcome does not support our hypothesis that a mindfulness induction would exert an immediate benefit on EF; however, the null findings are in line with current conflicting evidence for an immediate effect of a mindfulness induction on EF in adults.

The current evidence for an effect of a mindfulness induction on EF includes reported non-significant (e.g., Johnson et al., 2013) and significant positive effects (e.g., Keng et al., 2013). Similarly, there are differential effects reported when mindfulness inductions have been tested with children on other outcomes. Mindfulness was equally effective to distraction but superior to problem solving in lowering state rumination (Hilt & Pollak, 2012). Arousal was significantly lower following a mindfulness induction when compared to quiet play but there was no effect of induction on mood or social dominance (Nadler et al., 2017). Similarly, although mindfulness effected change in biases in attentional scope, no effect was reported on orienting, alerting or executive attention (Lim & Qu, 2017). Supporting this, evidence with adults supports the effectiveness of distraction as an approach for emotion regulation, which may be equitable to the regulating effect of mindfulness (Broderick, 2005). The current study used a dot-to-dot task as the comparison activity that may have acted in a similar way to other distraction activities and could have masked any effects of the mindfulness induction on EF. Therefore, the results of the current study fit within the differential effects reported in this field and may be a result of the selected comparison activity eliciting an equitable effect to the experimental induction on child EF.

Mindfulness inductions can be used empirically with high levels of control to compare the effects of a mindfulness practice with comparison activities (Keng, Smoski, & Robins, 2011). The contribution of this experimental approach is therefore valuable to the literature; particularly at a time when researchers are aiming to better understand under what instances and through what mechanisms mindfulness may effect change (e.g., Gu, Strauss, Bond, & Cavanagh, 2015). However, the deviation of mindfulness as an induction from the more traditional forms of training in mindfulness, such as MBI, is notable. Specifically, most mindfulness inductions are an isolated extracted component of a much broader MBI package, with the aim of the former to elicit immediate and short-term change and the latter a longer lasting change. The present findings did not detect an effect of the mindfulness induction on EF, which is in line with the differential findings of existing evidence. The reason mindfulness inductions do not consistently elicit immediate effects on EF may be due to methodological differences between experimental designs. Anecdotally, a review of the literature demonstrates differences in methodologies based on the

mindfulness induction (e.g., duration, instructions), measurement of EF (e.g., Flanker task, Stroop test) and comparison activity (e.g., distraction, no instruction). The present study selected a mindfulness induction practice that primarily targeted attention regulation, one of the core components of mindfulness, which is highly pertinent when the target outcome is EF (Bishop et al., 2004). Additionally, several measures of EF were taken to cover multiple components of EF and the comparison activity, a dot-to-dot drawing task, required focused attention and problem solving. These aspects of the method could have impacted on the absence of any detected effect of the induction. However, without a comprehensive review of the evidence it is difficult to determine the extent to which methodological differences may impact on the detection and strength of effects.[6]

An alternative explanation of the findings may be that mindfulness inductions are not always sufficient to effect change in EF, particularly for children. This explanation is particularly plausible in the context of what is known about the effects of MBI on EF for children. Specifically, where significant effects have been reported these are often caveated by other factors, such as that only those with low baseline EF improved significantly post-intervention (Flook et al., 2010). This interpretation of the findings brings forth a bigger question across the broader literature surrounding mindfulness, under what conditions does mindfulness elicit demonstrable effects? MBI offer a broader and more comprehensive mindfulness training with more time for experiential practices and mindfulness-based education. There is growing empirical evidence of which components of MBI significantly contribute to effecting change. For example, the extent to which participants of MBI practice mindfulness at home positively impacts on changes post intervention (Parsons, Crane, Parsons, Fjorback, & Kuyken, 2017).

There is little evidence exploring why mindfulness inductions may not deliver a hypothesised change, although many authors anecdotally comment on methodological limitations such as the choice of outcome measure (Johnson et al., 2013) or induction practice (Ridderinkhof, de Bruin, Brummelman, & Bögels, 2017). Beyond these interpretations one may speculate that mindfulness inductions differ from MBI as participants are expected to complete an experiential mindfulness practice without any context, such as supporting education or discussion, and without any internally driven motivation to engage with mindfulness. Three key components of

[6] The time point of publication of this chapter was before publication of chapter two which addressed this gap in the evidence base.

mindfulness practice are proposed as: intention, attitude and attention (Bishop et al., 2004). Both the attitude with which someone approaches a mindfulness practice, particularly one that is open and non-judgemental, and the regulation of attention toward present moment experience, can be directly targeted by the instructions of the mindfulness induction. It is more difficult to direct an individual's intention, which determines one's motivation to practice, such as a desire to alleviate difficult emotional or physical experiences. Participants of mindfulness inductions are often only motivated to participate in an experiment and are ordinarily unaware of the experimental aims, including the presence of a mindfulness practice, until the end of the experimental session. The motivation to practice mindfulness may be being indirectly measured through reports of amount of home practice in MBI, demonstrating a link between motivation to practice, actual practice and outcomes (Parsons et al., 2017).

The age of the sample in the current study may have introduced some additional barriers to the effectiveness of the mindfulness induction, in particular because children were at a pre-operational stage of development. Constructs highly relevant to mindfulness, such as decentering, may necessitate sufficient existing capacities of meta-cognition, attention, introspective awareness, memory and verbal fluency (Black, 2015), which are unlikely to have fully developed in children under 8-years old (e.g., Flavell, Green, & Flavell, 2000). Although these capacities can be enhanced in children by MBI (e.g., Felver et al., 2014; Flook et al., 2010) there is no empirical measure of the effect of a mindfulness induction on these constructs in children and therefore, it is difficult to elaborate on the effect that the developmental stage may have had on the null findings of this study.

The performance on the measures of EF was in part explained by parental reports of child behaviour difficulties. There is substantial evidence demonstrating deficits in EF as predictors of low pro-social behaviour and increased behavioural difficulties (e.g., Hughes, White, Sharpen, & Dunn. 2000). The causative nature of EF on behaviour is unsurprising, given that components of EF such as inhibitory control will directly determine one's capacity to override pre-potent responses (e.g., to hit a peer) that do not fit with overriding goals (e.g., not to be violent). Baseline differences were identified between those allocated to the mindfulness induction and comparison activity. Specifically, in the comparison group there was significantly higher behaviour difficulties overall and behaviour difficulties were negatively associated with EF. There are known associations between higher scores on the SDQ and other pertinent measures of child functioning including speech and language difficulties (Beitchman et al., 1996) and other psychopathological

conditions such as anxiety and depression (Muris, Meesters, & van den Berg, 2003). These factors were not measured in the present study and so the presence of between group differences and the subsequent effect on EF is unknown.

3.4.1 Limitations

The current study did not measure baseline or pre-induction EF, limiting interpretation of the findings as to within participant change following induction and the extent to which causal inferences can be made. The measurement of pre-induction EF presents some challenges, in cases where novelty of task is important (e.g., delay of gratification), learning effects are high (e.g., Tower of Hanoi success or fail), automatization can occur (e.g., HTKS) and where further extension of test duration is undesirable (e.g., for a child participant group; see Beck, Schaefer, Pang, & Carlson, 2011; Müller, Kerns, & Konkin, 2012). Addition of baseline testing sometime prior to the experimental testing session may reduce or negate some of these effects, but may not be practically feasible (e.g., time constraints) and normal development over time could mask the effects of the induction if baseline and experimental measures are taken too far apart. Taking a different measure of EF at pre-induction (e.g., Flanker Task) as an indicator of pre-induction performance may also overcome this, with evidence demonstrating that one measure of EF can predict performance on other EF measures (Senn, Epsy, & Kaufmann, 2004). Although this approach is limited as association between EF components are complex, not always highly correlated and the associations between EF components change across development (Best, Miller, & Jones, 2009).

A particular strength of this experiment was a large sample size and the use of block randomisation to induction group. Disappointingly there were baseline differences identified in parental reports of child behaviour. However, these were addressed statistically, and the findings were interpreted with consideration of these differences. Additionally, it is acknowledged that unequal allocation of baseline characteristics is common in small and moderate sample sizes (Shadish, Cook, & Campbell, 2002) and the use of randomisation to induction leads us to conclude that these between group differences occurred by chance (Miller & Chapmen, 2001).

The experiment benefitted from the use of multiple behavioural measures of EF, identified as a limitation of existing research (e.g., Black, 2015). Notwithstanding, the use of multiple measures extended the testing period and therefore prescribed that the effects of the short mindfulness induction (3-minutes) needed to extend over a relatively long testing time (approx.

25-minutes), if effects were to be detected. Additionally, each EF task presented participants with some cognitive, and for some tasks, affective load (e.g., delay of gratification) potentially masking the effect of the mindfulness induction over time. Further research could prioritise one aspect of EF requiring a single measure to reduce the impact of the EF tasks on each other and isolate the effect of the mindfulness induction on the outcome.

4

A SINGLE MINDFULNESS MEDITATION PRACTICE IMPROVES SUSTAINED ATTENTION IN CHILDREN AGED 7-11 YEARS: AN EXPERIMENTAL STUDY

4.1 Introduction

Sustained attention is the ability to concentrate or focus attention on a particular activity or stimulus for an extended period. Mindfulness training is a recognised approach to enhancing attention in adults (Jha, Krompinger, & Baime, 2007; Lutz, Slagter, Dunne, & Davidson, 2008), and there is emerging evidence for the potential of mindfulness training to enhance attention in children and adolescents (Diamond & Lee, 2011; Mak, Whittingham, Cunnington, & Boyd, 2018). There is present impetus in the UK and elsewhere, to expand mindfulness training in education settings, making it a feasible and popular option as a school-based preventative intervention (Mindful Nation U.K, 2015). The current task for researchers is to enhance the understanding of the mechanisms of mindfulness training for various outcomes and populations. With this in mind, there is good reason to direct research focus to sustained attention in children and adolescents. Sustained attention is a foundation for other cognitive functions such as learning and memory and so training targeted at enhancing sustained attention can have far-reaching effects (Fortenbaugh, De Gutis, & Esterman, 2017). Greater ability to sustain attention is linked to academic success (Posner & Rothbart, 2005), a reduced risk of developmental and psychological difficulties (Brocki & Bohlin, 2006; Joseph, McGrath, & Tager-Flusberg, 2005) and a reduced risk of behaviour and conduct problems (Hughes, White, Sharpen, & Dunn, 2000). It is therefore pertinent to increase understanding of how sustained attention can be enhanced in children and adolescents, and to explore further whether mindfulness may be a potential intervention in this domain.

4.1.1 Mindfulness training for attention in children and adolescents

Mindfulness is defined as "*open and receptive attention to and awareness of ongoing events and experience*" (Brown & Ryan, 2003, pg. 245). There is a large degree of individual difference in dispositional mindfulness, and it is a characteristic that can be enhanced through targeted training. Mindfulness training programmes have broad aims to teach present moment awareness, decentering from thoughts and emotions, approach rather than avoidant coping strategies, greater self-regulation, compassion, wisdom, and equanimity (Crane et al., 2017). Mindfulness training programmes have been designed for children and adolescents and there is growing empirical enquiry in this domain (see Semple & Burke, 2019). Notwithstanding, there are yet very few published studies measuring the effect of mindfulness training on attention in children and adolescents in community samples. Table 4.1 provides an overview of the four existing trials comparing mindfulness training programme to a non-active control on a range of attention measures. Of these there is only one significant effect (of six effect sizes) reported for selective attention (Napoli, Krech, & Holley, 2005). Non-significant effects were reported for self-reported difficulties with attention (Britton et al., 2014; Lam & Seidan, 2020), focused attention (Faces-R; Ricarte, Ros, Latorre, & Beltrán, 2015) and sustained attention (Ricarte et al., 2015; Napoli et al., 2005).

Of relevance are the two studies measuring sustained attention as main outcomes. Ricarte and colleagues (2015) randomised participants aged 6-13 years to either a 6-week Mindfulness Emotional Intelligence programme (n = 45; Ramos, Recondo, & Enríquez, 2012) or a non-active control (n = 45). Each week of the mindfulness intervention focused on one of three mindfulness meditation practices: breathing, the senses, or attention to the body. For this study, sustained attention was measured using part A of the Trail Making Test (Reitan & Wolfson, 1985), a pen and paper measure where participants are timed while connecting a series of encircled numbers.

The non-randomised study by Napoli and colleagues (2005) assessed whether children aged 6-9 years benefitted from a 24-week Attention Academy Programme (n = 97) compared to a non-active control group (n = 97). Each session of the intervention included three core exercises: breathing, physical (e.g., stretching, dancing), and sensory (e.g., noticing smells, sounds). The sustained attention measures were combined scores from three activities of the Test of Everyday Attention for Children (Manly et al., 2001). The activities were: Score! (Counting auditory tones), Walk, Don't Walk (a go/no go task using auditory prompts) and Code Transmission (detecting

infrequent visual targets in a stream of non-targets). Overall, the published evidence does not yet support that there is an effect of mindfulness training on attention in children and adolescents; however, there have been several systematic reviews that have synthesised the broader existing literature.

Table 4.1 Overview of intervention trials of mindfulness training on attention in community samples of children and young people

First author (year)	Mean age (*SD*)	*N* (RCT)	Intervention, duration hours, facilitator	Outcome	Cohen's *d* *[95% CI]*
Britton (2014)	11.79 (0.41)	100 (Y)	Novel, 4, Teacher	YSR	-.11 [-.62, .40]
Lam (2020)	12.40 (nr)	115 (Y)	Learning to BREATHE, 7, External	YSR	.18 [-.19, .55]
Napoli (2005)	~7.50 (nr)	194 (no)	Attention Academy, 9, External	TEA-Ch: Selective	.60 [.31, .89]
				TEA-Ch Sustained	.14 [-.15, .42]
Ricarte (2015)	8.90 (1.98)	90 (Y)	MEITP, 7.5, nr	TMTa	-.23 [-.62, .40]
				Faces-R	-.16 [-.57, .26]

Note. *SD* = standard deviation; *N* = sample size; *RCT* = randomised control trial; *CI* = confidence interval; *Y* = yes; *Non-act* = non-active control; *YSR* = Youth Self Report; *nr* = not reported; ~ = approximate; *TEA-Ch* = Test of Everyday Attention for Children; *Selective* = selective attention subscale; *Sustained* = sustained attention subscale; *MEITP* = Mindfulness Emotional Intelligence Programme; *TMTa* = Trail Making Test A.

There are several systematic reviews of the broader evidence base (e.g., inclusive of unpublished studies) that reflect the potential for an effect of mindfulness training on attention in children and adolscents. In a recent rigorous meta-analysis including only mindfulness training (e.g., not yoga, meditation) and randomized control designs (k = 8, N = 1158), there was a significant improvement in attention following the mindfulness training when compared to all control conditions d = .19 *95% CI* [.04 to .34]; but not when compared to only active controls d = .13 *95% CI* [-.01 to .28] (k = 5, N = 787; Dunning et al., 2019). Furthermore, in a review of potential mechanisms of change following mindfulness training (controlled designs only; (k = 10; N = 1243)), there was evidence to support attention as a significant mechanism of change following mindfulness training *Hedge's g* = 0.29 (Klingbeil et al., 2017). Conversely, in a comprehensive review including all study designs (k = 61), there was no support for a link between enhanced cognitive outcomes (k = 10; including attention) and subsequent benefits to academic or behavioural outcomes (Maynard, Solis, Miller, & Brendel, 2017). Overall, the findings from systematic reviews are promising but far from conclusive. Furthermore, the reported meta-analyses have often been highly heterogeneous, making interpretation of the synthesised

findings problematic. There is therefore reason to further explore the potential of mindfulness training on attention in community-based children and adolescents. In particular, the evidence base would benefit from investigations that might offer greater understanding of the components of mindfulness training programmes that contribute to overall effects.

4.1.2 Mindfulness meditation practice for attention in children and adolescents

Mindfulness meditation practices are recognised as a core component of mindfulness training (Crane et al., 2017) forming an experiential component that allows theoretical aspects of mindfulness training to be put into practice. Furthermore, mindfulness meditation practices are an active component of training in adults, with repeated practice of mindfulness meditation being associated with increased trait mindfulness over time (Kiken, Garland, Bluth, Palsson & Gaylord, 2015; Stein & Witkiewitz, 2020). There are several mindfulness meditations including mindfulness of breathing, mindful movement, mindful eating, and compassion-based practices such as the loving kindness meditation (see Kabat-Zinn, 1990). Mindfulness meditations are relatively brief (e.g., 3-45 minutes) and are known to induce in adults a state of mindfulness in experimental settings, even in novice meditators (e.g., Mahmood, Hopthrow, & Randsley de Moura, 2016). In addition, even as a novel practice systematic reviews and meta-analysis of single mindfulness meditations with adults, demonstrate that they can have a significant effect on self-regulation (Leyland, Rowse, & Emerson, 2019). More recently the effects of a single mindfulness meditation have been tested with children from as young as 4 years.

The short-term effects of a mindfulness meditation have been tested on self-regulation with children and adolescents. These published experimental studies have reported non-significant effects for attention (orienting, alerting, and executive; Lim & Qu, 2017) and executive function (Leyland, Emerson, & Rowse, 2018). Other published experimental studies have reported differential effects for emotion reactivity and regulation (Deng, Zhang, Hu, & Zeng, 2019), self-regulation (Nadler, Cordy, Stengel, Segal, & Hayden, 2017), and rumination (Hilt & Pollak, 2012). The published experimental studies to date have applied different outcome measures, mindfulness meditation practices, and the participant groups have been of varying ages. An overview of the published studies is presented in table 4.2.

The most pertinent published experimental study reported no significant effects for a 10-minute mindfulness practice on three attention networks (orienting, alerting, and executive) as measured by the Attention Network Task (ANT; Lim & Qu, 2017; Rueda et al., 2004). There is

evidence from systematic reviews that the ANT may not be a reliable tool for measuring pre-post changes (Macleod et al., 2010), although it is unclear whether this accounts for the non-significant findings in this instance. The study by Lim and Qu (2017) benefitted from a larger study sample than other published studies and is the only published example using a matched comparison activity (table 4.2). Experimental studies require a relatively lower investment (time, resources, money) than intervention studies, and they allow for a greater control of the study design (Levin, Hildebrandt, Lillis, & Hayes, 2012). Given the present view of the evidence base in this domain, experimental studies may have a lot to offer to determine if mindfulness meditation is an active component of mindfulness training for children and adolescents. Furthermore, they offer the potential to test the feasibility of sustained attention measures as an outcome for children and young people following instruction in mindfulness meditation. To the best of our knowledge, the effects of a mindfulness meditation practice on sustained attention has not previously been the focus of experimental research with children or adolescents.

Table 4.2 Overview of published experimental studies testing the short-term effect of a mindfulness meditation practice with children and adolescents

First author (publication year)	Age range years	Intervention (*n*)	Control (*n*)	Led by; Total minutes	Outcome Measure
Deng (2019)	9-11	Mindfulness of breathing (18)	Non-active (17)	Ext; 10	EEG ERP
Hilt (2012)	9-14	Mindful awareness & acceptance, mindfulness of breathing (31)	Distraction (32), Problem Solving (33)	Ext; 8	RUM
Leyland (2019)	4-7	Mindfulness of sound (80)	Dot-to-dot (76)	Ext; 3	HTKS; TOH; DOG; DS
Lim (2017)	4-6	Mindful movement, sound, breathing (46)	Dance, sing, count (46)	Ext; 15	ANT
Nadler (2017) 2 samples	7-9, 7-9	Movement, breathing (8, 6)	Non-active (15,15)	Ext; 10	SAM

Note. *n* = number of participants; *Ext* = external practitioner; *EEG* = electroencephalogram; *ERP* = event related potentials; *RUM* = rumination; *HTKS* = Head Toes Knees and Shoulders; *TOH* = Tower of Hanoi; *DOG* = Delay of Gratification; *DS* = Digit Span; *ANT* = Attention Network Task; *SAM* = Self-Assessment Manikin.

4.1.3 Measuring sustained attention

Sustained attention has classically been measured using vigilance tasks (detecting infrequent targets over an extended duration) or more recently continuous performance tasks (detecting infrequent non-targets over an extended duration; Fortenbaugh et al., 2017). With the

advantage of the latter method being that a greater number of responses are collected leading to possibilities for analysis of moment-to-moment attention fluctuations (Fortenbaugh et al., 2017). A popular continuous performance task is the sustained attention response task (SART) designed for use with healthy adults and those with brain injuries (Manly, Davison, Heutink, Galloway, & Robertson, 2000; Robertson, Manly, Andrade, Baddeley, & Yiend, 1997) and later adapted for use with children and adolescents (Zhang, Song, Ye, & Wang, 2015). There are three categories of performance errors in the SART: minor, major and disengagement (Cheyne, Solman, Carnere, & Smilek, 2009). Minor errors in sustained attention are measured as greater response time variations that reflect that the participant has caught a mistake or error before it happens. Minor errors in sustained attention are thought to reflect occasions of mind wandering and are sufficient to reduce memory recall and impair learning (Fortenbaugh et al., 2017; Mrazek, Smallwood, & Schooler, 2012). Major errors in sustained attention are errors of commission (response is incorrect) or omission (no response is incorrect). The respondent notices these major errors once they have occurred and returns attention to the task. Finally, disengagement of sustained attention leads to successional uncaught errors in the SART (Cheyne et al., 2009). The SART is a sensitive measure of moment-to-moment attention. The use of sensitive measurement tools has been recommended by authors in the field, both when measuring cognitive functions such as sustained attention in children (Mak et al., 2017) and when testing a single mindfulness meditation practice in experimental conditions (Leyland et al., 2019).

There is a high degree of intra-individual difference in performance on measures of sustained attention, such as the SART. Two state-dependent factors that are supported empirically to influence sustained attention performance are motivation and state affect (Cohen, Sparling-Cohen, & O'Donnel 1993; Diamond, 2013). Specifically, low task motivation and greater negative affect impairs sustained attention performance as measured by the SART (e.g., Smallwood et al., 2004, 2009). These state factors may disrupt sustained attention performance as they reflect both top-down volitional control of attention, and bottom-up automatic factors that can impair the regulation of cognitive functions such as attention (Zelazo & Lyons, 2012). Specifically, the top-down factors are an individual’s motivation or intention to continue to direct attention toward a task, and the bottom-up factors are greater levels of emotional arousal (or under arousal) that distract attention away from the task. In this way a mindfulness meditation may be effective at enhancing sustained attention performance as it may reduce bottom-up disruptions to sustained attention or enhance the volitional control of attention (Kaunhoven & Dorjee, 2017).

4.1.4 The present study

Given the importance of sustained attention for children's cognitive, emotional and academic functioning it is important to better understand how sustained attention can be enhanced. The present study randomised 191 children to either a 10-minute mindfulness meditation or active control activity to assess the between group difference in performance on a computerised sustained attention measure, the SART. The potential moderating effects of motivation and state affect were tested to contribute to the theoretical understanding of the pathways through which mindfulness meditation practices may exert short-term effects on sustained attention. Children completing the mindfulness meditation practice were expected to perform significantly better on the sustained attention task compared to those in the active control condition. These effects were predicted to be due to greater task motivation and/or state affect for those participating in the mindfulness meditation practice.

The present study builds on the evidence garnered from chapter two and three of this thesis. Specifically, the findings of chapter two emphasised the importance of the self-regulation of attention and emotion were affected by a single mindfulness meditation practice in adults. Furthermore, an experimental trial included in the narrative synthesis of evidence in chapter two found a moderate effect of a mindfulness meditation practice on sustained attention in adults, when using the SART as the main outcome measure (Mrazek et al., 2012). The use of the SART was supported more broadly by chapter two as the findings indicated that computerised measurement tools that are sensitive to reaction time differences may be appropriate for experimental studies testing short term changes following a mindfulness meditation.

The findings of chapter three were that a mindfulness meditation practice had no immediate effect on executive function in children aged 4-7 years. This outcome was supported by the findings of the narrative synthesis in chapter two that reported that there was little evidence for an effect of a single mindfulness meditation practice on executive function in adults. Chapter three was informative in refining the methodology used in chapter four in three main ways. Firstly, it was recognised that it was important to improve on the proportion of mindfulness *dosage* relative to the expected duration of any effects. Subsequently, for the study presented in chapter four the duration of the mindfulness meditation was increased from 3 minutes to 10 minutes, and the duration of outcome testing reduced from ~25 minutes to 5 minutes. Secondly, an older age participant group was selected for chapter four to support the use of more sensitive computerised

outcome measures and a validated measure of trait mindfulness. Finally, a weakness of the study in chapter three was the absence of a baseline measure of executive function as the main outcome. As a result, the methodology for the study presented in chapter four included a baseline measure of attention and working memory. These measures were used to indicate individual differences in baseline performance in attention and cognitive function without causing practice effects.

The consideration of this evidence motivated an empirical experimental trial with children aged 7-11 years testing the short-term effects of a mindfulness meditation practice on sustained attention. This investigation contributes to answering the second research question of this thesis, which asks whether a mindfulness meditation practice can effect short-term change for self-regulation in children aged 4-11 years.

4.2 Method

4.2.1 Participants

One hundred and ninety-one participants aged 7-11 years were recruited from four primary schools in a northern city in the United Kingdom. Participants were recruited by sending research information sheets and consent forms via schools to parents or carers. Of the 191 participants who consented to participate, data from 13 participants were excluded from the analysis. Of these one withdrew before randomisation, three were randomised but did not complete all measures, three had faults in the computer data files, and the testing sessions of six others were disrupted by school activity. Data from 178 participants were analysed (*M*age = 9 years 7 months; *Mrange* = 7 years 4 months to 11 years 8 months; 53% female). An *a priori* power analyses found that a sample size of $N = 175$ was required for 95% power to detect an effect size of Cohen's $d = .50$.

4.2.2 Design

The present study used a randomised experimental design to test the effects of a single mindfulness meditation practice compared to an active control activity on sustained attention. The moderating effects of motivation and state affect were assessed. The method of randomisation was that children selected a red or yellow counter from an opaque envelope, which signified condition allocation. The order of experimental tasks was baseline measures (attention, working memory, trait mindfulness, and sustained attention practice trial), activity (mindfulness meditation practice or active control activity), and outcome measure (sustained attention main trial; for more details of the procedure see appendix four). Attention at baseline was used as an indicator of inter-individual variability in sustained attention. Working memory was used as a global indicator of cognitive

function capacity. The practice and main trial of the measure of sustained attention were separated either side of the activity in order to reduce the potential for extinction of any effects of the mindfulness meditation practice during the training phase. Motivation and state affect were assessed at three time points: at baseline (Time 1), after the activity (Time 2), and after the outcome measure (Time 3). All data were collected in one experimental session in school lasting around 25 minutes for each child.

Measures

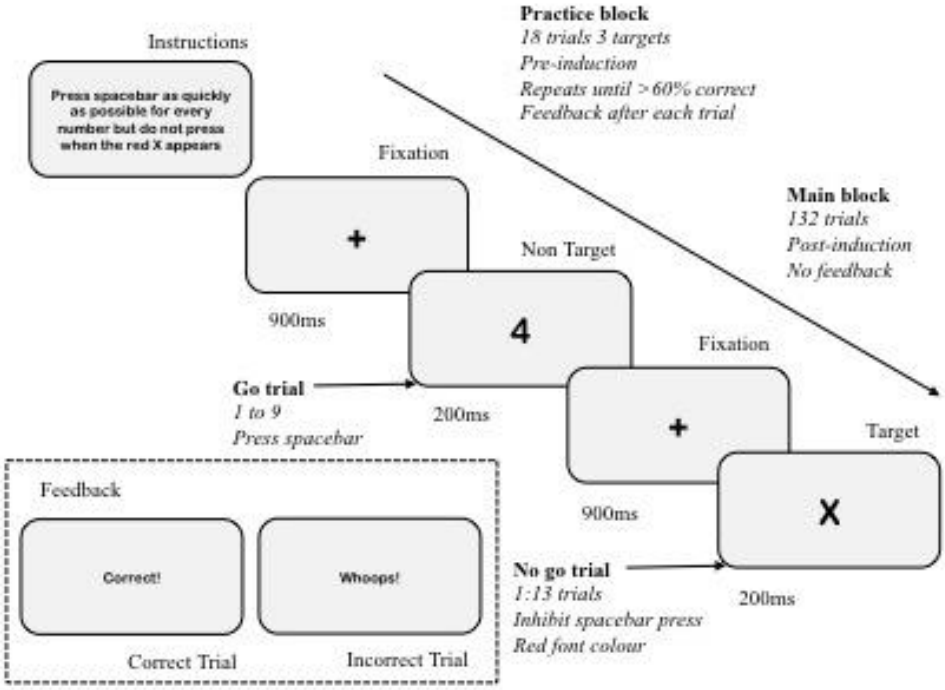
Sustained attention was measured using a 5-minute version of the SART, a computerised GO/NOGO task (Robertson et al., 1997). Figure 4.1 shows the schematic of the SART, which was delivered digitally via E-Prime software (Psychology Software Tools, Pittsburgh, PA). Participants were instructed to press a key in response to a rapidly presented series of non-targets (GO trials) and to withhold a response to the presentation of targets (NOGO trials). The SART has been successfully adapted for children aged 9 to 11 years by changing the target for NOGO trials to a red letter 'x' (Zhang et al., 2015). The practice block was repeated until accuracy reached greater than 60% of responses. Major sustained attention errors were calculated as the percentage accuracy for NOGO trials. Minor sustained attention errors were calculated as the reaction time coefficient of variability (RTCV), using the mean reaction time (M) and standard deviation of reaction times (SD) for GO trials (RTCV = SD/M). This provides a measure of reaction time variability while controlling for reaction time speed.

Attention was assessed using the child Attention Network Task (ANT; for a full description, see Rueda et al., 2004) presented on E-Prime software. The task was formed of a series of visual presentations of cues (single or double asterisk symbols) followed by congruent, incongruent, or neutral stimuli (determined by the direction of a lone fish or fish within a group). Participants were instructed to press a red or blue key in response to the direction of the lone fish or the central fish in a group. Outcomes were computed for percentage accuracy and three components of attention: alerting, orienting, and executive attention (Rueda et al., 2004).

Motivation and state affect were measured at three time points across the testing session using a series of questions answered by children marking along a 200mm visual analogue scale. Two questions assessed participant task motivation: How much did you want to play the game? *Not at all* to *really wanted to play*; and how important was it to you to do well in the game? *Not important at all* to *really important*. State affect was assessed with a single question "How do you

feel right now?" with an image of an unhappy and happy cartoon face, set at either end of the scale.

Figure 4.1 Schematic of SART



Working memory capacity was assessed using the Backward Digit Span test from the Weschler Intelligence Scale for Children (WISC; Wechsler, 1949). The digit span test verbally presents strings of digits that the participant is then asked to recall in reverse order. The length of the digit string is increased progressively as the participant is successful in each round. The dependent variable was the longest digit string recalled. Testing was discontinued once two consecutive incorrect responses were given.

Child trait mindfulness was assessed using the child and adolescent mindfulness measure (CAMM) a 10-item measure of trait mindfulness validated for children aged 10-17 years (Greco, Baer, & Smith, 2011). Children rated each item on a five-point Likert scale, *never true* to *always true,* summed to give a total score for mindfulness. Items include statements such as: *I tell myself that I shouldn't feel the way I'm feeling,* and *At school, I walk from class to class without noticing what I'm doing*. The internal consistency in the current sample was not satisfactory, Cronbach's α

=.63. When the sample was split for age, the consistency improved for those over 10 years (n = 73; i.e., in children for whom the scale was valid), Cronbach's α = .76, but not for those under 10 years of age (n =105), Cronbach's α = .51. Consequently, trait mindfulness is reported only for participants over 10 years of age.

Mindfulness meditation practice and the active control activity

Both the mindfulness meditation practice and the active control activity lasted 10 minutes and are summarised in table 4.3 (full scripts are available in appendix five). The conditions were matched to have three sections: settling, movement, and focused attention. Both the mindfulness meditation and the control activity were developed for the purposes of the present study and delivered as an audio recording. The mindfulness meditation activity was based on mindfulness of breathing and mindful movement meditations, two of the core experiential mindfulness practices in mindfulness training (Crane et al., 2017). The instructions directed participants to focus their attention on the movement of the body and sensations of breathing while holding a non-judgmental and accepting attitude. The author who is trained in mindfulness-based approaches voiced the recording of the instructions. A member of the supervisory team (LME), who is an experienced mindfulness teacher and clinical psychologist, approved the script and recording of the audio instructions. For both the mindfulness meditation practice and active control activity the experimenter followed the instructions alongside the child.

Table 4.3 Summary of task instructions for the mindfulness meditation practice and active control condition

Time minutes	Section	Mindfulness meditation practice	Active control activity
0-2	Settling	Focus visual attention on a marker on the ground and stand with a good posture	Stand with a good posture
2-6	Movement	Move arms slowly and with mindful awareness. Regulate attention toward the movement.	Moving head and stretching arms
6-10	Focused attention	Mindfulness of breathing while lying on the ground. Hands placed on abdomen to feel the movement of the breath. Breath counting. Hold accepting and non-judgemental attitude to experience.	Listening activity while sitting on the ground. Listen to animal noises and clap in response to particular animal e.g., horse, dog.

4.2.3 Data Analysis

Prior to analysis, data were screened and checked for pre-induction differences, and to assess associations between variables. Between activity group comparisons were made for demographic (age, gender) and baseline measures (attention, working memory, trait mindfulness). Moreover, analyses were conducted with each of the baseline and demographic variables entered as independent variables (IV) with sustained attention as the dependent variable (DV). Final checks were made for the effect of demographic variables entered as IVs on baseline variables entered as DVs in analyses. In all cases, only significant effects are reported. In the interests of parsimony, only the interaction effects that significantly predicted the main outcome were retained as covariates in the main analyses. The main analyses were two t-tests for major and minor sustained attention performance errors. Planned follow-up moderation analysis tested whether any significant findings from the main analyses were moderated by motivation or state affect. All statistical analyses were conducted in SPSS version 25 (IBM Corp, 2017) using the Process plug in for moderation analysis (Hayes, 2016).

4.3 Results

4.3.1 Preliminary analysis

The demographic and descriptive data split for activity (mindfulness meditation practice, active control activity) are presented in table 4.4. There were no baseline differences between those children who participated in the mindfulness meditation practice or active control activity for baseline attention or working memory. Associations between all continuous variables are presented in a correlation matrix in table 4.5. There was a positive association between major and minor sustained attention performance errors for both activities. In addition, there was a negative association between state affect at time two and minor sustained attention errors for the mindfulness meditation activity but not for the active control activity.

There was a significant negative effect of time but not activity on state affect $F(2, 358) = 1.919$ $p < .001$, and motivation $F(2, 358) = 4.297$ $p = .014$. Pairwise comparisons revealed that compared to time 1 state affect was significantly more negative at time 2 $F(1, 180) = 8.191$ $p = .005$ $d = -.16$, but there was no difference between state affect at time 2 and time 3 $F(1, 180) = 3.204$ $p = .075$ $d = .12$. The effect of time on task motivation was that it was significantly lower at time 2 compared to time 1 $F(1, 180) = 7.605$ $p = .006$ $d = -.14$, and at time 2 compared to time 3 $F(1, 180) = 4.328$ $p = .039$ $d = -.12$.

Table 4.4 Demographic, descriptive and outcome data split for condition

	Mindfulness meditation practice *n* = 86 *Mean* (SD)	Active control activity *n* = 92 *Mean* (SD)
Age years	9.51 (1.15)	9.65 (1.09)
Gender girls	55.8%	50.0%
Trait Mindfulness (Age 10+ years)	25.45 (6.78)	21.35 (6.07)
Working Memory	2.58 (.85)	2.78 (1.13)
Attention ms		
Alerting	37.58 (76.92)	18.72 (79.11)
Orienting	1.75 (72.91)	-3.72 (74.34)
Executive Attention	58.31 (83.52)	75.71 (91.19)
Task Motivation		
Time 1	130.19 (38.82)	130.32 (38.58)
Time 2	119.70 (48.59)	126.33 (43.78)
Time 3	124.94 (48.54)	133.30 (40.96)
State affect		
Time 1	171.13 (34.78)	166.39 (38.20)
Time 2	160.83 (44.28)	160.61 (44.28)
Time 3	150.92 (44.51)	157.72 (42.63)
Sustained Attention		
Minor errors	0.26 (0.08)	0.29 (0.08)
Major errors	59.69 (18.87)	59.15 (17.52)

Note: *SD* = Standard deviation; *ms* = milliseconds; *Time 1* = baseline; *Time 2* = after activity; *Time 3* = after outcome.

4.3.2 Does a single mindfulness meditation practice enhance sustained attention?

T-tests assessed whether a single mindfulness meditation practice could enhance sustained attention when compared to an active control activity. It was found that there was a significant positive effect of a mindfulness meditation practice when compared to an active control activity for minor sustained attention errors, $t(172) = 2.24$, $p = .027$, *95% CI* = [.00 to .05], $d = -.38$. There was no effect of the mindfulness meditation compared to the active control activity on major sustained attention errors, $t(176) = -.20$, $p = .843$, *95% CI* [-5.92 to 4.84], $d = -.03$.

4.3.3 Is the effect of a mindfulness meditation practice on sustained attention moderated by motivation and state affect?

Moderation analyses were conducted to test whether the effect of the mindfulness meditation on minor sustained attention errors was moderated by motivation or state affect. It was found that the effect of the mindfulness meditation practice on minor sustained attention errors was moderated by state affect, $F(3,170) = 3.86$, $p = .011$, $R^2 = .06$, $d = .12$ (Figure 4.2). There was a

significant moderation effect of state affect at the mean B = -.03, $t(170)$ = -2.26, p = .025, and maximum B = -.05, $t(170)$ = -3.07, p = .003, values of state affect for the mindfulness meditation practice but not when state affect was one SD below the mean B = -.00, $t(170)$ = .12, p = .901. When state affect was more positive the mindfulness meditation practice significantly enhanced sustained attention. Motivation did not act to moderate the effect of the mindfulness meditation practice on sustained attention.

Table 4.5 Pearson correlations between attention tasks, state characteristics and trait mindfulness split for activity (mindfulness meditation or active control activity)

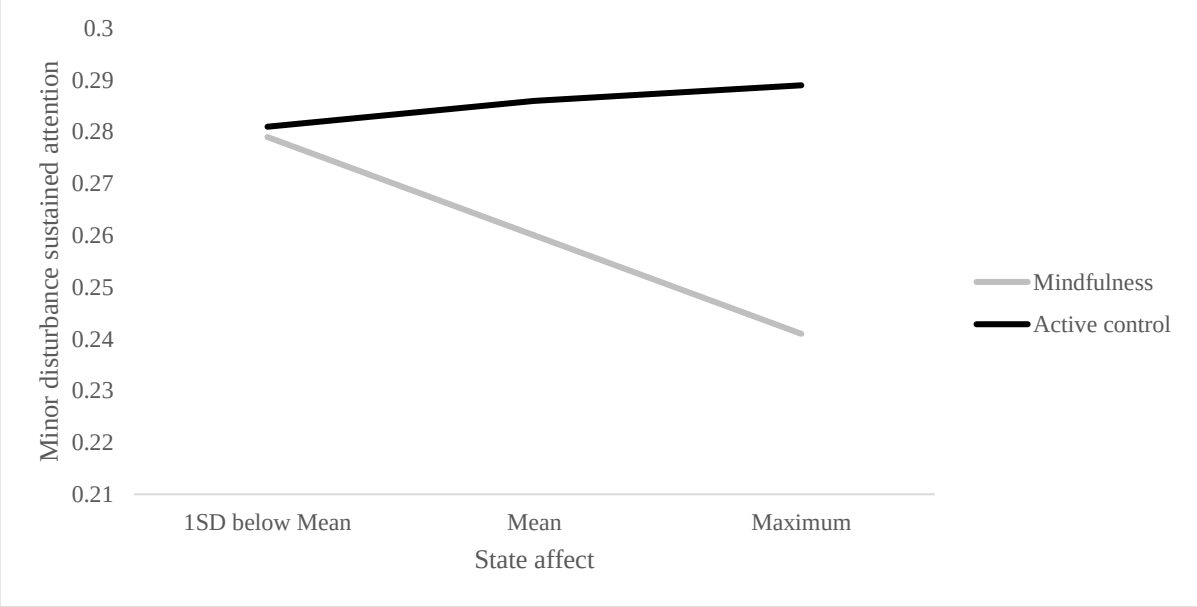
		Active control activity							
		1	2	3	4	5	6	7	8
Mindfulness meditation	1. Sustained attention major	+	-.32**	-.01	-.04	.06	-.01	.15	-.03
	2. Sustained attention minor	-.24*	+	-.04	-.10	-.06	-.12	-.12	.05
	3. Alerting	.08	.09	+	.60**	.08	-.07	-.09	-.04
	4. Orienting	.10	.18	.61**	+	-07	-.11	-.09	-.13
	5. Executive Attention	-.20	-.12	-.08	-.10	+	20	.13	-.04
	6. Age	-.10	-.09	-.04	-.11	-.05	+	-.08	.13
	7. Task motivation (T3)	.04	-.06	-.15	-.13	.07	-.17	+	.26*
	8. State affect (T2)	.15	-.27*	-.04	-.04	.05	-.08	.52**	+
	9. Mindfulness [a]	.22	-.07	-.04	-.13	.04	.06	.24*	-.07

Note. T3 = Time 3 (after sustained attention measure) T2 = Time 2 (after activity).
[a] Data represents only children aged over 10 years and without splitting for condition.
* = p <.05 and ** = p <.01

4.4 Discussion

The present study used a randomised experimental design to determine the effects of a 10-minute breath and movement-focused mindfulness meditation practice on an objective measure of sustained attention in 178 children aged 7-11 years. The effects of the mindfulness meditation practice were compared to an active control activity on a computerised task measuring sustained attention errors. Following the mindfulness meditation there were fewer minor sustained attention errors compared to the comparison group, and this effect was moderated by state affect. Sustained attention was significantly greater for those completing the mindfulness meditation where state affect was reported as being at the group average or higher. There were no significant effects of the mindfulness meditation on major sustained attention errors, nor did motivation significantly effect outcomes.

Figure 4.2 The moderation of state affect on minor sustained attention errors following the mindfulness meditation practice or active control activity



Note. Moderator is state affect at Time 2 the activity; Values of state affect at *Mean-1 SD* = 117.70, *Mean* = 160.55, Maximum = 200.00.

The present findings report on an immediate significant improvement in sustained attention for children following a mindfulness meditation practice, which was moderated by state affect. These findings partially support the hypothesis of the present study, which proposed that the effect would be moderated by state affect and motivation. Mindfulness is theoretically proposed to enhance attention through enhancing the volitional control of attention and reducing the effects of attention disruptions or distractions, such as emotional arousal or fatigue (Kaunhoven & Dorjee, 2017; Zelazo & Lyons, 2012). In the present study motivation was measured as an indicator of volitional control of attention and state affect was measured as an indicator of potential disruptions to sustained attention. In the present sample there was an interaction between state affect and the mindfulness meditation practice, but no interaction between state affect and the active control activity. Notwithstanding across both activities there was a significant negative effect of the activity on state affect (compared to baseline), and for the remainder of the testing sessions state affect did not recover for either activity. The conditions were matched for format and content to isolate the specific effects of the mindfulness instructions. Therefore, across the whole participant sample it can be inferred that it was the non-mindfulness aspects of the conditions that lowered state affect. On the backdrop of these unexpected effects of the condition on state affect, two possible explanations for the main findings of the present study are proposed.

The first potential explanation is that the mindfulness meditation practice acted to protect sustained attention performance from the potential deleterious impact of lower state affect (as a result of non-mindfulness aspects of the activity). This possible protective effect was limited as it did not extend to prevent state affect from lowering, nor did it protect sustained attention in those participants for whom participation in the condition had the most negative impact on state affect. Rather it may be proposed that the effect of the mindfulness meditation practice was to create distance or separation from the emotional experience. Reducing elaborative processing of emotional stimuli can free up cognitive resources for subsequent cognitive tasks and may have benefitted sustained attention performance in the present study. Reduced processing of emotional stimuli through cognitive distance and equanimity are mechanisms through which mindfulness is thought to enhance self-regulation (Shapiro, Carlson, Astin, & Freedman, 2006). The present findings do not support that there was an effect of the mindfulness meditation practice to enhance emotion regulation, as state affect did not recover for either condition.

The second potential explanation of the findings is that more positive state affect acted to facilitate the effect of the mindfulness meditation practice on sustained attention. Presently there are few theoretical models that help to explain how higher state affect may facilitate the effect of a mindfulness meditation practice. In the present sample for those in the mindfulness meditation practice group there was a stronger significant association between state affect and task motivation than for those participating in the active control activity (table 4.5). This might suggest that greater positive state affect facilitated the impact of the mindfulness meditation practice by enhancing task motivation. Greater task motivation may be an indicator of greater top-down control of attention toward a task that could result in enhanced sustained attention performance. Mindfulness is thought to be associated with greater volitional control of attention (Hölzel et al., 2011). Benefits to attention might be gained through mindfulness meditation practice that strengthens abilities in attention regulation and introspective awareness (Vago & Silbersweig, 2012). Moderation analysis did not find task motivation to be a significant moderator of the mindfulness meditation practice on sustained attention. Overall, the present findings offer preliminary evidence for an effect of mindfulness meditation practice to enhance sustained attention in children. Two potential explanations have been offered to explain the role of state affect as a moderator of this main finding. Neither the findings presented here, nor existing evidence can fully support either explanation.

The present findings report that a single mindfulness meditation practice improved sustained attention in children aged 7-11 years. This is greatly informative as it demonstrates that the mindfulness meditation component of mindfulness training may be an active component of mindfulness training for children from age 7 years. This is of particular importance as there is little evidence for the effectiveness and age appropriateness of mindfulness meditation practices as a component of mindfulness training for children and adolescents (Thompson & Gauntlett-Gilbert, 2008). Furthermore, the findings demonstrated that a mindfulness meditation practice can enhance sustained attention in children. There is reason to seek to enhance sustained attention ability in children, particularly as a component of self-regulation, as it is an important predictor of school performance and more general wellbeing across the life span (e.g., Hughes et al., 2000; Posner & Rothbart, 2005). It is therefore a key area for researchers to further enhance understanding of targeted ways through which sustained attention can be improved. To date there have been few intervention studies investigating the effects of mindfulness training on sustained attention in community samples of children and adolescents. Sustained attention is a prime candidate for mindfulness interventions in community populations as it has high intra-individual variability and is greatly affected by state characteristics such as motivation and state affect (Cohen et al., 1993). The present findings contribute to the growing evidence base in this domain as they give preliminary evidence that sustained attention can be enhanced in the short-term through a single mindfulness meditation practice.

The present findings report that the mindfulness meditation practice resulted in fewer minor sustained attention errors; however, there was no effect on major sustained attention performance errors. This finding was not aligned with previous evidence with adults that found an effect of a mindfulness meditation practice on minor and major sustained attention errors (Mrazek et al., 2012). The present study and an existing study conducted with adults (Mrazek et al., 2012) are similar in some respects (e.g. outcome measure), but differ fundamentally in the ages of the participant sample. This difference makes further comparison of these two studies inapposite. Nevertheless, minor sustained attention errors are predictive of major sustained attention errors (Cheyne et al., 2009) and in the present findings there was a significant association between the minor and major sustained attention errors (Table 4.4). It may be predicted that more (i.e., repeated or longer duration) mindfulness meditation practice would equate to greater and more readily observable benefits in sustained attention. However, this was not directly tested in the present study. There is evidence from the broader literature that amount of mindfulness meditation practice is positively associated with beneficial outcomes following mindfulness training (Parsons, Crane,

Parsons, Fjorback, & Kuyken, 2017). This informs understanding of the findings of the present study in that the small *dose* of mindfulness meditation practice equated to small but nevertheless significant gains in sustained attention.

The present study is the first experimental study to test for an effect of a mindfulness meditation practice on sustained attention in a community sample of children. The present findings are a valuable addition to this growing evidence base. Presently there is little evidence from empirical trials for an effect of mindfulness training on attention in community samples of children and adolescents ($k = 5$); and where sustained attention has been tested no significant effects have been found ($k = 2$; Table 4.1). Although the present study and previous studies testing sustained attention are comparable in terms of population age and setting, there are extensive other differences between the interventions, control groups and outcomes that may account for the different findings (Napoli et al., 2005; Ricarte et al., 2015). There are few published experimental studies testing the effects of a single mindfulness meditation with children or adolescents. In those studies that have been published the findings have reported non-significant or differential outcomes (table 4.2). For example, in the only published experimental study with children measuring attention as the main outcome, non-significant effects of a mindfulness meditation practice were reported (Lim & Qu, 2017). The present study contributes to the limited evidence base within the domain of children and adolescents by demonstrating that mindfulness meditation practice has a short-term significant effect on sustained attention, moderated by state affect.

The significant findings of the present study are not in line with most of the previous evidence in this domain. Notwithstanding, when the literature from broader populations and modes of intervention delivery are considered in meta-analyses the synthesised effect of mindfulness training on attention is significant (Dunning et al., 2019). Furthermore, the findings of the present study are particularly informative as the significant effect was detected even when compared to an active control activity. In a meta-analysis significant effects of mindfulness training on attention were not retained when only those studies using an active control activity were included (Dunning et al., 2019). The findings of the present study are therefore preliminary but promising and as such support the use of the SART as a measure of sustained attention for both experimental and intervention trials of mindfulness for this population. This is of relevance given that a recurring criticism of the evidence base in this domain is the high heterogeneity across intervention trials (Dunning et al., 2019; Semple & Burke, 2020), and as such replication studies may make a particularly valuable contribution.

Limitations

The study benefitted from a randomised design and a relatively large sample with 95% power to detect a moderate effect, $d = .50$. This study overcame the challenge of learning effects on assessments of sustained attention by utilising different baseline measurements as a control. The limitation of this approach is that there are no baseline measures of the main outcome, preventing the calculation of pre-post changes. The current study was limited by the validity and reliability of the measure of trait mindfulness, which was reliable enough only for participants over 10 years of age. Furthermore, a manipulation check to assess whether a state of mindfulness had been achieved following the mindfulness meditation practice, was not included as presently there is no state mindfulness measure available for this age group. Lastly, the measures of state affect and motivation were visual analogue scales created for the purposes of this study. Therefore, the extent to which these were valid or reliable measures of these phenomena cannot be qualified.

Future directions

The findings of the present study show that mindfulness meditation practice may be an active component of mindfulness training for children from age 7 years. This finding is preliminary and would benefit from replication. There is also motive to extend these findings by applying the same methodological design with younger children. This would be informative as to the lower age at which mindfulness meditation practice as a novel practice may exert short-term effects on sustained attention. Similarly, applying the same design to older children and adolescents (aged 11-18 years), would show whether these findings can be replicated across childhood and all stages of child development. The findings provide a basis for further research as to the effects of repeated mindfulness meditation practice and full mindfulness training programmes on sustained attention in community-based children and adolescents. In particular, the present study supports the use of sensitive computerised measures, such as the SART, for both experimental and intervention research studies in this domain.

Conclusion

There was a significant positive effect of a 10-minute mindfulness meditation practice compared to an active control activity on minor but not major sustained attention performance errors in children aged 7-11 years. This effect was moderated by state affect, in that those with average or higher levels of state affect benefited from the mindfulness meditation, whereas those with lower-than-average state affect did not. The results give preliminary support that experiential

mindfulness meditation practices may be an active component of mindfulness training for children from aged 7 years.

5

GENERAL DISCUSSION

The research presented in this thesis aimed to test the proposal that a single mindfulness meditation practice could affect short-term positive change in self-regulation in novice meditators. In addition, the thesis took a special interest in the potential of mindfulness meditation practice for the self-regulation of children and adolescents. The present state of research in this field reflects a growing interest in understanding the processes of change of mindfulness training programmes. One area of enquiry is seeking to identify the active components of mindfulness training and understand their mechanisms of action. The research presented in this thesis contributes to the understanding of the potential effects and mechanisms of action of mindfulness meditation practice as a typical component of mindfulness training. In addition, the research presented here offers a novel contribution in that it explores the potential effect of mindfulness meditation practice with community-based children age 4-11 years. This is of particular importance as mindfulness meditation practice and mindfulness training is being increasingly used with this age group in school settings. The findings of the thesis will now be discussed in relation to the thesis research questions as identified in chapter one:

1. What is the effect of a single mindfulness meditation practice on self-regulation?
2. Can mindfulness meditation practice effect a short-term change for self-regulation in children aged 4-11 years?

5.1.1 What is the effect of a single mindfulness meditation practice on self-regulation?

Chapter two reported that a mindfulness meditation practice exerted a short-term positive effect on some but not all components of self-regulation for novice meditators of all ages. Chapter two was a systematic review of existing evidence from experimental studies across all ages for the

effects of a single mindfulness meditation practice on three aspects of self-regulation: the regulation of negative affect, emotion regulation strategies, and executive function. The findings of chapter two demonstrated through a meta-analysis that a single mindfulness meditation practice enhanced regulation of experimentally induced negative affect relative to the effect of the comparison groups. A series of subgroup analyses found that the mindfulness meditation practice was equally effective to distraction activities, but superior to other activities (e.g., no instruction) in the regulation of negative affect. Furthermore, the ordering of experimental tasks and the nature of the affect induction was important for the strength of effects. Specifically, the mindfulness meditation was effective when it came ahead of the emotional induction and effective where the affect induction used self-referential primers or targeted a specific emotion. Furthermore, where an affect induction was included in the experimental design there was often but not always an indirect effect of the mindfulness meditation on executive function (e.g., inhibition). There was also preliminary evidence for a direct effect of the mindfulness meditation practice to increase sustained attention and decrease rumination.

5.1.2 Can mindfulness meditation practice effect a short-term change for self-regulation in children aged 4-11 years?

The findings of this thesis reported mixed evidence for an effect of a single mindfulness meditation practice on self-regulation of children aged 4-11 years. Specifically, a single mindfulness meditation practice exerted positive effects on sustained attention of children aged 7-11 years (chapter four) but there was no effect on executive function in children aged 4-6 years (chapter three). These findings were consistent with the evidence reported in the systematic review and meta-analysis presented in chapter two, where most evidence was obtained from experimental trials with adults. Chapter two reported that a single mindfulness meditation practice was not sufficient to elicit change in executive function but there was emerging evidence for an effect on sustained attention.

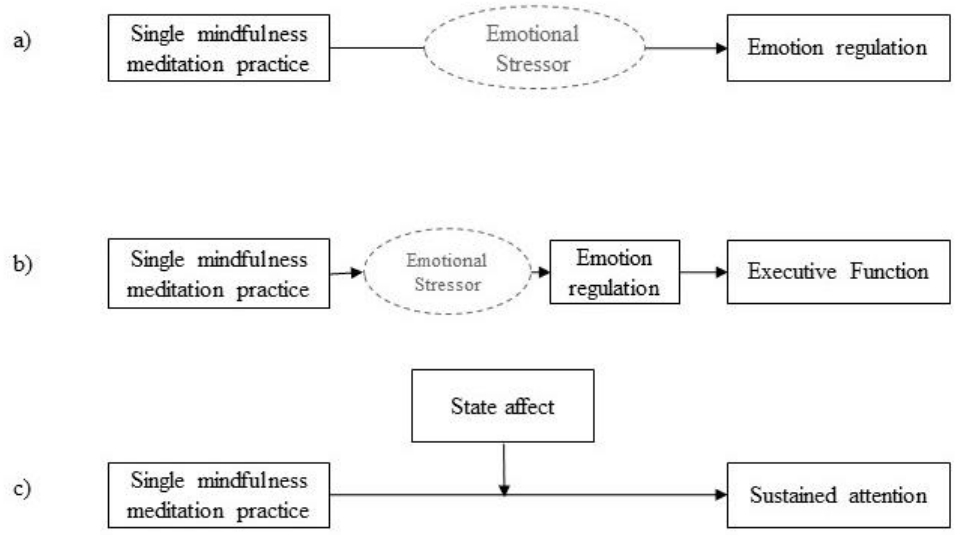
The experimental trial reported in chapter three tested the effect of a 3-minute mindfulness meditation practice compared to a dot-to-dot drawing activity on executive function in children aged 4-6 years. Four pen and paper measures of executive functions were used to gather a comprehensive representation of executive function as a multicomponent construct. There were no significant differences in executive function performance between those completing the mindfulness meditation practice and the comparison activity. The experimental trial reported in chapter four tested the effects of a 10-minute mindfulness meditation practice compared to a

matched active control activity on sustained attention in children aged 7-11 years. The results presented in chapter four report an immediate effect of a mindfulness meditation practice on minor sustained attention errors (response time fluctuations) but not major sustained attention errors. Moderation analysis found that the significant effect on sustained attention was moderated by state affect but not task motivation. Specifically, sustained attention performance was enhanced for those completing the mindfulness meditation practice where state affect was at the group average or higher.

5.1.3 What do the overall thesis findings reveal about the potential for a mindfulness meditation practice to impact on self-regulation?

The findings from this thesis all consistently demonstrate that mindfulness meditation practice can have immediate short-term direct effects on some components of self-regulation. The findings of the thesis are detailed as process models in diagrams a-c (figure 5.1).

Figure 5.1 Process models of a single mindfulness meditation on self-regulation

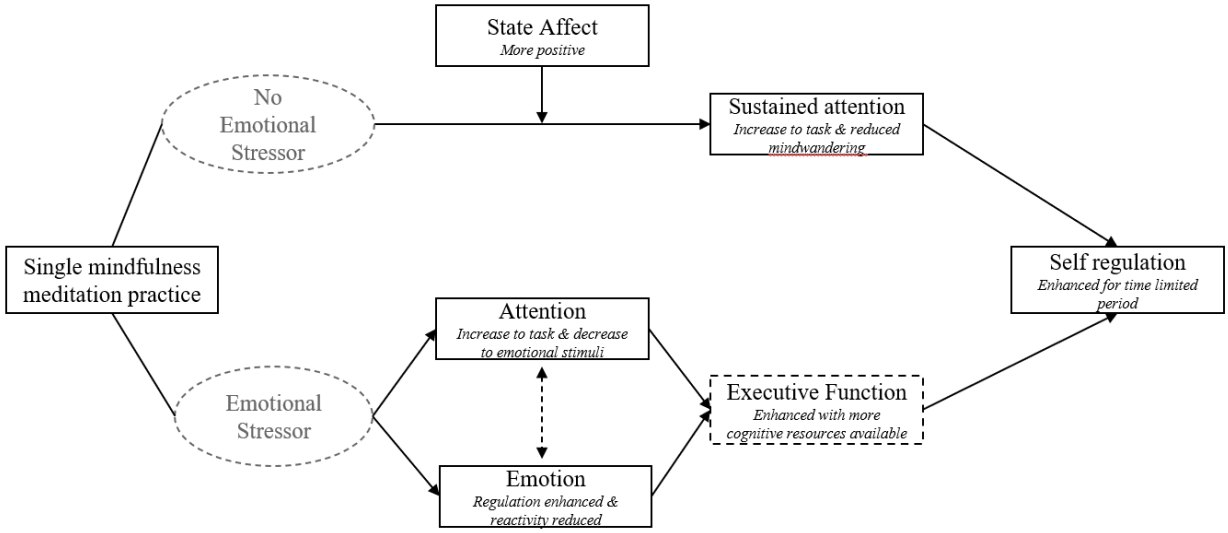


Chapter two reported on a direct effect of the mindfulness meditation practice on negative affect regulation, where the experiment design included an emotional stressor (diagram a, figure 5.1). In addition, chapter two gave preliminary evidence for an indirect effect of a mindfulness meditation practice on executive function only where the design of the experiment included an emotional stressor and so the effect on executive function is proposed to be mediated by emotion regulation (diagram b, figure 5.1). Chapter three supported this finding in so much as there was no detected direct effect of the mindfulness meditation on executive function in children. Lastly, both

chapter two and four reported an effect of a mindfulness meditation practice on sustained attention, and the findings from chapter 4 added that this effect was moderated by state affect (diagram c, figure 5.1). There is therefore reason to draw preliminary conclusions from these findings that a single mindfulness meditation can impact on self-regulation via attention and emotion pathways.

The combined evidence from the findings in this thesis is presented in a model of mindfulness meditation practice for self-regulation depicted in figure 5.2. The model reflects the findings from this thesis as well as existing evidence that indicate that the effect of a mindfulness meditation practice may be different depending on whether the individual encounters an emotional stressor or not. The model uses two types of line: solid (indicates significant effects supported by the evidence in this thesis), and dotted (indicate theoretically proposed effects derived from emerging evidence from this thesis).

Figure 5.2 Proposed model for the effect of a single mindfulness meditation for enhanced self-regulation



Note. The process through which a single mindfulness meditation practice might effect self-regulation differs if there is an emotional stimuli (lower route) or no emotional stimuli (upper route). Dotted lines for arrows or boxes indicate aspects of the proposed model for which there is currently less empirical support.

The upper route of the model (figure 5.2) shows a mindfulness meditation practice can enhance attention towards a task (sustained attention), particularly where state affect is higher. The lower route includes an emotive stimuli, which if not effectively regulated has the potential to cause emotional arousal that can be deleterious to self-regulation. The lower route of the model

(figure 5.2) shows that a mindfulness meditation practice can reduce the impact of the emotional stimuli on self-regulation by enhancing emotion regulation or by reducing emotion reactivity. The model proposes that the mindfulness meditation practice effects change in self-regulation via an emotional pathway. There were preliminary findings from chapter two that the emotion pathway may be interrelated with effects of a mindfulness meditation practice on attention. The effects on attention were proposed as increased attention towards the task and decreased attention from emotional stimuli, or attention redeployment. The model includes an indirect effect of a mindfulness meditation practice on executive function where the mindfulness meditation practice has effectively regulated emotional arousal, as was reported in chapter two.

Two other aspects of the model extend the findings of the present thesis and are theoretically proposed. A bidirectional relationship between attention and emotion and a time-limited effect of the mindfulness meditation practice on self-regulation. All aspects of the model are explained further in the next section where the chapter moves on to consider how the findings of the thesis relate to the existing evidence in this domain. Firstly, theoretical and empirical evidence across all ages will be considered and then evidence pertaining to children and adolescents.

5.2 How do the findings reported in this thesis fit within broader understanding of mindfulness and self-regulation?

The findings across this thesis are consistent in indicating the importance of attention and emotion in the potential effects of a single mindfulness meditation for self-regulation in novice meditators.

5.2.1 Mindfulness meditation practice effects change on self-regulation through an attention and emotion pathway

The findings of this thesis reported that the effect of a mindfulness meditation practice on self-regulation was due to greater attention control and attention redeployment and increased emotion regulation and decreased emotional reactivity. Specifically, the mindfulness meditation practice effected change on attention control, which in turn enhanced self-regulation by increasing task directed focus (upper and lower route of model, figure 5.2). In addition, when an emotional stressor was used in the experimental paradigm the mindfulness meditation practice acted on processes of attention redeployment. Attention redeployment acted to downregulate emotional arousal that has the potential to disrupt self-regulation (lower route of model, figure 5.2). The thesis also reported evidence that a mindfulness meditation practice enhanced self-regulation

through greater emotion regulation and less emotional reactivity in response to emotional stressors (lower route of model, figure 5.2). In addition, where there was no emotional stressor self-regulation was enhanced by the mindfulness meditation practice where participant emotional state was more positive (upper route of model, figure 5.2). The findings of the thesis are mostly supported by the existing evidence in the wider domain of mindfulness, although there were some disparities that will be discussed.

The existing theoretical evidence proposes that there is an association between mindfulness and attention. One proposed role of attention as a theoretical mechanism of mindfulness is that greater attention control leads to reduced elaborative processing of emotional stimuli (Bishop et al., 2004). In turn, this acts to reduce or prevent elevated affective states that can disrupt self-regulation (Zelazo & Lyons, 2012). This is supported by empirical evidence from intervention trials of mindfulness training demonstrating reduced emotional reactivity following training (Lin, Fisher, Roberts, & Moser, 2016; Wenzel, Rowland, & Kubiak, 2020). Similar findings have been reported from neurophysiological studies demonstrating that following a single mindfulness meditation practice there is reduced activation in brain activity in areas related to emotional reactivity in adults (Eddy, Brunye, Tower-Richardi, Mahoney, & Taylor, 2015) and children aged 9-12 years (Deng, Zhang, Hu, & Zeng, 2019). In support of this, the findings in this thesis indicate that the mindfulness meditation was more effective when it impacted on the processing of the emotional stimuli, rather than as a regulatory tool once the emotional response had occurred. In this way, the mindfulness meditation practice may have impacted on attention to regulate emotion by redeploying attention away from the emotional stimuli (or toward the task) reducing emotional reactivity (Gross, 2001). Attention redeployment is considered a resource efficient and effective emotion regulation strategy (Gross, 1998), and as such the findings of this thesis and the proposed model have implications for clinical practices that will be discussed later in this chapter (section 5.4.3).

The role of attention is recognised in existing theoretical understanding of the effects of mindfulness more broadly (i.e., mindfulness training, trait mindfulness) and is one of the agreed-upon defining features of mindfulness (Quaglia, Brown, Lindsay, Creswell, & Goodman, 2015). The model for the effects of mindfulness meditation practice on self-regulation presented in figure 5.2 also supports attention as one of the foremost processes of change following a mindfulness meditation practice. Notwithstanding, there are differences between the model presented here and pre-existing models of mindfulness. Broader considerations of mindfulness are associated with

enhanced use of cognitive reappraisal and decentering (for example see Baer, 2003; Grabovac et al., 2011). Chapter two found little evidence that the mindfulness meditation practice enhanced cognitive reappraisal or decentering. This highlights a potential difference between the effects of a single mindfulness meditation practice compared to a complete mindfulness training or repeated longer-term meditation practice. The findings of the thesis suggest there is a limited effect of the single mindfulness meditation practice compared to mindfulness more broadly.

The limited effect of the mindfulness meditation practice may in part be a consequence of the content of the mindfulness meditation instructions used within the study. Chapter two reported that across the studies included in the systematic review most of the mindfulness meditation practices included guidance to attend to or be aware of present moment experience. Comparatively, fewer of the mindfulness meditation practices included instructions relating to an attitude (e.g., openness, receptivity, or acceptance) towards experience (table 2.1, chapter two). To further support this, a systematic review of the effect of a single mindfulness meditation practice classified the mindfulness practices as either: focused attention, open monitoring or a mixture of both (Gill, Renault, Campbell, Rainville, & Khoury, 2020). The authors reported that only the mixed meditation practice had a significant effect on cognitive function, but not the focused attention practice (the open monitoring meditations were not analysed separately). The nature of the mindfulness meditation practice may then be an important determining factor in the subsequent effects. This is especially relevant as there is presently no clear guidance on what does or does not constitute a mindfulness meditation practice. Furthermore, authors do not always provide full scripts of mindfulness meditation practices and as such it is difficult to determine exactly what 'treatment' participants are receiving. This point is particularly pertinent to the domain of children and adolescents where mindfulness meditation practices, as with mindfulness training programmes, are often adapted and abbreviated to be appropriate for younger age groups. This will be further discussed in a later section of this chapter (section 5.3).

An important consideration for understanding the effect of a single mindfulness meditation practice on self-regulation is the theoretical proposal that self-regulation relies on cognitive resources that are limited and shared between multiple cognitive functions (Baumeister, Vohs, & Tice, 2007). This shared resource can be depleted by direct use (e.g., completing tasks that exert executive functions), through depleted energetic resources (e.g., lack of sleep, or food), or as a result of elevated emotional arousal (see Hagger, Wood, Stiff, & Chatzisarantis, 2010). Furthermore, it has been proposed that volitional attention control may be considered as *the* shared

resource that underpins other cognitive, emotional and behavioural functions (Kaplan & Berman, 2010). This theoretical position views depleted attention resources, and the associated fatigue resulting from the effort of volitional attention, as being causative of failures of self-regulation or poor executive function performance (Kaplan & Berman, 2010). Similarly, attention resources can be recovered, as in Attention Restoration Theory, through a variety of means, including sleep, meditation, and engaging with tasks that require little volitional control of attention, such as walking in the natural world (Kaplan, 2001). The importance of attention is certainly supported in the current model for an effect of a mindfulness meditation practice on self-regulation, as attention is a core component of the model. Notwithstanding, attention is not represented in the model as being a shared resource, rather it is implicated in both the upper and lower routes as being central to task directed attention and emotion regulation. Nevertheless, it is an important consideration that there may be a shared resource underpinning attention, executive function and self-regulation, or that volitional attention may be the shared resource. The potential implications of this limited capacity view of cognitive functions will be further considered in later sections of this chapter (section 5.2.2).

The model presented in figure 5.2 includes a proposed bidirectional relationship between attention and emotion, which is partially supported by the findings in this thesis. The nature of the bidirectional relationship is that emotion impacts on attention through enhanced emotion regulation or reduced emotional reactivity, which in turn increases the available attention resources that can be deployed towards the task (Gross, 2001; Hagger et al., 2010). In addition, attention impacts on emotion through the volitional control of attention away from emotive stimuli and towards the task, which acts to down regulate or prevent emotional arousal that can be deleterious to self-regulation (Zelazo & Lyons, 2012). Theoretically in people of all ages, mindfulness training is proposed to enhance self-regulation through gains in top-down volitional control processes (e.g. attention, executive function) and bottom-up automatic control processes (e.g. reduced emotional reactivity; Chiesa, Serretti, & Jakobsen, 2013; Kaunhoven & Dorjee, 2017). This bidirectional relationship operates so that volitional control mechanisms can elicit control over emotions, but they also rely on automatic control of emotions to work effectively (Zelazo & Lyons, 2012). Interestingly, the duration of mindfulness practice (short or long term) may be important in determining whether there is an impact on top-down or bottom-up emotion regulation. Specifically, short-term meditators (such as those who have participated in a mindfulness-based programme) may only confer benefit to top-down volitional control of emotions (Chiesa et al., 2013). Most experimental studies testing the effect of a mindfulness meditation practice include

participants who are novice meditators. The model proposed here certainly supports that the volitional control of attention exerted an effect on emotion regulation. Furthermore, there is some evidence suggesting that there may have been a separate effect on the emotional reactivity beyond the effect of attention control. The proposed bidirectional relationship included in the model for mindfulness meditation and self-regulation reflects the theoretical models proposed for emotion regulation more broadly (figure 5.2). Notwithstanding, at the present time there is more support for the role of volitional control mechanisms than automatic processes.

5.2.2 Mindfulness meditation practice may have an indirect but not direct effect on executive function

A second finding from the present thesis is the indirect effect of the mindfulness meditation practice on executive function ((lower route of model, figure 5.2). There was emerging evidence from the findings in this thesis and existing evidence, that there may be an indirect effect of a mindfulness meditation practice on executive function. Specifically, the down regulation of emotional arousal and increased attention toward the task may enhance the availability of executive function capacity that subsequently benefits self-regulation. Executive function is considered by many as a core component of self-regulation and some scholars propose that all self-regulation failures are due to executive function failures (Hoffman, Schmeichel, & Baddeley, 2012). The inclusion of executive function in this model reflects this standpoint, although there remains much conceptual uncertainty around executive functions in the literature (for example see Hoffman et al., 2012). Of relevance is the conceptual overlap that exists between the constructs. For example, attention can be conceptualised as an executive function, although that is not case in this thesis. This uncertainty emphasizes that the model for an effect of mindfulness meditation practice on self-regulation (figure 5.2) is necessarily tentative and that more empirical evidence and conceptual clarity is needed to support many aspects of the model including the retention of executive function.

There is theoretical reason to suppose that mindfulness training and even mindfulness meditation practice could exert an effect on executive function. Executive function is theorised as being particularly affected by the depletion of a shared cognitive resource, and it has been proposed that all self-regulation failures are due to poor executive function performance (for example see Baumeister, Vohs, & Tice, 2007, Hoffman et al., 2012). Notwithstanding, there seems little possibility that a mindfulness meditation practice could enhance executive function capacity. This is relevant as many empirical papers report on the effects of mindfulness training on

executive function for children, adolescents and adults, yet there are inconsistent and often non-significant effects reported (see Mak et al., 2018, Chiesa, Calati, & Serretti, 2011; Lao, Kissane, & Meadows, 2016). In contrast, there is fairly strong evidence supporting that longer-term meditation practice can result in structural and functional changes to neural networks that reflect changes in cognitive capacities (for example see Tang, Hölzel, & Posner, 2015).

The model presented in figure 5.2 presents that a single mindfulness meditation does not directly impact on executive function performance. That is to say, that a mindfulness meditation practice does not increase executive function capacity or function beyond an individuals' current level of ability. The model proposes that there may be potential for an indirect effect on executive function. It is important to be clear in describing that this indirect effect does not speak to increasing the upper limits of capacity or function. Rather the indirect effect may increase the availability of the pre-existing executive function capacity in three main ways. The mindfulness meditation practice may reduce potential disruptions or drains on executive function resources, more effectively recover from resource depletion, or increase the direction of resources for use by executive function. This distinction between a direct and indirect effect of mindfulness on executive function may be a worthwhile consideration to researchers seeking to understand and measure the impact of a mindfulness meditation practice or mindfulness training on executive function. This notion will be further explored later in the applications to methodological design section (section 5.4.2).

5.2.3 The effects of a single mindfulness meditation practice on self-regulation are time limited

A proposed aspect of the model is that the effect of a single mindfulness meditation practice on self-regulation will be time limited. This is primarily based on findings from existing evidence (e.g., Schumer et al., 2019) as the present thesis did not directly measure extinction of effects. Nevertheless, time was considered indirectly in two ways: the duration of the mindfulness meditation practice and the duration of the outcome testing period. In chapter two there was no support from a meta-regression regarding an effect of duration of the mindfulness meditation practice on the effect size. A similar non-significant finding was reported in two other reviews of the evidence for outcomes of negative affectivity and cognitive function (Gill et al., 2020; Schumer et al., 2019). Chapter three used a 3-minute mindfulness meditation practice and a 25-minute outcome-testing period and found no significant effects. Chapter four used a 10-minute mindfulness meditation practice and a 5-minute testing period and there was a significant effect. In

support of this a systematic review commented on a general trend, not supported by a meta-regression, that outcomes measured immediately after a mindfulness meditation practice were larger than those measured with less proximity to the meditation (Schumer et al., 2019). As such the inclusion of a time limit for effects is a necessary inclusion as this is a realistic assumption about the potential impact of a single mindfulness meditation. Furthermore, its inclusion may prompt further investigations into this assertion as will be considered later in this chapter (see section 5.6).

The model depicted in figure 5.2 fits well for evidence within this thesis and existing evidence for the potential short-term effect of a single mindfulness meditation practice for self-regulation. It is recognised that areas of the model are based on only preliminary findings or theoretical evidence and that some of the included constructs are not sufficiently conceptually clear. As such the model is tentative and there are several areas of the model that require further empirical investigation. The model may therefore be particularly informative in the design of experimental studies, and the model could incorporate new evidence by solidification of lines or adaptations as appropriate.

5.3 What are the effects of mindfulness meditation practice on self-regulation in children and adolescents?

This section aims to consider the findings from the present thesis in the context of self-regulation for children and adolescents. The section begins by considering the potential suitability of the model presented in figure 5.2 to child and adolescent population, and then considers the findings of the present thesis in relation to child development.

5.3.1 Does the model of mindfulness meditation practice for enhanced self-regulation fit for a child and adolescent population?

There is presently insufficient evidence within this thesis and from existing empirical evidence to support several aspects of the model presented in figure 5.2 as being a good fit for the effects of a single mindfulness meditation on self-regulation in children and adolescents. This is in part due to paucity of empirical experimental investigation in this domain. Nevertheless, there are some areas of the model for which there is some supporting evidence from this thesis.

Chapters three and four support that following a mindfulness meditation practice sustained attention is enhanced and there is no direct effect on executive function. Furthermore, existing

evidence gives some preliminary support that a mindfulness meditation practice can reduce emotional reactivity and enhance emotion regulation in response to an emotive stimulus (Deng et al., 2019). All other areas of the model would benefit from further empirical investigation. These include the potential for a mindfulness meditation practice to effect change in attention, which in turn alters the processing of emotional stimuli or emotion regulation (lower route of model). Furthermore, there is only preliminary support and emerging understanding for the direct effect of mindfulness meditation on sustained attention, with an identified role of state affect. Unquestionably there is more to learn about this upper route of the model particularly regarding children and adolescents. Furthermore, it is important to reiterate that the model remains tentative even where there is supporting empirical evidence. This is due to there being a lack of conceptual clarity for the constructs within the model and that the interactions between the constructs of the model are presently speculative.

Another potential restriction for the application of the present model to children and adolescents is that there is very little evidence supporting the fit of the model for younger children (aged under 7 years) or adolescents. This is a significant restriction for the applicability of the model as adolescence is a pertinent time for maturation of self-regulatory function. As a result, the capacity and function of self-regulation in adolescents is likely different from both younger children and adults. As such the model in figure 5.2 may not be a good fit for effects of a mindfulness meditation practice on self-regulation in adolescents. Similarly, children under 7 years are limited in developmental capacities and functions that are proposed to be pertinent to the practice of mindfulness meditation. These include executive function, emotion regulation and attention, all of which continue to develop across childhood (Casey, Getz, & Galvan, 2008; Peterson & Posner, 2012; Zimmerman & Iwanski, 2014). In the case of executive function and emotion regulation, these functions continue to mature well into adolescence and there can be rapid and distinct changes across this period. Furthermore, there is surely a lower age limit within which mindfulness meditation would not affect self-regulation, and as such a lower age limit at which the model proposed in figure 5.2 would not be appropriate.

5.3.2 Mindfulness meditation practice, self-regulation and child development

The empirical evidence in the present thesis found a non-significant effect of the mindfulness meditation practice for children in the pre-operational stage of development (aged 4-7 years; chapter three) and a significant effect of the mindfulness meditation practice for children in the concrete operation stage of development (aged 7-11 years; chapter four; Piaget, 1952). These

differential outcomes are in the expected direction when considering the developmental abilities of the children. The potential for the stage of child development to explain the findings of this thesis will now be discussed.

The age at which children can begin to effectively engage with mindfulness training, including mindfulness meditation practices, is unclear in the current literature. It is expected that there may be developmental milestones that may need to be reached to allow children to engage fully with mindfulness training. Several developmental capacities would likely be necessary to effectively follow guided mindfulness meditation practices. For example, the development of verbal fluency and memory may be of particular importance for comprehension of mindfulness meditation instruction (Black, 2015). Similarly, other developmental capacities such as meta-cognition and introspective awareness, and the volitional control of attention may be necessary for children to effectively implement the instructions of a mindfulness meditation practice (Black, 2015). These developmental processes are typically not fully formed in children at the pre-operational stage of development, but many are substantially enhanced during the concrete operation stage. These different developmental stages may have impacted on how the children could engage with and comprehend the mindfulness meditation practice. Nevertheless, it is not possible to confidently present a case that these developmental differences may in some way explain the differential outcomes reported between these two chapters.

There were numerous methodological differences between the two chapters beyond developmental stage (e.g., content and duration of the mindfulness meditation practice, outcomes) that may account for the differential findings. Furthermore, there is little within the broader evidence base to help elucidate the role of developmental stage in relation to accessing and gaining positive effects from mindfulness training or mindfulness meditation practice. For example, mindfulness training is delivered to children in the pre-operational stage of development and even younger children, with reports of significant effects for these age groups (e.g., Flook et al., 2010; Poehlmann-Tynan et al., 2016). Nevertheless, there is evidence from systematic reviews that mindfulness training may have greater effects for adolescents and that there are different effects from training across childhood (Carlsey, Khoury, & Heath, 2018; Dunning et al., 2019). Presently there are so few experimental studies with children and adolescents in this domain that they offer little to the conversation regarding mindfulness meditation, age and development. In this way the findings of the present thesis make a valuable contribution to this domain, and there is reason to continue to apply the experimental design with children in different developmental stages.

The empirical evidence within this thesis gives preliminary support that mindfulness meditation practice may be an active component of mindfulness training for self-regulation in children from aged 7 years. There are several practical and theoretical implications stemming from this preliminary finding. Firstly, the findings support the inclusion of mindfulness meditation practice as a component of mindfulness training to effect change in self-regulation in children from aged 7 years. There is emerging but by no means conclusive empirical support for the effects of mindfulness training on components of self-regulation in children and adolescents from synthesised reviews of the evidence (e.g., Dunning et al., 2019). Furthermore, very little is known about the contribution of mindfulness meditation practice for the potential effects of mindfulness training on self-regulation in children and adolescents. As such the preliminary findings presented here give a welcome contribution to understanding in this domain.

A second implication of the present findings are that they give initial evidence to support the use of mindfulness meditation practice to exert a short-term benefit to sustained attention. This may have practical applications in a school setting, perhaps as a transition activity before engaging in tasks that require relatively greater concentration. Notwithstanding, this potential application is caveated by several unknown factors, such as the potential for adverse effects, the time limit of any effects, and the difference in effects when the mindfulness meditation practice is delivered to a whole class rather than one-to-one (see section 5.4.3 for more discussion).

The evidence within the thesis is inconclusive as to whether there may be an effect of mindfulness meditation on self-regulation for children younger than 7 years. This position on the evidence is taken due to the potential deleterious impact of the method used in chapter three on the detection of effects. A pertinent methodological consideration was that chapter three tested a relatively small *dose* of mindfulness meditation (3 minutes) compared to the period of outcome testing (~25 minutes). This difference may have meant that any effects of the mindfulness meditation practice were extinguished or overshadowed by the demands of the outcome measures. Nevertheless, the evidence of chapter two indicates that there may be no direct effect of a single mindfulness meditation on executive function in any age group. As such the findings of chapter three may be accurately representing that a single mindfulness meditation practice is not sufficient to effect change in executive function in children. There are then three possible explanations for the null effects reported in chapter three. The findings may accurately represent that there is no

direct effect; the findings may be a consequence of limitations within the research design; or both explanations may be correct.

In practice mindfulness training is delivered to children in the pre-operational stage of development, with programmes typically adapting mindfulness meditation practices to be age appropriate. These adaptations include making practices briefer and the use of external objects to be the focus of attention (e.g., visual aids or sounds; Thompson & Gauntlet-Gilbert, 2008). There is no agreed-upon guidance for what does or does not constitute a mindfulness meditation practice and there are various practices that are considered examples of mindfulness meditation practice (e.g., mindful movement, mindful eating). Notwithstanding, there is a limit to how far instructions can be adapted before the guidance no longer constitutes a mindfulness meditation practice. At their most basic mindfulness meditation instructions guide individuals to pay attention to present moment experiences. In addition, they may include guidance to notice the nature and content of introspective experience, such as emotions and cognitions. In the context of mindfulness meditation practices the developmental abilities of children and adolescents may render some instructions of mindfulness meditation more suitable than others. For example, volitional control of attention may develop earlier than introspective awareness or meta-cognition, and as such attention-related instructions might be more suitable for the developmental capacities of younger children. For adolescents, practices centring on focused attention might remain a better fit relative to practices that require greater attendance to introspective experience or self-compassion. This latter group of mindfulness meditation practices may be more personally challenging, even though this age group have the developmental capacity to engage with these practices.

5.3.3 Mindfulness, self-regulation and children and adolescents: how do the thesis findings fit with existing theoretical understanding?

The findings of the present thesis state that mindfulness meditation practice may benefit sustained attention as a component of self-regulation for children from age 7 years. The thesis findings and the associated proposed model (figure 5.2) are partially supported by existing models of mindfulness in this domain.

One pre-existing model proposes that the effects of mindfulness on self-regulation in children and adolescents are grouped into three areas: coping processes (e.g., reduced rumination), psychological function (e.g., less anger reactivity), and cognitive function (e.g., attention; Perry-Parrish, Copeland-Linder, Webb, & Sibinga, 2016). Other models theorise that for children and

adolescents' self-regulation may be enhanced by reduced mind wandering, enhanced executive function, and greater automatic (bottom-up) emotion regulation (Zelazo & Lyons, 2012; Kaunhoven & Dorjee, 2017). The findings of the present thesis align with existing theoretical evidence that states there may be an effect of a mindfulness meditation on coping processes, cognitive and psychological function (e.g., attention, emotional reactivity) and on automatic emotion regulation. The other aspects of the theoretical models are less well supported by the evidence within this thesis. Furthermore, some of the evidence presented here conflicts with these models, such as the present thesis found little evidence of an effect of a single mindfulness meditation practice on executive function.

There is reason to further investigate aspects of these theoretical models of mindfulness on self-regulation as to whether these effects can be detected in experimental studies testing the effect of a single mindfulness meditation practice. Overall, the evidence presented in this thesis is partially explained by the pre-existing theoretical models of mindfulness and self-regulation for children and adolescents. As such, the model presented in figure 5.2 may be most useful in directing further investigation in this domain. Considering the thesis findings discussed thus far, the focus of this chapter will now progress to consider the potential application of the findings to theory, empirical enquiry and practice.

5.4 Applying the findings of the present thesis to theory, empirical research and practice

In this chapter so far, several potential applications of the thesis findings have been discussed. These applications will now be briefly summarised.

5.4.1 Application of the findings to theoretical understanding

The findings presented in this thesis provide the first model designed to explain the potential effects of a single mindfulness meditation practice as used in an experimental setting (figure 5.2). This model may have further applications to understand the effects following early stages of mindfulness training and to assess the potential contribution of the mindfulness meditation component of mindfulness training to outcomes of self-regulation. Of relevance was that the volitional control of attention or attention redeployment was implicated as the primary mode of emotion regulation. There was less support for an effect on cognitive reappraisal as a process of emotion regulation. Similarly, there was little support for any direct effects on cognitive function following a mindfulness meditation practice, and as such this differs from theoretical understanding of the mechanisms through which mindfulness exerts effects.

5.4.2 Application of the findings to methodological design

The discussions of this chapter highlight several ways in which the findings of the present thesis may inform methodological design. One such implication is there is a time limit for the effects of a single mindfulness practice (see Schumer et al., 2019). This has implications for the design of future experimental studies, particularly as to the proximity of the mindfulness meditation practice to the outcome measure. Furthermore, the model (figure 5.2) proposes two routes for an effect of a mindfulness meditation practice, one route uses an emotional stressor in the experimental design and one route does not. There is much stronger evidence from this thesis for an effect of a mindfulness meditation practice on self-regulation where there has been an emotional stressor as part of the experimental design. This is a useful line of research enquiry and there remains much to learn about the processes through which mindfulness may down regulate emotional arousal, and the subsequent benefits to other areas self-regulation. Notwithstanding, there is greater need for understanding around the potential for a mindfulness meditation practice to effect change without an emotional stressor. Research designs exploring this can offer much as to the emerging role of resting state affect and other yet unidentified factors, on the potential for mindfulness meditation practices to exert effects in experimental settings without emotional stressors.

There are other findings from this thesis that may be informative to methodological design. There is little evidence to support that in experimental designs the length of the mindfulness meditation practice is an important factor for determining the detection of effects or size of effects. However, the lower limit for mindfulness meditation practice where an effect duration has been detected is 5 minutes (e.g., see Mahmood, Hopthrow, & Randsley de Moura, 2016), and the upper limit for mindfulness meditation practice length is around 25 minutes (e.g., see Johnson, Gur, David, & Currier, 2013). The choice of this upper limit for mindfulness meditation practice duration seems to be one of practicality rather than being underpinned by theoretical reasoning. Contrastingly, the content of the mindfulness meditation instructions may be influential in either producing a detectable effect on functioning, or the areas of functioning that are affected by the mindfulness meditation practice.

There are various forms of mindfulness meditation practice, for example mindfulness of breathing, mindful movement, mindfulness of eating, and body scan. Furthermore, within each mindfulness meditation practice there is more often a range of instructions. For example, in a

mindfulness of breathing practice, in addition to the instructions to focus attention on the breath, there may be instructions to have an open and accepting attitude to experience, or to focus on sounds, or monitor thoughts or emotions. Given that the content of the mindfulness meditation practice may be important, the selection or creation of a suitable practice should be well considered based on the needs and hypothesis of each research design. For example, if an experiment seeks to test outcomes of attention, then perhaps it is appropriate to select mindfulness meditation instructions that principally use guidance to focus attention on present moment experience. Notwithstanding, for greatest transparency and clarity it is appropriate that the mindfulness meditation practice should always be thoroughly reported in any subsequent research manuscripts.

The choice of outcome measure and comparison activity may be particularly relevant to the eventual detection of effects. Relative to longer mindfulness practice, the effects of the mindfulness meditation practice are proposed to be shorter lived, more unstable, and smaller (see Schumer et al., 2019). Furthermore, there is longstanding concern for the rigour of research within the domain of mindfulness, which extends to experimental designs (see Leyland, Rowse, & Emerson, 2019; Gill et al., 2020). Consequently, outcome measures for experimental designs testing the effect of a single mindfulness meditation practice should seek to be highly sensitive and objective. This may take the form of computerised measures, and there is good support for using this option where it is available (see chapter two and chapter four). Nevertheless, computerised measurement tools may not be practical or appropriate for some outcomes or in some settings. In these cases, researchers should aim to find the most valid and appropriate measurement tool and apply a procedure that has the least risk of bias.

Lastly, the choice of comparison activity is also highly pertinent. As discussed in chapter two, where comparison activities are active or likely to have a positive effect, the detected effect of the mindfulness meditation practice is more likely to be smaller or not significantly different from the comparator. Furthermore, some comparison activities may be deleterious to the outcome (e.g., rumination on negative affect) and as such these may artificially inflate the relative effect of the mindfulness meditation practice (see chapter two). An even more subtle consideration for a comparison activity is that non-active comparisons, such as where there is no activity, may in fact present an opportunity for mind wandering. In this way the comparison activity although nominally non-active, may act to enhance negative state affect and inflate the apparent effect of the mindfulness meditation practice. The choice of comparison activity and the way in which it is

reported in any research manuscript is important and has the potential to impact on the detection and strength of any effects.

5.4.3 Application of the findings to practice

This section seeks to present the potential application of the findings to practices outside of research, such as in clinical, education or community settings. One direct application of the findings is that mindfulness meditation practices may be an effective form of coping strategy, particularly in response to challenging situations or where one is experiencing emotional arousal. The findings of the thesis provide particularly useful evidence in this regard, as many MBPs now incorporate very brief mindfulness meditation practices that are designed to be used through the day in response to difficulties or as a regular brief daily activity (Williams & Penman, 2011). For example, the 3-minute breathing space has three sections of instructions: becoming aware, gathering and focussing attention, and expanding attention (Segal, Williams, & Teasdale, 2018). Similarly, the Dot Be intervention suggests that adolescents send phone text messages to each other that simply read ".b", that when received signals that that person should pause and just breath (Kuyken et al., 2013). The findings of this thesis give support to the use of brief mindfulness meditation practices to reduce emotional arousal when there has been a mild stressor. Although, it should be noted that there is little evidence to support mindfulness meditation practices of under 5-minutes in duration. Similarly, there is little empirical evidence for the effects of mindfulness meditation practices applied in everyday settings, although there is emerging and promising evidence in this domain (e.g., Blanke & Brose, 2017; Huffziger et al., 2013).

The findings of the present thesis give tentative support to the use of standalone mindfulness meditation practices (rather than as part of a mindfulness training programme) in educational settings to enhance sustained attention of children aged over 7-years. There is no descriptive evidence to indicate the extent to which mindfulness meditation practices are already being used in this ad-hoc way by educators. Although it may be assumed that mindfulness meditation practices are being used in this way due to the growing popularity of mindfulness and the availability of resources designed for use in school settings. In addition, this more informal approach to delivering mindfulness training in school settings fits with what is known about the barriers to implementation in this environment (e.g., time pressures; McKeering & Hwang, 2019; Meiklejohn et al., 2012). There is recent empirical evidence demonstrating the effects of repeated sessions of mindfulness meditation practice on adult anxiety and depression even where there were no other features of mindfulness training (Blanck et al., 2018). Although this effect is yet to be

tested with children or adolescents, collectively there may be preliminary reason to repeatedly use mindfulness meditation practices as an adjunct to the standard curriculum in school settings. This potential application of the evidence to education practice is caveated by several unknown factors, most pertinently the potential for adverse effects of mindfulness meditation practices. There was relatively early consensus that mindfulness training did not pose any risk for harm to children and young people (Burke, 2010); however more recently concerns have been reraised about adverse effects of mindfulness training and mindfulness meditation practice for this population (for examples see Johnson et al., 2016; McKeering & Hwang, 2019).

There is growing evidence that mindfulness training may be of benefit for children, adolescents and adults who have attention and self-regulatory deficits, such as those with ADHD or autistic spectrum disorder (Bögels et al., 2021; de Bruin, Blom, Smit, van Steensel, & Bogels, 2015; Lee et al., 2017). The findings of the present thesis may have potential applications in this domain. The thesis reported an immediate effect of a mindfulness meditation practice on sustained attention through reduced reaction time variability (RTCV). Greater RTCV is a core feature of ADHD, consistently measured across tasks related to working memory, inhibitory control and attention (Kofler et al., 2013). Although the present thesis represented a community and not clinical population, the findings could be extended to those with ADHD, and those who have ADHD as part of a comorbid diagnosis. Mindfulness meditation either as a standalone practice or as part of a mindfulness-based intervention may have potential applications for those with ADHD to reduce RTCV. This may be particularly relevant as presently changes to RTCV in those with ADHD have only been demonstrated following psychopharmaceutical treatments and not psychosocial interventions. As such demonstrating an effect of mindfulness on RTCV would be a significant advancement to research and clinical practice (Kofler et al., 2013).

5.5 Limitations

The research presented in this thesis reports on the immediate effects of one component of mindfulness training, mindfulness meditation practice, in novice meditators. The findings therefore do not contribute to the understanding of the longer-term effects of a single mindfulness meditation practice, the cumulative effects of numerous mindfulness meditation practices, the effects of mindfulness meditation when combined with other mindfulness training components, or for the potential effects of any other components of mindfulness training. Nevertheless, the findings from the present thesis remain useful in exploring under controlled conditions the

potential of a single mindfulness meditation practice to effect change in self-regulation in adults and children in the immediate term.

A notable limitation of the research presented in this thesis is that there was no further examination of the potential effect of a mindfulness meditation practice on sustained attention in children aged 4-6 years. This would have been the expected next step given the significant effects for sustained attention reported in chapter four for children aged 7-11 years. The COVID-19 pandemic in 2020-21 meant that the plan for this final empirical study was abandoned. The absence of this investigation means it is unclear as to whether the findings of chapter four would have been replicated for a younger age group representative of an earlier developmental stage. This evidence may have given preliminary support for the active effect of mindfulness meditation as a component of mindfulness training for children from age four. Alternatively, it may have been informative as to the age limit at which a mindfulness meditation practice is no longer beneficial or effective for sustained attention in children.

There are several potential limitations arising within the empirical evidence of this thesis that should be considered in relation to the findings presented here. The mindfulness meditation practices used in chapters three and four were informed by existing meditation practices (e.g., Greenland, 2010; Lim & Qu, 2017) but were unique to the present research. Chapters three and four used mindfulness meditation practices that were different in their duration and primary focus. Specifically, the mindfulness meditation in chapter three lasted 3 minutes and focused on sound, and in chapter four it lasted for 10 minutes and focused on movement and the breath. These differences are aligned with mindfulness meditation practices used in other experimental studies. The systematic review presented in chapter two detailed differences in the content of the mindfulness meditation instructions (e.g., present moment awareness of experience, non-judgement) used in experimental studies. The mindfulness meditation practices used in chapters three and four were appropriate mindfulness meditation practices for this age group and were informed by existing manualised mindfulness training practices (Greenland, 2010) and published experimental studies (Lim & Qu, 2017).

There are several limitations arising outside of the thesis study methods that may have impacted on the applicability and quality of the findings. One notable limitation is that there was no manipulation measure in chapters three or four assessing whether the mindfulness meditation practice was successful in inducing a mindful state (state mindfulness). There is evidence

demonstrating the successful induction of a mindful state following a single mindfulness meditation practice for adults (e.g., Gill et al., 2020; chapter two), but there is no comparable evidence for children and adolescents. This limitation reflects the absence of a valid age-appropriate measure of state mindfulness (see Goodman, Madni, & Semple, 2017). The lack of a state mindfulness measure for those under 18 years of age is a barrier to the progression of research in this domain in general, but it presents a substantial barrier when the experimental method is applied to test a single mindfulness meditation with this population. Specifically, for the evidence presented in this thesis it cannot be asserted whether the differential results reported for chapters three and four were due to the degree to which the different mindfulness meditation practices were successful at inducing a state of mindfulness.

To overcome the limitations imposed by a lack of a valid measure of state mindfulness, chapters three and four measured trait mindfulness as an indicator of inter-individual differences in mindfulness. The measure used was the CAMM, which is valid for children aged 10 years and over (Greco, Baer, & Smith, 2011). The participants represented in chapters three and four were aged 4-11 years so as may be expected, the reliability of the questionnaire was insufficient for those under 10 years and subsequently the data was not usable. There are presently no valid measures of trait mindfulness for children under nine years of age (see Goodman et al., 2017). This presents a further barrier to the developing evidence base. Specifically for the evidence presented in this thesis, a lack of a valid measure meant that there could be no investigation of the potential effect of baseline trait mindfulness on subsequent effects of a single mindfulness meditation practice.

The thesis presents on the use of experimental methods to explore the effect of a single mindfulness meditation practice on self-regulation. There is potential for the use of this design to be deleterious to the overall integrity of mindfulness. The addition of experimental designs to expand the existing evidence base is particularly useful in the optimisation of interventions (e.g., mindfulness training programmes) and in theory development. This design allows a controlled comparison of mindfulness meditation practices to other activities. Furthermore, the use of an experimental design allows for inclusion of more objective and sensitive measurement tools. Nevertheless, some proponents of mindfulness may not view favourably the application of experimental designs within the domain of mindfulness. Upholding the integrity of mindfulness and ensuring it is not divorced from its ethical and spiritual foundations is of great importance to many stakeholders (for examples see Keddie, 2016; Grossman, 2011). There are several ways in

which the values and principles of mindfulness can be diluted down or overlooked, or ways that findings from mindfulness research can be misinterpreted or misapplied. With regards to the use of experimental designs it is important that the findings are not overstated, or that the diverse and rich psychoeducation is not reduced to a 'mindfulness technique'.

There is however a move within research domains to adapt and optimise mindfulness training for different groups and settings, and to understand better the processes of change. This includes in some cases understanding which aspects of training are most essential (or active) so that the duration of training and the time commitment for practitioners can be efficient while remaining effective. There is good reason to progress the theoretical and empirical evidence for optimal delivery of mindfulness training, most notably to increase accessibility of training and increase uptake of home practice. For many, mindfulness will remain a core component of their lifestyle or an element of a broader spiritual lifestyle, whereas for others it may be a means for personal improvement. This may be by way of reducing suffering (e.g., alleviating depressive symptoms), or learning to live well despite suffering (e.g., chronic pain), or to enhance a personal attribute or capacity (e.g., concentration). In each case it is appropriate to enhance empirical understanding and refine mindfulness training programmes in order to meet the diverse needs of those seeking to participate in it.

With regards to this thesis, it was intended that the findings were accurately represented with regards to their applicability, implications and limitations. In particular, the findings have been presented to inform further experimental research methodology and to garner evidence of the potential short-term effect of mindfulness meditation practice on self-regulation. The findings were most broadly interpreted as demonstrating the potential for mindfulness meditation practice to actively contribute to the effects of mindfulness training from aged 7-years.

5.6 Directions for future research

There are numerous potential avenues for future research that would make a valuable contribution in this domain. The future research proposed here focuses on the use of the experimental design to measure the effect of a mindfulness meditation practice. In addition, for children and adolescents' investigations that may broaden understanding of mindfulness for self-regulation are also proposed. This section of the chapter sets out a limited number of the possible directions for future research.

There are several aspects of the model presented in figure 5.2 that would benefit from further empirical investigation with adults. Specifically, researchers may seek to test further the potential impact of a mindfulness meditation practice on executive function where an emotional stressor is included in the design. Furthermore, the potential bi-directional role of attention and emotions as a pathway for the effects of mindfulness meditation practice on self-regulation may be the focus of future experiments. For example, this may be explored by comparison of a mindfulness meditation practice with active comparators known to rely on attention mechanisms, such as a distraction activity, and a non-active comparator, all within a single experiment. Alternatively, the time limit of effects of mindfulness meditation practice could become the focus of any experimental study. This could be achieved by testing outcomes at differing proximities to the mindfulness meditation practice, perhaps immediately, 5 and 10 minutes after.

There is still much to learn about the potential for mindfulness meditation practice to impact on self-regulation in children and adolescents. This extends beyond the need for more experimental research to include more rigorous cross-sectional and intervention trials (Semple & Burke, 2019). The findings presented here would be useful in the future design of intervention studies for mindfulness training, particularly for the choice of outcome measures. For example, outcome measures should be sensitive enough to detect small changes and should measure the attention or emotion regulation components of self-regulation rather than executive function. A systematic review, and where appropriate meta-analysis, of the findings from evidence pertaining to self-regulation in children and adolescents would make a useful contribution to the evidence base. There would be great benefit in this systematic review including all experimental studies (including unpublished literature) testing self-regulation outcomes for children and adolescents.

There is rich opportunity for experimental research testing the effect of mindfulness meditation practice with children and adolescents, which can be greatly informed by the model presented in figure 5.2. The findings presented here would promote that researchers should first seek to test the effect of a mindfulness meditation practice on self-regulation following an emotional stressor. This line of investigation would hope to replicate with children and adolescents the effects that have been consistently supported with adults (Leyland et al., 2019; Schumer et al., 2019). Alternatively, researchers may seek to learn more about the effect of the mindfulness meditation practice on sustained attention and the moderating role of state affect on this effect. In the first instance researchers may seek to replicate the findings of chapter four with the same age group, before testing the design with children under 7 years or adolescents. This evidence would

contribute greater understanding to the ongoing discussions around mindfulness meditation practice, child development and the potential effects and limits of effects on self-regulation.

5.7 Conclusion

The research presented here explores the effect of a single mindfulness meditation practice on self-regulation on novice meditators of all ages, with a special interest in children and adolescents. The thesis presents a systematic review and meta-analysis of experimental investigations using an experimental design to test a single mindfulness meditation on self-regulation and two empirical studies applying the same design with children aged 4-11 years. The findings demonstrate that a mindfulness meditation practice exerts an immediate effect on self-regulation, particularly by impacting on the components of attention and emotion regulation. In addition, the findings provide preliminary support that mindfulness meditation practice may be an effective component of mindfulness training for children from age 7 years. As such the findings of this thesis offer a novel contribution to an emerging area of research within the domain of mindfulness. The findings of the thesis informed an original theoretical model for the short-term effect of mindfulness meditation practice on self-regulation.

APPENDICES

Appendix One: Testing booklet for data collected in chapter three

School Data Collection Pack

Child's Code:	
Comments	

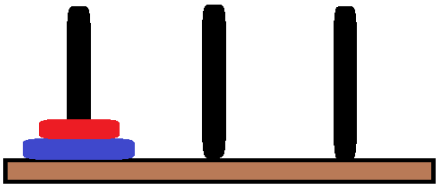
Tower of Hanoi

Welsh, Satterlee-Cartmell & Stine (1999); Lillard & Peterson (2011)

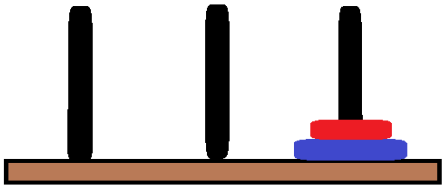
Imagine that each of these disks is a monkey and they are playing on this tree (point to the left peg where the disks are).
But the monkeys are tired and want to move to their sleeping tree (point to the peg on the right).
Can you help move the moneys to their sleeping tree? (show the picture of the pegs on the sleeping tree)
It's very important that you follow three rules when you move the monkeys.

1) Only one monkey can be moved at a time.
2) The monkeys always need to be on a tree.
3) The daddy monkey (the blue one) can never go on top of the mummy monkey (the red one).

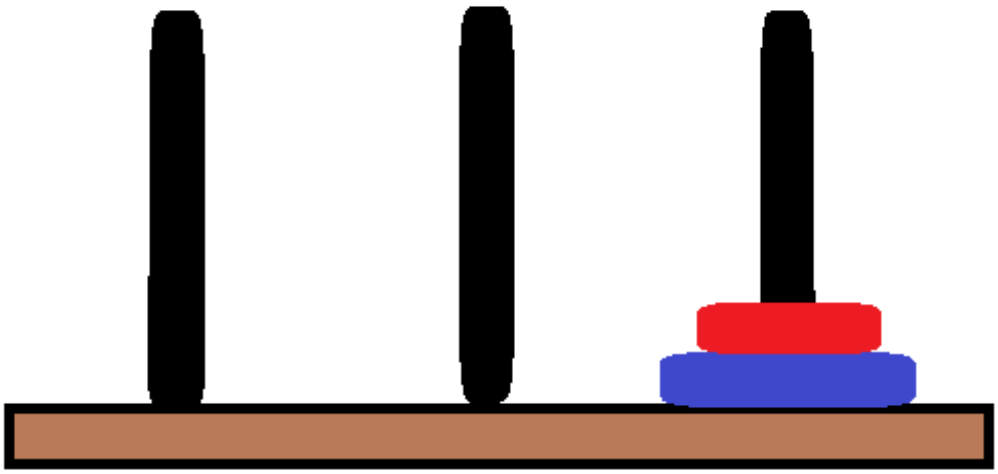
1) Starting Position



2) Finishing Position



Score 1 if the disks are moved from the first to the third peg following all the rules. Score 0 if a rule was broken or the child did not complete the task.	



Heads Toes Knees and Shoulders

Ponitz, McClelland, Matthews and Morrison (2009); Lillard & Peterson (2011).

HEAD & TOES

When I say touch your **head**, I want you to touch your **toes** but when I say touch your **toes** I want you to touch your **head**.

Practice: Touch your head. Touch your toes. Touch your toes.

OK, now we're going to start the game.

Command	2 = Correct 1 = Initially wrong but corrected 0 = Wrong
Head	
Head	
Toes	
Head	
Toes	
Toes	
Head	
Toes	
Head	
Toes	
	Total =

If total **more than 10** move to next round – turn over.

HEAD, TOES, KNEES & SHOULDERS

Now we are going to add some more rules. So the same as before when I say touch your **head**, I want you to touch your **toes** and when I say touch your **toes** I want you to touch your **head**. But now when I say touch your **knees**, I want you to touch your **shoulders** and when I say touch your **shoulders**, I want you to touch your **knees**.

Practice: Touch your knees. Touch your shoulders. Touch your toes. Touch your head.

Command	2 = Correct (c), 1 = Initially wrong but corrected (I) & 0 = Wrong (W)
Knees	
Head	
Toes	
Head	
Shoulders	
Knees	
Shoulders	
Toes	
Head	
Knees	
	Total =

If total **more than <u>14</u>** move to next round

SWITCHING RULES

Now we are going to change around the rules. So now when I say touch your **head**, I want you to touch your **shoulders** and when I say touch your **shoulders** I want you to touch your **head**. And now when I say touch your **knees**, I want you to touch your **toes** and when I say touch your **toes**, I want you to touch your **knees**.
Practice: Touch your knees. Touch your shoulders. Touch your toes. Touch your head.

Command	2 = Correct (c), 1 = Initially wrong but corrected (I) & 0 = Wrong (W)
Knees	
Head	
Toes	
Head	
Shoulders	
Knees	
Shoulders	
Toes	
Head	
Knees	
	Total =

Delay of Gratification Task

Mischel, Shoda & Rodriguez (1989); Lillard & Peterson (2011)

Now we are going to play a different game. Which of these do you prefer? (show treats)
OK, I'm going to put 10 of these on to one plate and 2 onto another plate (put onto plate).
I'll put both the plates here with this bell. If you wait for me to come back into the room then you can eat all ten of the *biscuits* from this plate. Or you can ring the bell at any time and eat the two *biscuits* from this plate straight away. Do you understand?
OK I'm going to leave the room now.

Leave room and start timer. Return to room when bell rings or after 330 seconds (5 minutes 30 seconds)	Time (Secs):

Numbers Reversed/ Backward Digit Span Test

Woodcock-Johnson Test of Cognitive Abilities see McGrew, Dailey & Schrank (2007); Lillard & Peterson (2011)

Now in this game I am going to say some numbers and I want you to say them backwards; for example I say 3, 4 and you say 4, 3.

Practice (as soon as child gets one correct move on to test or do all four practice items and then move on to test). If child struggles then remind them of the rule.

1) 2, 7…now you say it backwards
2) 5, 9
3) 6, 4
4) 9, 1

If child gets three consecutive items wrong then stop the test.

Command	1 = Correct 0 = Wrong
2, 1	
2, 1	
4, 7	
3, 8	
9, 1	
3, 2	
5, 6, 9	
9, 2, 3	
7, 9, 1	
1, 3, 6	
6, 4, 9, 5	
8, 5, 2, 7	
4, 8, 2, 9	
9, 4, 2, 6, 3	
2, 3, 8, 5, 1	
8, 2, 7, 4, 6	

Child and Adolescent Mindfulness Measure - Adapted

Greco, Baer & Smith (2011)

We want to know more about what you think, how you feel, and what you do. **Read** each sentence.

Then decide **how often each sentence is true for you.**

	Never true	Almost never true	Some times true	Almost always true	Always true
1. When I have feelings that I don't understand, I get upset with myself	0	1	2	3	4
2. At school, I walk around without noticing what I'm doing	0	1	2	3	4
3. I try to do lots of things so that I don't notice my thoughts or feelings	0	1	2	3	4
4. I tell myself that some of my feelings are wrong	0	1	2	3	4
5. I try not to think about things that I don't like	0	1	2	3	4
6. It's hard for me to pay attention to only one thing at a time.	0	1	2	3	4
7. I think about things that have already happened instead of thinking about things that are happening right now	0	1	2	3	4
8. I get upset with myself for having certain thoughts.	0	1	2	3	4
9. I think that some of my feelings are bad and that I shouldn't have them.	0	1	2	3	4
10. I stop myself from having feelings that I don't like.	0	1	2	3	4

Always true	
Almost always true	
Sometimes true	
Almost never true	
Never true	

Appendix Two: Strengths and difficulties questionnaire

For each item, please mark the box for Not True, Somewhat True or Certainly True. It would help us if you answered all items as best you can even if you are not absolutely certain.

Please give your answers on the basis of the child's behaviour over the last six months or this school year.

	Not True	Somewhat True	Certainly True
Considerate of other people's feelings	☐	☐	☐
Restless, overactive, cannot stay still for long	☐	☐	☐
Often complains of headaches, stomach-aches or sickness	☐	☐	☐
Shares readily with other children (treats, toys, pencils etc.)	☐	☐	☐
Often has temper tantrums or hot tempers	☐	☐	☐
Rather solitary, tends to play alone	☐	☐	☐
Generally obedient, usually does what adults request	☐	☐	☐
Many worries, often seems worried	☐	☐	☐
Helpful if someone is hurt, upset or feeling ill	☐	☐	☐
Constantly fidgeting or squirming	☐	☐	☐
Has at least one good friend	☐	☐	☐
Often fights with other children or bullies them	☐	☐	☐
Often unhappy, down-hearted or tearful	☐	☐	☐
Generally liked by other children	☐	☐	☐
Easily distracted, concentration wanders	☐	☐	☐
Nervous or clingy in new situations, easily loses confidence	☐	☐	☐
Kind to younger children	☐	☐	☐
Often lies or cheats	☐	☐	☐
Picked on or bullied by other children	☐	☐	☐
Often volunteers to help others (parents, teachers, other children)	☐	☐	☐
Thinks things out before acting	☐	☐	☐
Steals from home, school or elsewhere	☐	☐	☐
Gets on better with adults than with other children	☐	☐	☐
Many fears, easily scared	☐	☐	☐
Sees tasks through to the end, good attention span	☐	☐	☐

Thank You

☺

Appendix Three: Script for mindfulness meditation practice in chapter three

The Sound in Space Game

Now we are going to play the sound in space game.
Start by sitting on the floor in a cross legged position or kneeling with your backs nice and tall and your hands resting in your lap. Settling down so you feel comfortable

(Short Pause)

Looking now down at the marble in front of you and keep looking at the marble as you play the game
Now placing your hands gently on your tummy and seeing if you can feel your tummy rising and falling as you breath in and out

(Short Pause)

Keep looking at the marble and keep your hands on your tummy as your breathe comes in and out
Now listening for the sound of a chime

(Strike Tone on Bowl)

(Speak while tone still sounding) Listening to the sound of the chime as it fades - raise one of your hands when you think the sound has stopped.
Noticing the sound fading *(Allow the chime to stop plus a few seconds)*

Now placing both your hands back on your belly and feeling your breath as your belly rises and falls
Keep looking at the marble in front of you
Listening carefully to the chime as it is played again and when you can't hear it anymore raise one of your hands in the air

(Play the tone and allow the tone to fade plus a few seconds)

Now returning your hand to your tummy and feeling it rise and fall as you breathe in and out
Keep looking at the marble in front of you and feeling your hands moving as you are breathing
Listening again to the sound of the chime and raise one hand when you can no longer hear the sound

(Play the tone and allow the tone to fade plus a few seconds)
Placing both your hands back in your lap. Now noticing the sounds in the room
Looking up from the marble in front of you and noticing what else is around you.

We have now completed the sound in space game.

Appendix Four: Data collection booklet for chapter four

Participant Number			
Date of testing			
Gender Female 1; Male 0			
Time of testing	Start	Finish	Duration (mins)
Age in days on date of testing (use age calculator online/app)			
School Code 0-3 0 UNS / 1 TOT / 2 CAR / 3 BRU			
Experimenter 0-3 0 AL / 1 EM / 2 SS			
Randomised 0 1 0 Control / 1 Mindfulness			
Disturbances or concerns about data quality 0 none; 1 minor; 2 major			

	ANT	IND	SART
MOT			
SUC			
AFF			
CAMM			
WM			

You are being asked to take part in some research. We will play a few different games today and I will ask you some questions.

You can tell me that you would like to stop at any time. You are free to leave the room and go back to your classroom whenever you might like.

Would you still like to take part? (*verbal ascent*)

(ANT)
Firstly we will be playing a game on the computer. I'll help you to read the instructions of the game and you can ask me if you have any questions or don't understand anything

Experimenter set up ANT on computer and help child to understand the instructions. Check they can answer the questions correct

How much did you want to play the computer game?

Not at all — Really wanted to play

How important was it to you that you did well on the computer game?

Not important at all — Really important

How are you feeling right now?

(Backward digit span – working memory)
Now we are going to play a numbers game. I'm going to read out some numbers and I would like you to repeat them back to me in the reverse order. So if I say 5 7 you would say 7 5. Shall we have a practice? If I say 4 3, you would say?
If correct
Well done. As we play, the list of numbers will get longer. Let's start now
If incorrect
That's not quite right. Remember what you are trying to do is repeat the numbers I say but in the opposite order. So if I say 8 4, you would say 4 8. Shall we have another practice? 2 6
If incorrect again score child at 0
Maybe this game is a little tough. Never mind, we have other games we can play.
Read out list of numbers at steady pace. Repeat once if child requests it, if they ask to repeat again move on to next sequence. Once two consecutive mistakes are made, stop the game. Child needs to get one sequence right to get score, i.e. if they repeat back 3 9 correctly but 4 5 incorrectly they score 1.

Numbers	Repeated in reverse Yes 1; No 0	Highest score reached (SPSS)
3 9		0 or 1
4 5		0 or 1
9 2 4		2
8 3 7		2
2 1 6 4		3
4 7 5 8		3
1 3 2 6 5		4
7 9 8 1 4		4
5 1 9 3 2 7		5
6 2 7 8 3 1		5
8 9 4 6 1 7 3		6
3 1 5 6 2 8 9		6
7 2 8 1 9 6 5 4		7
4 1 6 8 7 9 2 5		7

(Mindfulness questionnaire)
I'm going to ask you a few questions about yourself now.
I'll read each question out and you can answer by telling me how true each thing is about you.
If you don't understand the questions, then just let me know and I will read it again. Any answer you give is fine, there are no right or wrong answers. You can take as long as you like to think about your answer.
While looking at questionnaire say
These are the all the questions and I will read them each out in turn. And these are the possible answers *Read out each answer*
You can write a tick or a cross in the answer that is right for you.

Possible things the child may struggle to understand, read out if necessary:
What feelings are…

When we say feelings, we mean all the emotions that we have like angry, sad, happy, excited. We may like or enjoy some feelings but some feelings we may not like very much.

What thoughts are…

Our thoughts are the talking and pictures that go on inside us. No one else can hear or see our thoughts. We may like or enjoy some thoughts but some thoughts we may not like very much.

SCORING
Never True = 1
Rarely True = 2
Sometimes True = 3
Very often true = 4
Always True = 5

Total Score / 50:

	Never true	**Rarely true**	**Sometimes true**	**Very often true**	**Always true**
1. I get upset with myself for having feelings that don't make sense.					
2. At school, I walk from class to class without noticing what I'm doing.					
3. I keep myself busy so I don't notice my thoughts or feelings.					
4. I tell myself that I shouldn't feel the way I'm feeling					
5. I push away thoughts that I don't like.					
6. It's hard for me to pay attention to only one thing at a time.					
7. I think about things that happened in the past instead of thinking about things that are happening right now.					
8. I get upset with myself for having certain thoughts.					
9. I think that some of my feelings are bad and that I shouldn't have them					
10. I stop myself from having feelings that I don't like.					

SART practice (No feedback VAS questions)

Now we are going to practice a game that we will play properly later. We will practice now so you know the rules for later on. This game is on the computer and we can read the instructions together.

Experimenter: Set up SART practice and help guide through instructions

Mindfulness and Control game

Now we're going to play a game where we need to listen to this recording and follow the instructions of the person on there. I'll follow the instructions as well.

We are going to stand up for this game and during the game the person will ask us to either sit or lay down

We need to know which game we are going to play. If you can choose a coin out of this [bag] we will know if we are going to play the red or yellow game.

Circle which was selected:

Yellow 0 RED 1

So you pulled out a [yellow/red] coin
(If RED) we will need a blue paper circle in front of each of us and we will stand back from circle about a metre.
(IF YELLOW) you can stand there (point) and I'll stand here.

Now I will play the recording for the game now and we can both follow the instructions.
If red place blue circle in correct place. Experimenter and child stand about 1.5-2 metres apart facing the same direction, preferably away from the computer screen. Experimenter follow instructions but be as invisible as possible. Try not to fidget or be too dramatic in movements etc. Initiate some actions before child, e.g. sitting/lying down, or moving arms when first instructed to; so they feel comfortable to copy.

YELLOW = CONTROL
RED = MINDFULNESS

How much did you want to play the game?

Not at all — Really wanted to play

How important was it to you that you did well on the game?

Not important at all — Really important

How are you feeling right now?

(SART) Now we're going to play our last game for the day. This is the number game you played earlier on the computer. You just did the practice earlier but this is the real game.

You can ask me if you have any questions or don't understand anything.

Are you ready to play? *When the child is ready press play on the SART game*

How much did you want to play the computer game?

Not at all — Really wanted to play

How important was it to you that you did well on the computer game?

Not important at all — Really important

How are you feeling right now?

Thank you for coming out of your class to play games with me today. We have some stickers if you want to choose one?

I'm from the University of Sheffield and the reason I am seeing people in your school is to see if playing simple games can help with concentration.

Do you have any questions about the games we have played today? If you think of anything later you can ask you teacher or your parents have a letter that has an email address on there.

I'll walk back with you to your classroom now.

Appendix Five: Scripts for mindfulness meditation practice and active control activity in chapter four

Mindfulness meditation practice script

Today we are going to play some games. To play the games you will need to pay attention to my voice and follow the instructions. If you aren't sure of what to do you can look at the person next to you. Paying attention means listening to what I say. Not being distracted by other things in the room, and not being distracted by other things in your mind. {25 secs}

We will start by standing up tall with your feet a little bit apart. Put your arms by your sides. Stand still like this for a few seconds. Tune in to the muscles in your body, they need to work a little bit to help you stand strong and tall. But they don't need to be working very hard. See how your muscles feel now. (5sec pause) Now see if you can feel yourself breathing. When you breath, air comes in through your nose or mouth, travels down through your throat and chest and sometimes moves your tummy too. See if you can feel your breath in your nose, mouth, chest or tummy. If you don't feel your breath anywhere, that's ok too. (10sec pause) {50 secs}

Mindful Movement

Now we are going to do some slow movements. While we are doing this keep looking down to the ground in front of you at the [ ] placed there. Slowly move your arms up to the sky by lifting them out to the side. When your arms are pointing up above your head, gently clap your hands together (5 secs) Now bring them back to the sides of your body, very slowly (7 secs). This time we will do the same movement but I'll help you move slowly by counting to five. Start at 1 with your arms at your side and you can clap your hands together above your head after I reach the number 5. Lets practice now. 1 2 3 4 5 clap (take 5 secs to reach 5). Your hands should be above your head now. Now we will do the same thing bringing your hands down to your sides as I count backwards from 5 to 1. 5 4 3 2 1. We will repeat this a few more times. {120 secs}

(Repeat 3 times gradually increasing duration of movement. 1st and 2nd repetition = 8 sec movement + 3 second pause at the top.] We are going to do this movement with our arms once more. [3rd repetition = 12 secs movement + 3 second pause at the top.] {75 secs}

That's great. Now rest again standing with your arms by your sides. If it feels ok you could close your eyes too. Notice how your arms feel now. Perhaps they feel different from before (2 secs) And now seeing if you can feel your breathing (3 secs). Perhaps it feels slow, fast, long or short. However your breath is feeling is OK, just let it be as it is without changing it. (2 secs). {50 secs} 4 minutes.

Mindfulness of Breathing

Now you are going to lay down on our backs. Make sure you are comfortable. It might be more comfortable for you to have your legs bent with your feet on the ground or to have your legs stretched out straight. You can keep your eyes open and look at the ceiling or you can close your eyes. Let your body be as still as possible (5 secs pause). {25 seconds}

Place your hands gently on to your belly. You may be able to feel your belly going up and down as you are breathing (7 secs pause). Your belly may move a lot or not very much. Notice how your belly feels under your hands. Try to let your breathing happen without changing it. You can breathe without

thinking about it but you can also change your breathing on purpose. Allow your breath to move on its own without changing it (7 secs pause).

In a moment I will ask you to start to counting your breaths. When our belly goes up we are breathing in and our body is filling with air. When our belly goes down we are breathing out and the air is emptying from our body. We can count one breath when our belly empties and we breath out. Breathing out counts as one breath. We will practice now counting our breaths for a few seconds (4 sec pause). When you breath out in your head count one. On your next out breath count two. Keep going in this way for a few more seconds counting each out breath (10 secs). If you lose count of the number of breaths start again from number one (20 secs). It is easy to get distracted when you are counting your breaths. If you notice you have lost count of your number of breaths. Don't worry. Just start again from number one. Remember to try to let your breathing happen on its own without changing it. Spend a few more seconds counting your breaths. (20 secs). You can stop counting your breaths now. Notice how your body feels now. Notice your breathing. See where you can feel your breath now. Maybe in your belly with your hands moving. Or maybe in your chest, throat, nose or mouth. Perhaps your breath feels big in your body, maybe it is a small feeling or there is not much feeling at all. However your breath is feeling to you now, it is OK just as it is. (10 sec pause). {210 seconds}

Stay lying where you are on the floor and keep your hands resting gently on your belly. Now we are going to change our breathing on purpose. We are going to take big long breaths that make our belly rise up big like a balloon. We want to keep our breathing slow and gentle. I will help you to breath slowly by counting as you breathe in and out. Breathe in slowly and steadily as I count to three. 1 2 3 (5 secs). Hold your breath in for a second. Now breathe out slowly as I count from 3 to 1. 3 2 1 (5 secs). Notice how your belly feels now. Maybe it felt different being full of air to how it feels now. We are going to try that again. You might need to slow your breathing down even more this time so that it takes longer to fill up your belly with air. Keep your breath slow and gentle. Breathe in slowly now 1 2 3 (7 secs). Hold your breath in for a second. Now breathe out slowly as I count from 3 to 1. 3 2 1 (7 secs). Now let your breathing go back to normal without trying to change it. Notice how your breathing feels now. You were controlling your breathing by taking deep breaths in to your belly and now you are letting your breathing happen without trying to change it. Notice how different it feels to let your breathing flow on its own. (6 secs) Well done.

Now we have come to the end of our games. If your eyes have been closed open them now. Move your hands off your belly. Have a stretch and when you are ready, sit up. (10 secs pause) {90 seconds} 5 minutes 40 secs

Active control activity script

Today we are going to play some games. To play the games you will need to pay attention to my voice and follow the instructions. If you aren't sure of what to do you can look at the person next to you. Paying attention means listening to what I say. Not being distracted by other things in the room, and not being distracted by things in your mind.

We will start by standing up tall with your feet a little bit apart. Put your arms by your sides. [35 Secs]

Stretching

Now we are going to do some stretching. We will start with some gentle stretches of our head. When you are ready slowly turn your head to look over the left shoulder. Try to keep your shoulders relaxed and away from your ears. Now turn your head to the right and look over your right shoulder. Now bring your head back to the middle and lower your chin to look down to the ground. Now gently look up to the sky. Remember to keep your shoulders relaxed and away from your ears. Bring your head back to centre now. Now when you are ready raise your shoulders up to your ears. Hold them there for a few seconds. Then lower them back down. Do this twice more. Raise your shoulders up to your ears. Hold. Then lower them down. And last time. Raise your shoulders up. Hold and lower back down. Well done. [1.10min]

Now starting with your hands by your sides, sweep your arms out to side and raise them up above your head so that your fingers are pointing to the sides. Bring them back down to your sides. And again. Raise your arms out to the sides and up above your head. Keep your feet on the ground but stretch your fingers up to the sky. Nice and tall. Then lower them back down.

We will move like this again but using just one arm at a time. First we will move your right arm. Start with both arms by your sides. Bring the right arm out to the side and take the arm up above your head. Point the fingers of the right hand up to the sky. Your left hand can be by your side or you can place your hand on your hip. Gently lean your upper body and arm to the left so you're making a crescent moon shape with your whole body. Straighten up again so your arm and body are standing straight. Bring the right arm back to your side and relax your left hand. Now we will do the left side in the same way. Bring your left arm up and out to the side finishing with it above your head. Lean your hand, arm and upper body slightly to the right so you are back in the crescent moon shape. Straighten up again and lower your left arm back to your side. [1.30min]

Now we will move just one arm again but we will only raise it as high as your shoulder. So your arm will point out to the side. When you are ready bring your right arm up and out to the side, keeping it at shoulder height sweep it across your body so your upper arm ends up on your chest and your fingers are pointing out to the opposite side. Using your other hand, hold you arm here for a moment. Well done. We will repeat this stretch using your left arm. Bring your left arm up and out to the side at shoulder level sweep it across your body so your fingers are pointing out to the opposite side and your upper arm is resting on your chest. Hold your arm with your other hand. And stay here for a moment. And now relax both arms back down to your sides. [57 secs]

Listening to sounds

For the next game we will sit down where we have been dancing. Take a moment now to sit down and get comfortable. In a moment I will play some animal sounds. Listen to the sounds and when you hear the sound of a dog clap your hands. Are you ready? [Play 12 animal sounds, dog #12] Well done. This time listen for a dog and a duck. When you hear a dog or a duck clap your hands. [Play 12 sounds duck #5 dog #10] Did you hear the dog and the duck? Well done. We'll have one more turn. This time listen for the sound of a lion and a horse, when you hear them clap your hands.[Play 12 sounds, lion # 5 horse # 9] Did you hear the lion and the horse. Well done. [2.20min]

[animal sounds https://www.google.com/search?q=animal+sounds]

We will play a different listening game now. This time we will listen to the sound of an instrument. The instrument will make a sound and we will copy that sound by clapping So if the instrument makes three sounds we will clap three times. Get ready to clap. 3 4 2 2. Very good. Now the

instrument will play at different speeds. So this time copy the number of sounds and the speed of the sounds when you clap. 2 (slow) 2 (slow) 3 (fast) 3 (fast)4 (very fast) 2 (slow) That was good. [1.15mins]

Now we have come to the end of our games. Well done.

ABBREVIATIONS

ANT	Attention network task
EF	Executive function
HTKS	Head toes knees and shoulders
MBI	Mindfulness-based intervention
MBP	Mindfulness-based programme
RCT	Randomised controlled trial
RT	Reaction time
RTCV	Reaction time coefficient of variability
SART	Sustained attention response task
SDQ	Strengths and difficulties questionnaire

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